Board of County Commissioners Business Meeting Minutes – DRAFT

A complete video copy and packet including staff reports of this meeting can be viewed at https://www.clackamas.us/meetings/bcc/business.

Thursday, September 11, 2025 – 10:03 AM
In person and via virtual technology (Zoom)

PRESENT: Chair Craig Roberts
Commissioner Paul Savas
Commissioner Martha Schrader
Commissioner Ben West
Commissioner Diana Helm

CALL TO ORDER

I. PUBLIC COMMUNICATION

Ed Wagner (Tualatin) – Opposition to PGE high voltage lines conditional use permit

Kelly Bartholomew (Tualatin) – Opposition to PGE high voltage lines conditional use permit and provided a report for the Board (included in minutes)

Rick Dodge (Milwaukie) – Reflected on recent death of national figure Charlie Kirk

Brainard Brauer (Oregon City) – Shared frustration about County permit process

Patty Boyd (Milwaukie) (Virtual) – Inquired about future evening Business Meetings

II. HOUSING AUTHORITY CONSENT AGENDA

A. Approval of an Amendment to an Intergovernmental Agreement with Clackamas County to transfer funds to the County for coordinated delivery of housing and homeless services. Amendment Value is $235,156.59 for 1 year. Total Agreement Value is $955,219.59 for 5 years. Funding is through Housing Authority federal and state administrative funds. No County General Funds are involved.

B. Approval of an Amendment to an Intergovernmental Agreement with Clackamas County to receive funds from the County for the coordinated delivery of housing and homeless services. Amendment Value is $30,050,409.96 for 1 year. Total Agreement Value is $61,527,111.33 for 5 years. Funding is through the Governor's State of Emergency Due to Homelessness and Metro. No County General Funds are involved.

Commissioner Helm moved to approve and Commissioner Schrader seconded. Motion passed 6-0 (Commissioner Leenstra aye).

III. PRESENTATION

A. Spirit of Excellence Employee Awards

IV. CONSENT AGENDA

A. Elected Officials

1. Approval of Previous Business Meeting Minutes – BCC
2. Approval of a Grant Application to the Oregon Criminal Justice Commission for organized retail theft enforcement cost assistance. Application Value is $800,000 for 2 years. Funding is through the Oregon Criminal Justice Commission. No County General Funds are involved. – CCSO
3. Approval of a Grant Application to the Oregon Criminal Justice Commission for Phase 1 expansion of deflection and conditional discharge programs. Application Value is $395,000.50 for 18 months. Funding is through the Oregon Criminal Justice Commission. No County General Funds are involved. – DA

B. *County Administration

1. Approval of a Grant Application to the Oregon Department of Energy for rooftop solar at the Recovery Campus. Grant Value is approximately $300,000 for one-time costs. Funding is through the Oregon Department of Energy. No County General Funds are involved.

C. County Counsel

1. Approval of a Purchase and Sale Agreement with the North Clackamas Parks and Recreation District for the condominium re-plat of the Oak Lodge Library property. Purchase price is $190,693.89. Funding is through budgeted County General Funds.
2. Approval of an Agreement with the North Clackamas Parks and Recreation District for permanent storm line and right of way easements at Concord Park and Community Center and Oak Lodge Library properties. No fiscal impact. No County General Funds are involved.

D. Tourism

1. Approval of a Professional Services Contract with Snowfish to provide search engine marketing management. Contract Value is $651,956 for 4 years. Funding is through the Transient Lodging Tax. No County General Funds are involved.

E. Transportation & Development

1. Approval of a Resolution Declaring the Public Necessity and Purpose for the Acquisition of Rights of Way, Easements, and Fee Property, and Authorizing Good Faith Negotiations and, if necessary, Condemnation Proceedings, for SE 172nd Avenue Improvements Project. Project Value is $44,922,808. Funding is through the City/County Transportation System Development Charge District Funds, Developer Contributions, and City of Happy Valley Funds. No County General Funds are involved.

2. Approval of a Board Order for a Purchase Order of a tractor mower. Purchase Order Value is $151,858. Funding is through the County Road Fund. No County General Funds are involved.

F. **Health, Housing & Human Services**

1. Approval of an Amendment to an Intergovernmental Agreement with the Housing Authority of Clackamas County to receive funds from the Housing Authority for coordinated delivery of housing and homeless services. Amendment Value is $235,156.59 for 1 year. Total Agreement Value is $955,219.59 for 5 years. Funding is through Housing Authority federal and state administrative funds. No County General Funds are involved.

2. Approval of an Amendment to an Intergovernmental Agreement with the Housing Authority of Clackamas County to transfer funds to the Housing Authority for the coordinated delivery of housing and homeless services. Amendment Value is $30,050,409.96 for 1 year. Total Agreement Value is $61,527,111.33 for 5 years. Funding is through the Governor's State of Emergency Due to Homelessness and Metro. No County General Funds are involved.

3. Approval of a Subrecipient Grant Agreement with the West Linn-Wilsonville School District to provide youth substance use prevention programming. Agreement Value is $200,000 for 2 years. Funding is through the Oregon Health Authority. No County General Funds are involved.

4. Approval of an Amendment to a Subrecipient Grant Agreement with the Senior Citizens Council of Clackamas County to provide guardianship, conservatorship and diversion services for at-risk seniors and adults. Amendment Value is $179,550 for 1 year. Total Agreement Value is $530,100 for 3 years. Funding is through the Older Americans Act and $99,965 in budgeted County General Funds.

5. Approval of an Amendment to a Subrecipient Grant Agreement with Friends of the Estacada Community Center to provide meal and transportation services to older adults. Amendment Value is $123,898 for 1 year. Total Agreement Value is $472,072 for 3 years. Funding is through the Oregon Department of Human Services and Statewide Transportation Improvement Funds. No County General Funds are involved.

6. Approval of an Amendment to a Subrecipient Grant Agreement with the North Clackamas Parks & Recreation District, on behalf of the Milwaukie Community Center, to provide meal and transportation services to older adults. Amendment Value is $395,255 for 1 year. Total Agreement Value is $1,352,517 for 3 years. Funding is through the Oregon Department of Human Services and Statewide Transportation Improvement Funds. No County General Funds are involved.

7. Approval of a Revised Intergovernmental Revenue Agreement with the Oregon Department of Human Services for intellectual and developmental disabilities programs. Agreement Value is $38,187,575 for 2 years. Funding is through Oregon Department of Human Services and $136,724 in Budgeted County General Funds.

8. Approval of an Amendment to a Subrecipient Grant Agreement with the City of Wilsonville, on behalf of its Wilsonville Community Center, for meal and transportation services to older adults. Amendment Value is $97,589 for 1 year. Agreement Value is $358,859 for 3 years. Funding is through the Oregon Department of Human Services. No County General Funds are involved.

9. Approval of Personal Services Contract with Uncommon Bridges for recruitment, facilitation, and ongoing support services for the Housing Services Advisory Group. Agreement Value is $187,740 for 10 months. Funding is through Supportive Housing Services Measure funds. No County General Funds are involved.

10. *Approval of Amendments to a Service Agreement with OCHIN Incorporated for the operation of Epic electronic health records and delegation of future signing authority for up to $50,000 of future amendments. Combined Amendments Value is $9,461.40. Funding is through Health Centers' Fee for Services. No County General Funds are involved.

Commissioner Savas moved to approve and Commissioner Helm seconded. Motion passed 5-0.

V. NORTH CLACKAMAS PARKS & RECREATION DISTRICT CONSENT AGENDA

A. Approval of a Purchase and Sale Agreement with Clackamas County for the condominium re-plat of the Oak Lodge Library property. Purchase price is $190,693.89. Funding is through budgeted County General Funds.

B. Approval of an Agreement with Clackamas County for permanent storm line and right of way easements at Concord Park and Community Center and Oak Lodge Library properties. No fiscal impact. No County General Funds are involved.

C. Approval of an Amendment to a Grant Agreement with Clackamas County for delivery of Older Americans Act funded senior services. Amendment Value is $395,255 for 1 year. Total Agreement Value is $1,352,517 for 3 years. Funding is through the Oregon Department of Human Services and the Older Americans Act. No County General Funds are involved.

Director Savas moved to approve and Director Schrader seconded. Motion passed 5-0.

VI. DEVELOPMENT AGENCY CONSENT AGENDA

A. Approval of an Amendment to an Intergovernmental Agreement with Water Environment Services for the Monroe Street Improvement Project. Amendment Value is $18,000 and no time increase. Total Agreement Value is $233,940 for 2 years. Funding is through the Water Environment Services Sanitary Sewer Construction Fund. No County General Funds are involved.

Director Helm moved to approve and Director Savas seconded. Motion passed 5-0.

VII. WATER ENVIRONMENT SERVICES CONSENT AGENDA

A. Approval of an Amendment to an Intergovernmental Agreement with the Clackamas County Development Agency for the Monroe Street Improvement Project. Amendment Value is $18,000 and no time increase. Total Agreement Value is $233,940 for 2 years. Funding is through the Water Environment Services Sanitary Sewer Construction Fund. No County General Funds are involved.

B. Approval of a Resolution of Necessity and Purpose Authorizing the Acquisition of Necessary Easements by Good Faith Negotiations and, if necessary, Condemnation for the Rock Creek Sewer Extension. Funding is through Water Environment Services Sanitary Sewer Construction Fund. No County General Funds are involved.

Director Helm moved to approve and Director Savas seconded. Motion passed 5-0.

VIII. COUNTY ADMINISTRATOR UPDATE

Administrator Schmidt shared praise from the public for County road crew work in repaving a road.

VII. COMMISSIONER COMMUNICATION

Commissioner Schrader reflected on 9/11 and shared her excitement on Oak Lodge Library progress.

Commissioner Savas recalled 9/11 and reported on the tour of the Parrott Creek facility.

Commissioner West spoke on the shooting of national figure Charlie Kirk and political violence.

Commissioner Helm remarked on the Caring Place groundbreaking and echoed excitement for the new Oak Lodge Library.

Chair Roberts noted the upcoming Veterans Day of Service.

Chair Roberts adjourned the meeting at 11:26AM.

BEFORE THE HEARINGS OFFICER

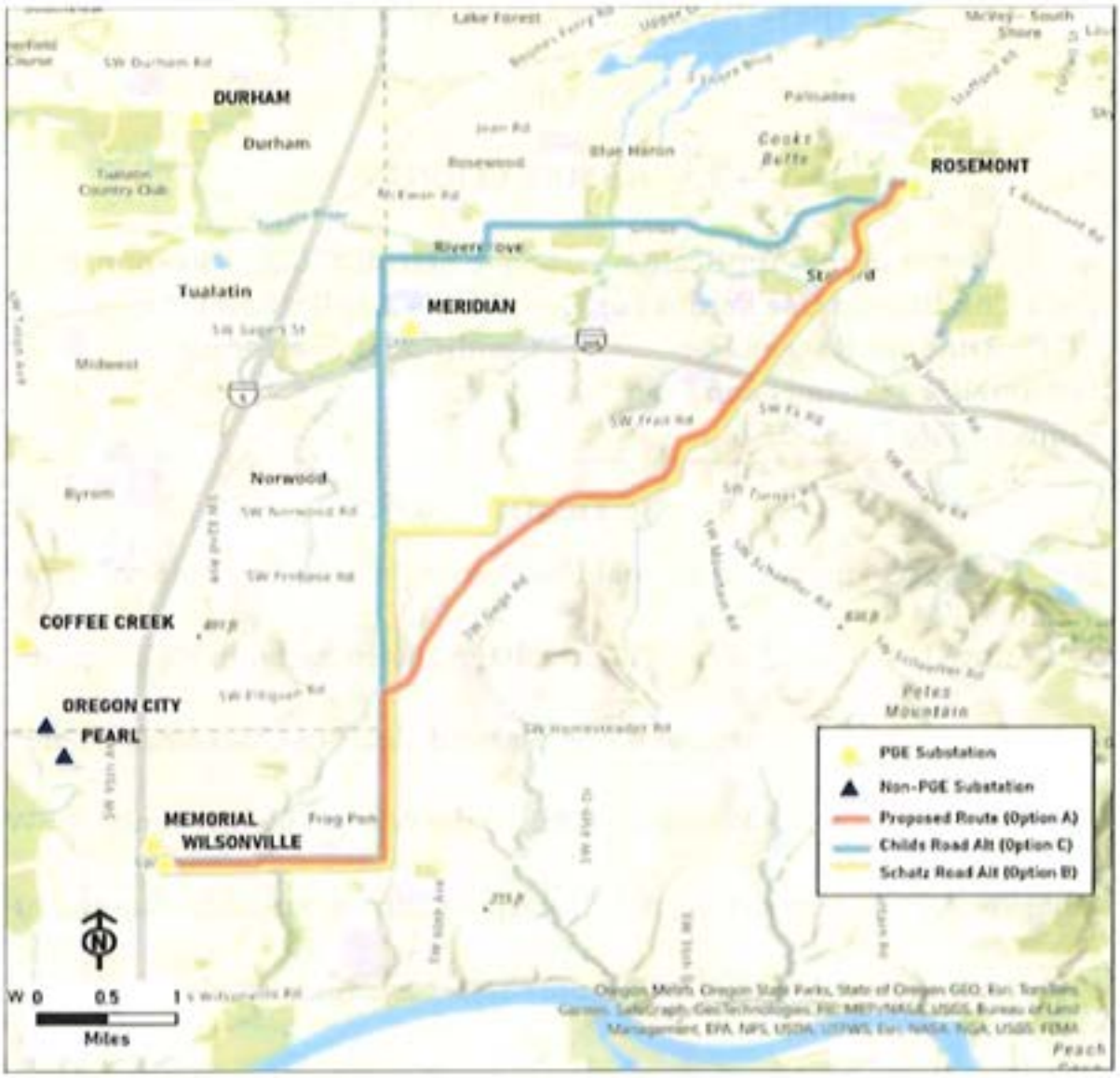
OF

CLACKAMAS COUNTY

In the Matter of the Application For a Conditional Use Permit For PGE's Tonquin Rosemont-Wilsonville Transmission Line Project – File Z0282-25	**Save Stafford Road's Response to PGE's Application for a Conditional Use Permit**

I. INTRODUCTION

PGE is seeking a Conditional Use Permit ("PGE's Application") from the County to construct a new high-voltage transmission line ("Proposed Project") in a 5.9-mile corridor along Stafford Road in Clackamas County from a substation at SW Rosemont Road to the Wilsonville city limits at SW Kahle Road. PGE Application, p. 5. The Application is part of the Rosemont-Wilsonville segment of PGE's Tonquin Project as depicted below:



Save Stafford Road opposes PGE's Application. Save Stafford Road consists of property owners in the Stafford Road Area of Clackamas County who will be adversely affected by the Proposed Project.[1] The Stafford Road

[1]County Staff advised PGE representatives at the Pre-Application Conference that they viewed the area to be evaluated as the area within ½ miles of the Proposed Project. Pre-Application Summary, p. 5. This area is referred to in Save Stafford Road's Response as

Area is recognized by many as a special part of Clackamas County with rolling fields, scenic views, and rural ambience. Stafford Road is recognized as a Rural Scenic Road in the County's Comprehensive Plan.

Save Stafford Road is concerned about the aesthetics of the proposed new PGE structures, including many poles that would be over twice as tall with a much larger diameter than existing poles. Residents remain concerned about the effects on their local farm businesses, the character of the Stafford Road Area, scenic views, and property values.

Additional concerns include increased fire risks, electromagnetic radiation risks, and electrocution from arcing, all associated with the higher levels of energy of the Proposed Project. Many of the new transmission lines would be routed dangerously close over homes, front yards, and children waiting for buses.

Because the project would require the removal of over 250 trees, residents are also troubled by the potential destruction of wildlife habitat as

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the "Stafford Road Area." There are 1,462 property owners within the Stafford Road Area. Notice of Decision (File ZO236-24), County's denial of PGE's Application for the Alteration of a Nonconforming Use, p. 8.

well as the decimation of the last remaining triangle of farmland (and carbon sink) separating the cities of Tualatin, Wilsonville, and West Linn.

More broadly, and perhaps most importantly, the community is concerned that this project is a "test case" that could set a precedent for placing high-voltage transmission lines along many designated Rural Scenic Roads in Clackamas County.

PGE has been issued a Certificate of Public Convenience and Necessity ("CPCN") by the Oregon PUC to condemn dozens of private properties along Stafford Road to accommodate the easements required for the larger pole clearance necessitated by the new high-powered transmission lines. This Certificate is currently being appealed in the Oregon Court of Appeals.

In PUC testimony, safety risks were inappropriately discounted. The potential for dangerous electromagnetic fields exposure and accidents, including fire and electrical arcing, are unfortunately real. Save Stafford Road does not believe that PGE has adequately addressed the mitigation of such risks, and therefore, the Proposed Project poses a true threat and significantly changes the character of the Stafford Road Area.

Save Stafford Road's response to the Proposed Project sets forth the reasons why the Hearings Officer should deny PGE's Application. As

described below, PGE cannot bear its burden of proof demonstrating satisfaction with the County's Conditional Use Criteria.

II. LEGAL ISSUES RAISED BY PGE

PGE raises the following legal issues to avoid having to apply for a Conditional Use Permit for its Proposed Project. It is apparent to Save Stafford Road that the purpose and intent behind these issues is PGE's efforts to overcome its difficult and impossible burden of satisfying the County's legal requirements entitling PGE to build its new Proposed Project.

A. Whether the County's Code requires conditional use approval where public transmission lines already exist.

It is PGE's position that it is not required to obtain conditional use approval for its Proposed Project since the County's conditional use provisions apply only to "new" Public Transmission Line projects—not an alteration or upgrade to an "existing" facility.

The County's Code does not distinguish between a "new" Public Transmission Line or an "existing" facility. The Code unambiguously states that "Public Transmission Lines" require a conditional use in the RRFF-5 Zoning District. County Staff advised PGE in their Pre-Application Summary that:

> "ZDO Section 316 Rural Residential Zoning - Public Transmission Lines are a conditional use in all of the rural residential zoning districts including the RRFF-5 Zoning District that is under a large portion of the 7-mile distribution corridor."

Pre-Application Summary, File No. ZPAC-0018-25.

Based on the foregoing, the Hearings Officer can find that PGE is required to obtain a conditional use permit.

B. Whether ORS 758.010(1) pre-empts Clackamas County from requiring PGE to apply for a Conditional Use Permit for its Proposed Project.

PGE argues that ORS 758.010(1) pre-empts Clackamas County from requiring PGE to acquire land use approval for its Proposed Project:

> Under ORS 758.010(1), public utilities have a statutory "right and privilege" to construct, maintain, and operate electric transmission lines "along the public roads in this state," outside city limits, "free of charge." This right is not contingent on discretionary land use approval. Rather, the rights and privileges granted under this statute are expressly excluded from counties' general authority under ORS 374.309 to adopt reasonable regulations and issue permits for the use of county right-of-way. ORS 374.325.4.

PGE Application, p. 13.

As noted above, it is County Staff's position that proposed Public Transmission Lines require conditional use approval in the RRFF-5 Zoning District. ORS 758.010(1) states:

> Except within cities, any person has a right and privilege to construct, maintain and operate its water, gas, electric or communication service lines, fixtures and other facilities along the public roads in this state, as defined in ORS 368.001 (Definitions) or across rivers or over any lands belonging to state government, as defined in ORS 174.111 ("State government" defined), free of charge, and over lands of private individuals, as provided in ORS 772.210 (Right of entry and condemnation of lands for construction of service facilities). Such lines, fixtures and facilities shall not be constructed so as to obstruct any public road or navigable stream.

ORS 758.010 grants a public utility a right, but with conditions. ORS 758.010(2) grants Clackamas County the authority to "designate the location" of utility facilities on County roads. Clackamas County uses the authority vested by ORS 758.010(2) to require a conditional use permit to locate a Public Transmission Line. Further, ORS 758.010(3) provides that Clackamas County may impose "reasonable requirements for the location, construction, operation and maintenance" of utility facilities permitted under ORS 758.010(1). ORS 758.010(3).

Based on the foregoing, the Hearings Officer can find that PGE has a statutory right under ORS 758.010(1) to construct its Proposed Project along Stafford Road, but that Clackamas County has the authority to impose reasonable requirements in the precise location of PGE's high-powered transmission lines. Simply put, this statute confers no immunity from land use laws, nor does it create a right to override county zoning codes or permitting procedures that have been acknowledged by the State of Oregon.

PGE's assertion that the State legislature "has clearly preempted local governments in the area of access to and use of rights-of-way by utilities in Oregon" is wrong. On the contrary, the State provides specific authority for Clackamas County to regulate the location of a public utility and provides it the tools to do so by permitting the County to require PGE to obtain conditional use approval.

PGE's reference to *Brentmar v. Jackson Cnty.*, 321 OR. 481, 900 P.2d 1030 (1995) is misplaced. PGE uses *Brentmar* for the proposition that the Oregon Supreme Court "has unequivocally held that when a land use is authorized by state statute as a matter of right, a local government may not apply conditional use or other types of discretionary review that would…override those statutory criteria." PGE Application, p. 13.

PGE's proposed Public Transmission Line is not an authorized land use as a matter of right by state statute. As noted above, ORS 758.010(1) grants a public utility a right, but with limitations subject to a County's land use regulations. As a result, *Brentmar* is not controlling.

Based on the foregoing, the Hearings Officer can find that ORS 758.010(1) does not pre-empt Clackamas County from requiring PGE to acquire a conditional use for its Proposed Project.

III. IMPORTANT CONSIDERATIONS

There are two important considerations that Save Stafford Road would like to bring to the attention of the Hearings Officer. These considerations stand for the proposition that PGE does not have to construct its Proposed Project along Stafford Road to achieve its purposes.

While these considerations are not technically relevant, the Hearings Officer can deny the Proposed Project on legally relevant grounds with the understanding that PGE will still be able to achieve its purposes through other alternatives <u>without</u> altering the character of the Stafford Road Area.

A. PGE's Proposed Project does not need to be located along Stafford Road. There are other alternative routes that would avoid altering the character of the Stafford Road Area.

In PUC testimony, PGE claims to have examined "alternative routes" but there appears to be many less-impactful routes that were prematurely discounted by PGE. In fact, PUC staff concluded that the Rosemont-Wilsonville Line may not be necessary at all:

> "PGE's evidence suggests that it can and will construct the remainder of the Tonquin Project even if it cannot build the Rosemont–Wilsonville Line. Thus, it could be argued that the proposed line is not strictly necessary to the operation of the Tonquin Project."[2]

The below satellite image shows that a superior route would head straight up SW 65th to Borland Road where the line would follow the existing Rosemont-Meridian 115 kV line all the way to Rosemont. PGE's preferred route already double circuits the existing Rosemont-Meridian 115 line from Rosemont to Borland but diverts to scenic Stafford Road at Borland circle. PGE filed the routing study in PCN-6, but although the report identified the route, the report did not explain why the SW 65th-Borland Road alternative was ignored and not evaluated.

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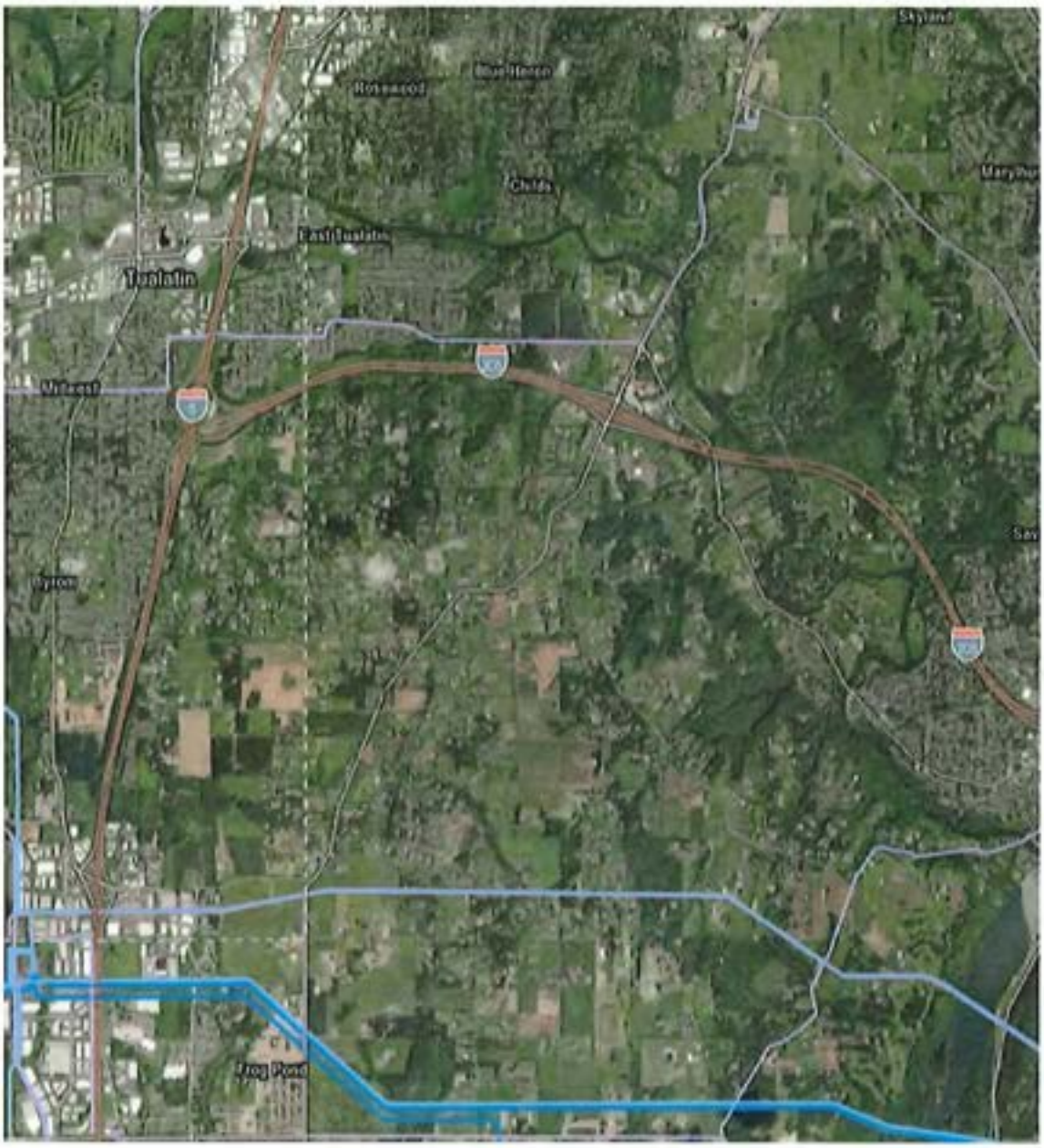
[2](PUC/Docket PCN 6/Staff 100/p. 38/lines 7-13).



B. PGE does not have to construct a transmission line to achieve its business purpose. There are other non-transmission alternatives that would achieve PGE's purpose that would avoid altering the character of the Stafford Road Area.

While high-voltage transmission lines are very profitable for power companies, they are often not necessary. Advances in distributed energy

resources (DERs), battery energy storage, and smart grid systems are rapidly reducing or eliminating the need for long-distance power transmission infrastructure. PGE has recognized this by implementing "475 MW of Battery Energy Storage to Boost Grid Reliability and Keep Costs Low for Oregonians."[3] In fact, in its 2024 Distribution System Plan, PGE recognized the myriads of technologies that it is using to enhance the power grid without building more transmission lines.[4] Unfortunately, these technologies were not examined in the PUC CPCN application for the Stafford Road transmission line.

Given the rapidly evolving power grid technology, careful consideration must be given to permanently disfiguring the Clackamas County rural landscape to accommodate an antiquated system of transmission infrastructure that is rapidly evolving and will be largely obsolete in the near future.

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[3]PGE Energizes 475 MW of Battery Energy Storage to Boost Grid Reliability and Keep Costs Low for Oregonians: https://www.morningstar.com/news/pr-newswire/20250807sf46315/pge-energizes-475-mw-of-battery-energy-storage-to-boost-grid-reliability-and-keep-costs-low-for-oregonians

[4]https://downloads.ctfassets.net/416ywc1laqmd/6fsVybjYRmGNV4M7PwBOl2/c9ffcaa9e432ea82d67e6359c24c76ac/2024_PGE_DSP_2024_12_18.pdf

IV. PGE HAS FAILED TO DEMONSTRATE THAT ITS APPLICATION SATISFIES THE COUNTY'S CONDITIONAL USE CRITERIA

It is Save Stafford Road's position that PGE cannot demonstrate that its Proposed Project complies with the County's Conditional Use Criteria and should be denied. Save Stafford Road identifies those reasons below and respectfully requests the Hearings Officer to adopt those reasons and deny PGE's Application.

CONDITIONAL USE CRITERIA

ZDO 1203.03(A): The use is listed as a conditional use in the zoning district in which the subject property is located.

Finding: Save Stafford Road agrees with Staff that PGE's Proposed Project is listed as a conditional use in the RRFF-5 zone.

ZDO 1203.03(B): The characteristics of the subject property are suitable for the proposed use considering size, shape, location, topography, existence of improvements, and natural features.

Finding: The Stafford Road Area is not suitable for this project for multiple reasons as explained below, but the fact that PGE's Proposed Project is located along Stafford Road, a recognized Rural Scenic Road by the County's Comprehensive Plan, is determinative that the location is clearly not suitable. Clackamas County Comprehensive Plan (Section 5.I).

As described above, there are many viable, less impactful alternative routes that were prematurely eliminated by PGE early in this process that would not limit or impair uses within the Stafford Road Area–and would not require placing industrial-style transmission lines near residential front yards, removing over 250 trees and vegetation along a County designated Rural Scenic Road, and placing dangerous high-voltage power lines near homes and sleeping children, along a single lane road with narrow shoulders, frequent traffic congestion, and many accidents.[5]

Due to the "location," "topography," and "natural features" of Stafford Road, the area is uniquely poised for a catastrophic, uncontrollable fire on a dry, windy summer day. Constructing high-voltage power lines near homes, without fire hydrants or public water and no adequate egress for miles along a one lane road, surrounded by dry hay fields and trees, is a recipe that will place residents in unacceptable fire danger.

PGE consulted with local fire departments who confirmed that the Stafford Road Area has rapid fire response times and "adequate resources."[6]

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[5]According to a Wilsonville Transportation System Performance Report, Stafford Road in Clackamas County experiences approximately two crashes involving fatalities or serious injuries annually, based on data since 2013.
[6]PUC/PCN 6/PGE Reply Brief/p. 2/lines 20-21.

Unfortunately, resources and response time did not control three of the deadliest fires in this country: Lahaina, Eaton, and Paradise. The conditions that created the "perfect storm" (that were started by faulty electrical lines) in these deadly wildfires are precisely replicated in the "location," "topography," and "natural features" of the Stafford Road Area in the summer: frequent strong winds, dry grasses, and trapped residents with "no way out."[7] The Stafford Road Area also has the additional risk factors of no public water and no fire hydrants.

PGE is proposing to add high-voltage transmission lines to a residential location where "perfect storm" catastrophic fire conditions exist all summer. PGE's "fire mitigation plan" is to ensure residents that Stafford Road is not in a "high risk zone (HFRZ)" and that local fire department response time is "adequate."[8] This cannot be acceptable.

Based on the foregoing reasons, the Hearings Officer can find that PGE's Proposed Project is not suitable along Stafford Road in the Stafford Road Area.

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[7]Google AI overview of "why the Eaton and Lahaina fires were so deadly?"
[8]PUC/PCN 6/PGE Reply Brief/p. 2/lines 20-21.

ZDO 1203.03(C): The proposed use complies with Subsection 1007.07, and safety of the transportation system is adequate to serve the proposed use.

Finding: Subsection 1007.07 requires that:

"Development adjacent to scenic roads identified on Comprehensive Plan Map 5-1, *Scenic Roads*, shall conform to the following design standards, as deemed appropriate by the Department of Transportation and Development:

i. Road shoulders **shall be** [emphasis added] improved to accommodate pedestrian and bicycle traffic; and

b. Turnouts **shall be** (emphasis added) provided at viewpoints or for recreational needs."

As stated above, the Clackamas County Comprehensive Plan designates Stafford Road as a Rural Scenic Road (Section 5.I). Stafford Road is a narrow, one-lane road with minimal shoulders. Pursuing the Proposed Project along Stafford Road is not only dangerous but the project cannot meet the requirements of Subsection 1007.07 above.

Based on the above Finding, the Hearings Officer can conclude that PGE has not met its burden of proof that its Proposed Project complies with Subsection 1007.07 nor demonstrated that Stafford Road is adequate to serve its Proposed Project.

ZDO 1203.03 D: The proposed use will not alter the character of the surrounding area in a manner that substantially limits, impairs, or

precludes the use of surrounding properties for the primary uses allowed in the zoning district(s) in which the surrounding properties are located.

Clackamas County's Zoning and Development Ordinance does not define the terms included within ZDO 1203.03(D). The meaning of these terms is significant in applying this legal criterion to the facts associated with PGE's Proposed Project and the Stafford Road Area.

How are the terms "surrounding area" and "surrounding properties" defined?

The character of the "surrounding area" that could potentially be altered by the Proposed Project needs to be described and examined. County Staff advised PGE representatives at the Pre-Application Conference that they viewed the term "surrounding area" as the area within ½ miles of its Proposed Project. Pre-Application Summary, p. 5. County Staff further advised PGE representatives that they viewed the term "surrounding properties" as the surrounding properties within the surrounding area:

> In context of the code it is the surrounding properties within the surrounding area. Therefore, for a linear project like a power line it would be the legal lots of record under the poles and wires along with properties adjacent to those legal lots of record.

Pre-Application Summary, p. 7.

Based on the foregoing, the area to be examined under ZDO 1203.03(D) are the properties within ½ mile of Stafford Road or the Stafford Road Area.

How is the term "will not alter the character" defined?

In *York v. Clackamas County* ___ Or LUBA ____, LUBA No. 2018-145, April 10, 2019 ("*York*"), LUBA held that a determination whether a proposed use "alters the character" of the surrounding area depends on whether the proposed use substantially limits or impairs the character of surrounding properties:

> "ZDO 1203.03(D) does not prohibit alteration of the character of the surrounding area, only alterations 'in a manner that substantially limits, impairs, or precludes the use of surrounding properties for the primary use[.]' As ZDO 1203.03(D) is structured, if the hearings officer concludes that the proposed use does not substantially limit, impair or preclude the primary uses of the surrounding area, there is no need to address whether it has 'alter[ed] the character' of the surrounding area in some other manner."

How are the terms "substantially limits, impairs or precludes the use of surrounding properties allowed in the zoning districts in which the surrounding properties are located" defined?

In *York*, LUBA explained that the inquiry under ZDO 1203.03(D) must analyze whether the proposed use substantially limits primary uses on surrounding properties and whether the proposed use substantially impairs primary uses on surrounding properties.

LUBA citing Webster's Third New International Dictionary (unabridged ed. 2002) defined "limit" as: "1. To: confine to within certain limits: fix, constitute or appoint definitely, allot, prescribe * * * 3a: to set the bounds or limits; b: to curtail or reduce in quantity or extent." LUBA defined "impair" as: "to make worse, diminish in quantity, value, excellence or strength, do harm to: damage, lessen ."

The term "substantially impairing" means that the Proposed Project must not interfere with, diminish the value of, or negatively affect the ability to enjoy existing and legally established uses in the EFU and RRFF-5 zones. The purpose of such a rule is to protect the character and integrity of a neighborhood. This is referred to as the "non-impairment standard."

Save Stafford Road understands that it must establish that PGE's Proposed Project demonstrably interferes and impairs the primary uses allowed in the Stafford Road Area rather than a general dislike of the Proposed Project.

Based on these definitions, ZDO 1203.03(D) requires the following examination by the Hearings Officer to determine whether PGE has met its burden of proof with substantial evidence demonstrating that its Proposed Project will not alter the character of the surrounding area in a manner that

does not substantially limit, impair, or preclude the use of surrounding properties for the primary uses allowed in the EFU and RRFF-5 zones.

First, the primary uses allowed in the applicable zoning districts need to be identified where the Proposed Project will be located. Here, the Proposed Project will traverse through property zoned EFU and RRFF-5.

Second, the character of the "surrounding area" that could potentially be altered by the Proposed Project needs to be described and examined. County Staff advised PGE representatives at the Pre-Application Conference that they viewed the term "surrounding area" as the area within ½ miles of its Proposed Project. Pre-Application Summary, p. 5. County Staff further advised PGE representatives that they viewed the term "surrounding properties" as the surrounding properties within the surrounding area:

> In context of the code it is the surrounding properties within the surrounding area. Therefore, for a linear project like a power line it would be the legal lots of record under the poles and wires along with properties adjacent to those legal lots of record.

Pre-Application Summary, p. 7. Based on the foregoing, the area to be examined are the properties within the Stafford Road Area.

Third, the scope of the Proposed Project must be defined to be able to measure whether the potential impact of the Proposed Project would alter

the character of the Stafford Road Area. Here, the Proposed Project is the introduction of a new high-voltage 115 kV transmission line on significantly taller steel poles mounted on large cement block within the Stafford Road Area.

Fourth, the impacts of the Proposed Project must be analyzed to determine if the Proposed Project substantially limits, impairs, or precludes the use of surrounding properties in the Stafford Road Area.

Fifth, whether conditions of approval can be imposed on the Proposed Project that would mitigate any substantial impairment or limitation that alters the character of the Stafford Road Area.

A. Identification of the primary uses allowed in the EFU and RRFF-5 zones.

The Stafford Road Area consists of properties zoned RRFF-5 and EFU. The primary uses in the RRFF-5 zone are listed in ZDO 309.03.[9] The purpose

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[9]ZDO 309.03 – PRIMARY USES IN RRFF-5 ZONES

A. One single family dwelling, residential home as defined in Section 202 or manufactured dwelling subject to the provisions of Section 824. *(11124/99)*

B. Current employment of land for general farm uses, including:

1. Raising, harvesting and selling of crops.
2. Feeding, breeding, selling and management of livestock, poultry, fur-bearing animals or honeybees.
3. Selling of products of livestock, poultry, fur-bearing animals or honeybees.
4. Dairying and the selling of dairy products.
5. Preparation and storage of the products raised on such lands for man's use and animal use.

of the EFU zone is explained in ZDO 401.01[10]. The question before the Hearings Officer is whether the Proposed Project would substantially impair or limit the uses permitted in the RRFF-5 and EFU zones. As addressed below, the Proposed Project will substantially impair the use of surrounding property and alter the character of the Stafford Road Area.

B. Examination of the character of the Stafford Road Area that will be potentially altered by the Proposed Project.

The proposed route for the Proposed Project runs through the heart of the Stafford Road Area. Along Stafford Road, there are rolling hills,

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6. Distribution by marketing or otherwise of products raised on such lands.
7. Any other agricultural use, horticultural use, animal husbandry or any combination thereof.

C. The propagation or harvesting of a forest product.

D. Public and private conservation areas and structures for the conservation of water, soil, forest, or wildlife habitat resources.

E. Fish and wildlife management programs.

F. Public and private parks, campgrounds, playgrounds, recreational grounds, hiking and horse trails, pack stations, corrals, stables and similar casual uses provided that such uses are not intended for the purpose of obtaining a commercial profit.

[10]ZDO 401.01 PURPOSE OF EFU ZONES

A. To preserve agricultural use of agricultural land.

B. To protect agricultural lands from conflicting uses, high taxation and the cost of public facilities unnecessary for agriculture.

C. To maintain and increase the agricultural economic base of Clackamas County.

D. To increase agricultural income and employment by creating conditions which further the growth and expansion of agriculture and which attract related industries.

E. To maintain and improve the quality of air, water and land resources.

F. To conserve scenic and open space.

G. To protect wildlife habitats.

beautiful views, old trees, pristine 5- to 15-acre farmland parcels, open spaces, and abundant wildlife.

The Stafford Road Area is recognized as a special and unique part of Clackamas County with scenic views and rural ambience, including the Farmlandia Farm Loop. The Farmlandia Farm Loop is described as a "self-guided farm loop" that spans 17 farms featuring animals, horse stables and corrals, vineyards, nurseries, strawberry patches, lavender farms, pumpkin patches, Christmas trees, honeybee farms, and more.[11] All of these uses are specifically identified in ZDO 309.03.

The Farmlandia Farm Loop is well publicized throughout the Portland Metropolitan area.[12] The local farms attract many school children, bus tours, and visitors from the surrounding urban areas each year. These visitors come to experience the natural scenic beauty of the Stafford Road Area.

The natural scenic beauty of the Stafford Road Area has been recognized by Clackamas County in its Comprehensive Plan, which

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[11]https://oregonfarmloop.com/map/
[12]https://www.travelportland.com/region/farm-loops-near-portland/
https://www.shareoregon.com/things-to-do/en/listings/124917-farmlandia-farm-loop-tour
https://www.mthoodterritory.com/articles/farm-loops-guide
https://www.willamettevalley.org/farmlandia-farm-loop-guide

specifically designates Stafford Road as a "Rural Scenic Road." Save Stafford Road is concerned that taking a scenic tour along Stafford Road through chopped down trees and new tall high-powered, industrial-style transmission lines would clearly not be a desirable rural experience along a County designated Rural Scenic Road.

The Stafford Road Area also includes rural residential uses that are located in the RRFF-5 zone. Many of these rural residences are located along Stafford Road who are members of Save Stafford Road that will be adversely affected by the Proposed Project.

Most residents living along Stafford Road were drawn to this small area of unincorporated Clackamas County because of the rural "character." As such, many residents report having protected wildlife species living in the trees and grasslands on their properties along Stafford Road. These include endangered species such as bald eagles and peregrine falcon, and threatened species such as spotted owl, pygmy rabbits and other wildlife. Removing over 250 trees will clearly impact on the scenery and habitats of local wildlife along Stafford Road and the surrounding areas.

C. The Scope of the Proposed Project.

The Proposed Project must be defined to be able to measure whether the impact of the Proposed Project would alter the character of the Stafford Road Area.

The northern 2.4 miles of the Corridor has existing PGE transmission, distribution, and communication lines. The southern 5.0 miles of the Corridor consists of distribution lines and wooden poles. The Proposed Project would add high-voltage 115 kV transmission lines to the existing 12.5 kV distribution and communication lines within the Southern Corridor and increase the height of all poles from approximately 50-60 feet to 85-120 feet taller steel poles mounted on large cement blocks. PGE's proposed alteration of its existing facilities adds an entirely new system of transmission power within the Southern Corridor.[13]

The Proposed Project would necessitate the removal of over 250 trees and vegetation and the replacement of 177 wooden poles, with much larger diameters and significantly taller steel poles, mounted in large cement

[13]PGE previously applied to the County for an Alteration of a Non-Conforming Use of its existing transmission lines to enable the construction of the Proposed Project. The Planning Director denied PGE's Application. One of the bases was that the Proposed Project would create a "greater adverse impact" on the Stafford Road Area.

blocks. The additional height of the new poles would allow the high-voltage (115 kV) transmission lines to be supported above the existing distribution lines in order to carry nearly 10 times greater amount of electricity. These taller steel poles will require the removal of all metal barns, metal gates, and farm equipment (all frequent in the farming community on Stafford Road) due to arcing risks.

D. Analysis whether the Proposed Project alters the character of the Stafford Road Area by substantially limiting and impairing the use of "surrounding properties."

County Staff advised PGE representatives at the Pre-Application Conference how this standard will be applied and reviewed by County Staff:

> [T]he Conditional Use review looks at the transmission line to see if it would "alter the character of the surrounding area in a manner that substantially limits, impairs, or precludes the use of surrounding properties for the primary uses allowed in the zoning district(s) in which surrounding properties are located." Therefore, staff would be considering whether the character of the surrounding area would be changed by the construction of the transmission line in a way that would substantially limit the rural residential use and would be making a recommendation to the Hearings Officer based on our findings. No consideration of the existing power line would be required because this criteria is not comparing the proposed use to the existing use. It is solely looking

> at how the proposed use would affect, or alter the surrounding area.

Pre-Application Summary, p. 5.

Save Stafford Road agrees with Staff's characterization of the difference between the County's review of an application for an alteration of a nonconforming use and an application for a conditional use permit.[14] However, the County's decision in its denial of PGE's application for an alteration of a nonconforming use is instructive and relevant in the County's review of PGE's application for a conditional use permit. The reason being that the County reached conclusions regarding the effect of PGE's Proposed Project on the Stafford Road Area in its "after" construction state that is instructive in examining whether PGE's Proposed Project alters the character of the Stafford Road Area.

Therefore, the Hearings Officer can take into consideration County Staff's prior assessment of PGE's Proposed Project in applying the requirements of ZDO 1203.03(D). Save Stafford Road will refer to Staff's prior assessment in its analysis below.

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[14]It should be noted that PGE's proposed project for its alteration of a nonconforming use is identical to its Proposed Project for its request for a conditional use permit.

PGE identified seven specific possible impacts that could alter the character of the Stafford Road Area: (1) Fire Risk, (2) Tree Removal, (3) Natural Resources, (4) Visuals/Aesthetics, (5) Property Values, (6) Noise, and (7) Health Impacts. Save Stafford Road concurs these are the specific possible impacts and addresses them below.

1. **The Proposed Project will substantially limit and impair property within the Stafford Road Area by increasing the fire risk of a catastrophic fire due to the installation of new high-voltage transmission lines.**

The Stafford Road Area presents a unique and greater risk of a catastrophic fire with the installation of PGE's proposed high-voltage transmission lines.

PGE represents it has "adequate fire response resources" to mitigate any increased risk of fire with its new high-voltage transmission lines in the Stafford Road Area. In its Opening PUC Brief, PGE represented that the Rosemont-Wilsonville Line would be located outside a high-risk fire zone, the risk of wildfire would be minimal, and that available fire response resources in the area would be sufficient to ensure that the new high-voltage transmission lines would not significantly increase wildfire hazards. PGE's representations are not supported by the facts.

The Stafford Road Area is located in unincorporated Clackamas County where there is a lack of public infrastructure, no public water, no fire hydrants, and limited access to be able to respond to the risk of a catastrophic fire caused by PGE's proposed high-voltage transmission lines. Only well water would exist if electricity were available, and without electricity, there is no power for well pumps – and consequently – no water. A fire response without fire hydrants or public water infrastructure with limited emergency access is not adequate to mitigate this increased risk.

Part of the reason that the recent Los Angeles fires spread so rapidly was due to palm fronds carrying embers for long distances and the sparks ignited fires in multiple different locations. Without fire hydrants or public water infrastructure, shuttling water occupies an entire firefighting team to extinguish one fire. This raises the risk of embers igniting a new fire in another location and all resources being used to shuttle water to a single fire.

The combination of the recent high-voltage power line fires in Lahaina, Paradise, and Southern California have clearly demonstrated that climate change has put every neighborhood at risk. Like Lahaina, there is no way out from Ek Road to Mountain Road and Mountain Road to SW

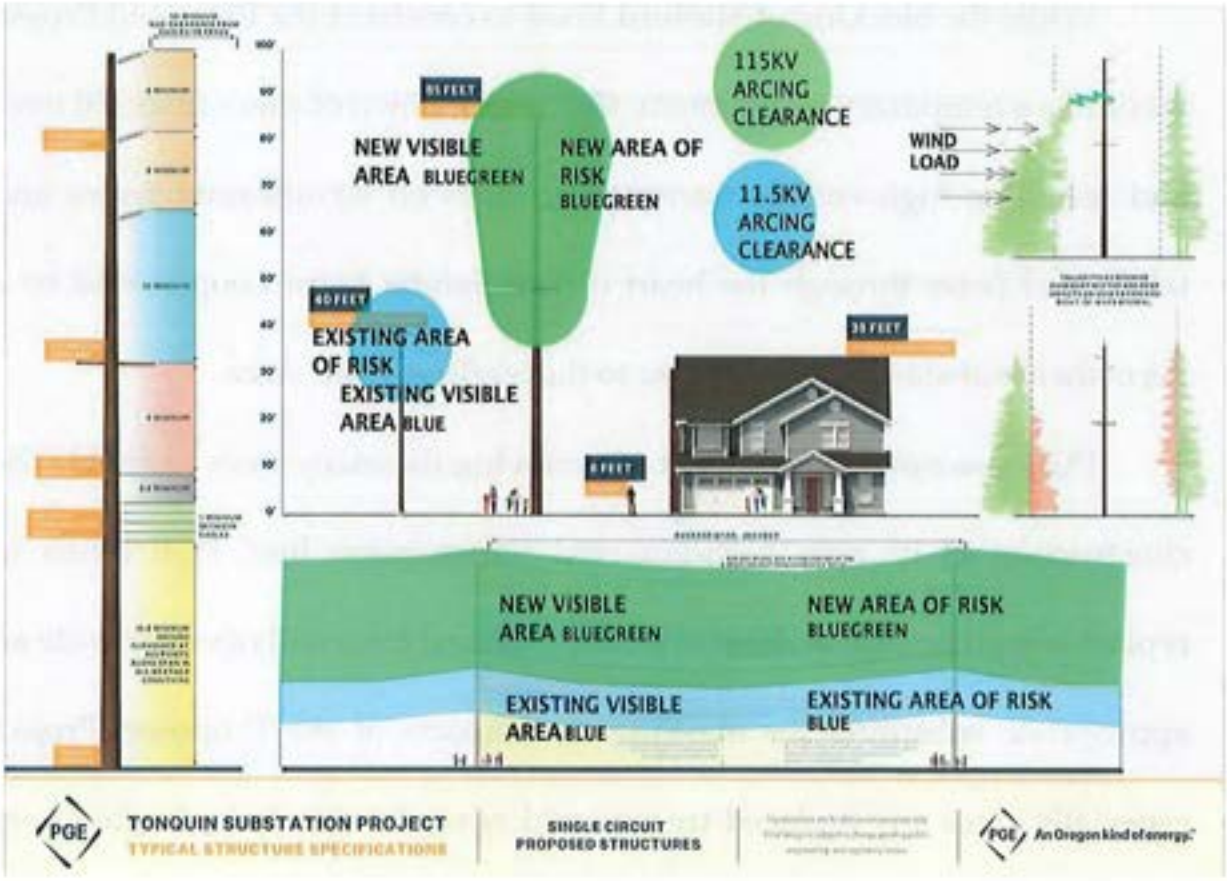
65th, a three-mile stretch of road. Many of the deaths from the Lahaina fires were because there was only one way in and one way out.

This additional risk is a direct byproduct of the Proposed Project and substantially impairs property within the Stafford Road Area. There are no conditions which can be imposed that would provide the necessary assurances that this greater risk can be mitigated.

The Proposed Project will also substantially limit and impair properties within the Stafford Road Area by increasing the risk and danger of "arcing" due to the installation of high-voltage transmission lines. Arcing, also known as a flashover or arc flash, is an electrical discharge that occurs when electricity jumps across a gap in the air between two conductors or between a conductor and a grounded object.

Arcing with high-voltage transmission lines poses severe risks, including electrical burns, potential for electrocution, and even death as well as damage to equipment and structures. As a farming area, the Stafford Road Area would be at a high risk of electrical arcing due to the metal barns, large metal gates, and metal farm equipment that would be adjacent to the proposed high-voltage transmission lines.

PGE's own graphic below from its failed attempt to alter a nonconforming use demonstrates this additional risk.



PGE downplays this Fire Risk. However, this additional risk is a direct byproduct of the Proposed Project and substantially impairs property within the Stafford Road Area pursuant to ZDO 1203.03(D). There are no conditions that can be imposed that would provide the necessary assurances that this risk can be mitigated.

2. **The Proposed Project will substantially limit and impair property within the Stafford Road Area by the removal of trees.**

While the blocking of Stafford Road to construct the Proposed Project would be a temporary impairment, the cutting down of more than 250 trees and installing high-voltage transmission lines on significantly larger and taller steel poles through the heart of Farmlandia Farm Loop would be a permanent substantial impairment to the Stafford Road Area.

PGE downplays the impact of removing the many trees to enable the construction of its new high-powered transmission line. PGE offers to replant trees if necessary. However, any replaced trees will never provide an appropriate substitute for masking the impacts of the Proposed Project especially since any replaced trees would never be able to be located near the new high-powered transmission lines.

3. **The Proposed Project will substantially limit and impair property within the Stafford Road Area by creating adverse visual impacts affecting the scenic views and rural ambience along Stafford Road, a County recognized Scenic Rural Road.**

The non-impairment standard includes a review of aesthetic (visual) impacts and if the project alters the character of an area that is substantially out of place with the surrounding community. Visual impacts are changes

to the scenic attribute of the landscape brought upon by the introduction of visual contrasts such as development and the associated changes in the human visual experience of the landscape that affect a viewer's perception and emotions. See attached Exhibit 1.

PGE's preexisting power lines along Stafford Road currently impose an adverse visual impact within the Stafford Road Area. PGE's Proposed Project imposes an even more significant impact that limits and impairs the surrounding properties which alters the character of the Stafford Road Area.

The best way of demonstrating the adverse visual impact of the Proposed Project is through photographic exhibits. See attached Exhibits 2-15 that visually depicts PGE's Proposed Project along Stafford Road. These photographic exhibits were prepared directly from PGE's website for its Tonquin Project, including the Rosemont-Wilsonville line.[15]

County Staff was persuaded by the above photographic exhibits in Staff's denial of PGE's application for the alteration of a nonconforming use.

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[15]Please note that all of the simulations are directly from PGE's Tonquin project website. When you click on Structures, this shows every pole that is part of the 177-pole replacement project. If you place your cursor on each pole and click on it, it will tell you exactly the height of the existing pole and the height of the replacement or new poles that will be needed. At the bottom of the web page there is a category called photo simulations. There are a couple of areas—Stafford Road is listed second. When you click

Staff made the following finding that can be adopted by the Hearings Officer in the review of the current application:

> Staff is most persuaded by Exhibits 3 through 17 of Save Stafford Road's submittal, which Save Stafford Road states were derived from PGE's website for the Tonquin project, of which this proposal is a part. These simulations clearly demonstrate that the project will have significant visual impacts in comparison to the existing lines. The added height, larger-diameter poles, and additional wires combine to create a far more industrial aesthetic than the current power lines, *an aesthetic that is inconsistent with the current visual identity of the area*. (Emphasis added).

Notice of Decision, File ZO236-24, p. 27.

Staff also recognized the significance of the County's Comprehensive Plan designating Stafford Road as a Rural Scenic Road:

> Staff concur with the applicant that the Plan policies are not approval criteria for a nonconforming use alteration. However, the Plan designation demonstrates that part of Stafford Rd was deemed scenic enough to warrant a special designation as such. It is reasonable to conclude that effects on the aesthetic qualities that led to the road's designation as scenic may constitute adverse impacts to the neighborhood.

Notice of Decision, File ZO236-24, p. 26.

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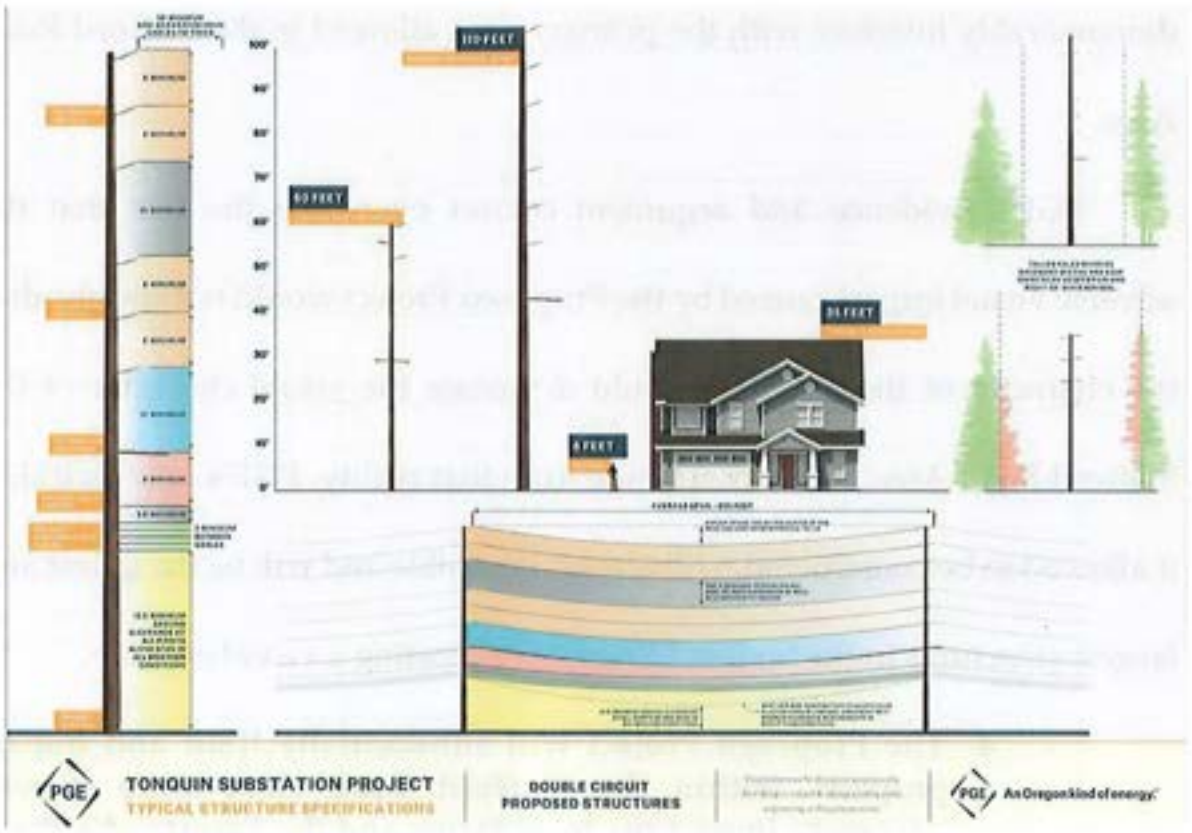
on Stafford Road, 21 simulations come up. You can make a side-by-side comparison directly from PGE's website.

One of PGE's own exhibits entitled "Original PGE Graphic" was an exhibit in PGE's failed attempt in seeking approval for an alteration to a nonconforming use. This exhibit is instructive regarding the adverse visual impact caused by the Proposed Project. It provides a visual comparison and perspective between PGE's current facilities and its Proposed Project.



By any measure, the aforementioned exhibits demonstrate that PGE's proposed "new" construction will have an adverse impact that will substantially limit and impair the scenic views and rural ambience of the Stafford Road Area.

PGE downplays the adverse visual impact its Proposed Project will have on properties located within the Stafford Road Area. However, a review of the above graphics and photographs demonstrate that Save Stafford Road's concerns rise beyond a general dislike of PGE's Proposed Project. This evidence clearly demonstrates that the proposed use will demonstrably interfere with the primary uses allowed in the Stafford Road Area.

PGE's evidence and argument cannot overcome the fact that the adverse visual impact caused by the Proposed Project would not simply alter the character of the area but would devastate the visual character of the Stafford Road Area. PGE cannot hide from that reality. PGE's new facilities, if allowed to be constructed, will always be visible and will be the tallest and largest structures in the Stafford Road Area creating a visual eyesore.

4. The Proposed Project will substantially limit and impair property within the Stafford Road Area since it will adversely impact the local farms and the Farmlandia Farm Loop and the recreational value of the Stafford Road Area.

Clackamas County planning officials have recognized the scenic beauty of the small remaining triangle of farmland separating the three cities of Wilsonville, West Linn, and Tualatin. Consequently, the County

specifically named Stafford Road as a protected rural scenic road with very specific requirements that any changes along the road have very specific aesthetic specifications.

Stafford Road is in the heart of the Farmlandia Farm Loop, which attracts many school children, bus tours, and visitors from the surrounding urban areas each year. These visitors come to experience the natural scenic beauty of the area, the flower farms, pumpkin patches, Christmas tree farms, and berry patches.

Farmlandia Farm Loop is widely publicized in the Portland Metropolitan Area, and the route of the Farm Loop is the last rural area between three cities (West Linn, Wilsonville, and Tualatin). It attracts hundreds of people every year. See attached Exhibit 16.

While the blocking of Stafford Road to construct the Proposed Project would be a temporary impairment, the removing of more than 250 trees and installing high-voltage transmission lines on significantly larger and taller steel poles through the heart of Farmlandia Farm Loop would be a permanent substantial impairment to the Stafford Road Area.

5. The Proposed Project will substantially limit and impair property within the Stafford Road Area by decreasing property values.

The presence of power lines decreases property values. See attached Exhibit 17 entitled, "Do Power Lines Decrease Property Value," which states:

> For buyers, a lower upfront cost when purchasing near power lines may seem like a good deal. However, the same lines will remain when reselling, hampering value. In extreme cases near high-voltage towers, a study shows nearby property values reduced by 44.9 percent.

The non-impairment standard includes a review of whether a proposed project will substantially limit and impair property within the Stafford Road Area by decreasing property values.

Staff addressed this issue in its denial of PGE's application for an alteration of a nonconforming use. Staff concluded:

> The degree of property value loss due to the presence of transmission lines is not definitively identified in either the application or the information provided by the opponents. However, even the potential 2-percent decrease in property values estimated by the applicant's own consultant constitutes a greater adverse impact to the neighborhood. Neither the applicant nor staff has identified mitigating conditions of approval that could ensure no greater adverse impact.

Notice of Decision, File ZO236-24, p. 30.

As noted above, while the legal standard applicable to the County's review of PGE's current application for a conditional use permit is different, the County's prior findings are instructive and relevant in the Hearing Officer's review here. The County's prior finding demonstrates that PGE's Proposed Project will in fact decrease property values of properties within the Stafford Road Area.

PGE downplays the reality that its Proposed Project will decrease property values. Property owners within the Stafford Road Area would need to file Inverse Condemnation proceedings in Clackamas County Circuit Court to be properly compensated for any decrease in property value. These property owners should not be required to bear that burden.

6. The Proposed Project will substantially impair and limit property within the Stafford Road Area due to the adverse health impacts of increasing the danger to children waiting for school buses at bus stops underneath or near the new high-voltage transmission lines.

The dangers of proximity to high-voltage transmission lines are a well-known reality and fact. The World Health Organization - International Agency for Research on Cancer – has classified EMF as "possibly carcinogenic" to humans. Many peer-reviewed medical studies have shown

a significant increase in the risk of childhood leukemia in children who live within 50 meters of high-voltage transmission lines.[16]

PGE's proposed high-voltage transmission lines would be located directly over children waiting for buses along Stafford Road and playing in the Resurrection Church School Gym. Also, there are 250 community members that live within 50 meters of the proposed high-voltage transmission line as evidenced by the following addresses and distances: **West Linn Wilsonville School District Offices, Resurrection Catholic Parish School:** within 20 meters of power lines; **25124 Stafford:** 11 meters; **22400 Stafford:** 12 meters; **25900 Stafford:** 15 meters; **22185 Stafford:** 17 meters; **22720 Stafford:** 21 meters; **22201 Stafford:** 23 meters; **23510 Stafford:** 23 meters; **23662 Stafford:** 23 meters; **23662 Stafford:** 25 meters; **22350**

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[16]British Journal of Cancer, May 2018-Pool analysis from 11 other studies with 29,049 cases and 68,231 controls -Found a **33% increase in childhood leukemia** from children living **< 50m** from high voltage power lines.
American Journal of Epidemiology, October 1993 -Case-control study of 558 controls from Swedish Cancer Registry living close to high voltage power lines increased risk of childhood leukemia **380% for those with greater exposure**.
British Journal of Cancer, September 2000 - Analysis from 9 countries of 3203 children with leukemia and 10,338 controls. Found a **200% increased risk of leukemia** among children with exposure to higher magnetic fields.
British Journal of Cancer, April 2013 Case-control study. 2779 cases of childhood leukemia diagnosed in France from 2002- 2007 with 30,000 controls.
70% increased risk of childhood leukemia (OR 1.7) for children living within **50m** of high voltage power lines.

Stafford: 25 meters; **22801 Stafford**: 26 meters; **25015 Stafford:** 27 meters; **22251 Stafford:** 28 meters; **4285 Stafford:** 30 meters; **22291 Stafford:** 31 meters; **22185 Stafford:** 31 meters; **5615 Blackberry Ln:** 31 meters; **22727 Stafford:** 33 meters; **22560 Stafford:** 35 meters; **22125 Stafford:** 38 meters; **23418 Stafford:** 39 meters; **24024 Stafford:** 41 meters; **21892 Stafford:** 43 meters; **23635 Stafford:** 46 meters; and **3600 Trail Rd:** 49 meters.

The Federal Occupational Safety and Health Administration has established a 15-foot minimum distance from high-voltage power lines (29 CFR 1910.269). PGE's own electrical safety internet page recommends people "stay at least 10 feet away from overhead power lines." See attached Exhibit 18.

The Oregon Electric and Magnetic Field ("EMF") Committee was established in November 2009, to review the health risks of EMF exposure (OAR 345-001-0035). The conclusion of the Oregon EMF Committee was "prudent avoidance" to limit exposure to electromagnetic fields because of the potential risks associated with EMF produced by high-voltage transmission lines. The Oregon EMF Committee also recommended prudent avoidance be included in the planning of high-voltage transmission lines to

minimize public exposure. See attached Exhibits 19-23, additional information related to the EMF issue.

By anyone's measurement, this additional risk of exposure to children and residents within the Stafford Road Area is real and a dangerous health hazard. This additional risk is a direct byproduct of the Proposed Project and substantially impairs and limits property within the Stafford Road Area differently than with PGE's preexisting power lines.

7. Whether conditions of approval could be imposed that could mitigate any substantial limitation or impairment that would not alter the character of the Stafford Road Area.

There is only one condition that could be imposed that might mitigate the adverse impacts caused by PGE's Proposed Project within the Stafford Road Area: require PGE to "underground" its Proposed Project. As described below, Policy 5.I.2.8 (Scenic Road Policies) requires the underground placement of utility service lines unless prohibited by the utility service provider.

There is no evidence that PGE prohibits the underground placement of utility services lines. In fact, just to the contrary, PGE has previously acknowledged that "undergrounding" would have certain safety and reliability benefits as well as creating no adverse "visual impacts." Notice of

Decision, File ZO236-24, p. 22. PGE also explains that the company is reducing fire risk by increasing the undergrounding of power lines each year. PGE has plans to underground over 26 miles of lines in 2025, and states that "it's all about making the right investments in the most impactful areas."[17]

However, PGE dismisses the "undergrounding" alternative here due to the additional costs associated with "undergrounding" its Proposed Project. The Hearings Officer has a choice. The Hearings Officer can either impose a condition requiring PGE to underground its Proposed Project; or deny PGE's Application.

Based on the above, the Hearings Officer can conclude that PGE has not met its burden of proof that its Proposed Project will not alter the character of the Stafford Road Area.

ZDO 1203.03(E): The proposed use is consistent with the applicable goals and policies of the Comprehensive Plan.

Finding: The Proposed Project is not consistent with the following Goals and Policies of the Comprehensive Plan:

[17]PGE official Instagram page: https://www.instagram.com/reel/DJ7IM_0Pq4i/

Saum Creek and its' tributaries reside in the heart of the proposed construction area for this project, but this creek was not mentioned in any of the environmental impact analyses completed by PGE during the PUC process.[20]

2. <u>3.K.9.3 Agriculture</u>

This section identifies County agricultural goals of "preserving agricultural lands" and "conserving scenic areas, open spaces and wildlife habitats." The Comprehensive Plan also identifies wildlife habitat and distinctive resource area goals of "protecting the scenic landscape and natural beauty of Clackamas County" and "working towards placing utility lines underground." Clearly, a project that proposes to remove over 250 trees, install 100- to 150-foot-tall, above-ground, industrial-style high-voltage transmission lines through farm country, in a rural residential neighborhood, along a County designated a Rural Scenic Road, is not consistent with any of these agricultural Comprehensive Plan goals.

[20]See PUC docket PCN 6.

Chapter 5: Transportation System Plan

1. 5.H Rural Tourism Policies 5.H.1.

The goal is to "Encourage agri-tourism and other commercial events and activities that are related to and supportive of agriculture." The Farmlandia Farm Loop runs through the heart of the last remaining triangle of farmland separating Wilsonville, Tualatin, and West Linn. This Farm Loop is the embodiment of agri-tourism. Permitting the destruction of over 250 trees and installation of 100- to 150-foot-tall steel, high-voltage transmission lines along a designated, frequented, rural scenic farm road is antithetical to "Encouraging agri-tourism."

2. 5.I Rural Scenic Roads Policies (5.1.1, 5.1.2 (5.1.2.1-5.I.2.8), and 5.I.3 Designated Scenic Roads.)[21]

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[21]The Clackamas County Comprehensive Plan designates 24 roads as Rural Scenic Roads and Stafford Road is one of them. Requirements for these specific roads include the following:

- 5.1.1 Implement a County Scenic Road System that is safe and attractive for all users.
- 5.1.2 Promote the protection of recreation values, scenic features and an open, uncluttered character along designated scenic roads. Developments adjacent to scenic roads shall be designed with sensitivity to natural conditions and:
- 5.I.2.1 Scenic roads shall have strict access control on new developments.
- 5.I.2.2 Scenic roads should have shoulders wide enough for pedestrians or bicycles, or a separated path where feasible and when funding is available.
- 5.I.2.3 Turnouts shall be provided where appropriate for viewpoints or recreational needs.
- 5.I.2.4 Design review of developments adjacent to scenic roads shall require visual characteristics and signing appropriate to the setting.

policies. The fact that it may have "reclassified" its transmission lines along other County Scenic Roads does not amend the County's Code or Comprehensive Plan excusing PGE from addressing the County's Scenic Rural Roads Policies.

(a) 5.I.1 <u>"Implement a County Scenic Road System that is safe and attractive for all users."</u>

The Proposed Project is not safe. High-voltage transmission lines introduce increased fire risks and a real danger of electrical "arcing." Arcing, also known as a flashover or arc flash, is an electrical discharge that occurs when electricity jumps across a gap in the air between two conductors or between a conductor and a grounded object. Arcing with high-voltage transmission lines poses severe risks, including electrical burns, potential for electrocution, and even death, as well as damage to equipment and structures. Metal barns, metal fences, and metal gates all exist frequently along Stafford Road, many directly under the proposed high-voltage power lines. The risk of electrical arcing is explained in PGE's own depiction. <u>See</u> attached Exhibit 22. There are no conditions that can be imposed that would provide the necessary assurances that this risk can be mitigated.

In addition to safety risks, contrary to the requirements of 5.I.1, the proposed project is not "attractive." Removing over 250 trees and installing large, metal, industrial-style transmission lines along a "rural scenic road" is not "attractive."

(b) 5.1.2 "Promote the protection of recreation values, scenic features and an open, uncluttered character along designated scenic roads. Developments adjacent to scenic roads shall be designed with sensitivity to natural conditions."

(i) 5.I.2.1 "Scenic roads shall have strict access control on new developments."

Building a new transmission line is clearly, "new development." The process involves site identification, planning and design, securing necessary permits and approvals from various agencies, acquiring land rights-of-way (which can involve complex negotiations and potential legal challenges), and construction activities, including land clearing, tower erection, and line installation. All of these activities collectively constitute the "development" of new infrastructure. Thus, this project requires "strict access control."

(ii) 5.I.2.4 "Design review of developments adjacent to scenic roads shall require visual characteristics and signing appropriate to the setting."

Rural scenic roads are defined by their integration into the natural landscape and heightened visual experience they offer travelers. The visual characteristics that contribute to this include natural features (i.e., undisturbed landscape), openness and vistas (i.e., expansive views), minimal human intervention, diverse natural vegetation, and native plants.

Despite mitigation efforts by making the transmission poles "weathered steel" or brown, PGE's new facilities, if allowed to be constructed, will always be visible and will be the tallest and largest structures in the Stafford Road Area. Additionally, the visual characteristics of any replacement plantings cannot replace the removal of trees that are hundreds of feet tall, in their natural habitat.

Finally, poles that are several feet wide and over 100 feet tall will clearly obstruct any expansive views that also define the scenic area.

(iii) **5.I.2.8 <u>Underground placement of utility service lines shall be required unless prohibited by the utility service provider.</u>**

PGE explains that undergrounding power lines are very expensive.[22] PGE also explains that the company is reducing fire risk by increasing the undergrounding power lines each year. PGE has plans to underground over 26 miles of lines in 2025, and states that "it's all about making the right investments in the most impactful areas."[23] Therefore, it appears that undergrounding is not "prohibited" by PGE.

Rather, it is a choice. It is a choice that should be made here to mitigate the adverse impacts of the Proposed Project on the Stafford Road Area that is designated as a Rural Scenic Road.

Based on the above Finding, the Hearings Officer can conclude that PGE has not met its burden of proof that its Proposed Project complies with the County's Comprehensive Plan.

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[22]Tonquin Project FAQ Page: https://portlandgeneralprojects.com/wp-content/uploads/2024/07/ PGE_Rosemont-Wilsonville_FAQ_V9.pdf

[23]PGE official Instagram page: https://www.instagram.com/reel/DJ7IM_0Pq4i/

V. CONCLUSION

Based on the foregoing, Save Stafford Road respectfully requests the Hearings Officer to deny PGE's Application.

Dated this 4th day of September 2025.

HATHAWAY LARSON LLP

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Visual Impact Assessment Methodologies

What Are Visual Impacts?

Visual impacts are changes to the scenic attributes of the landscape brought about by the introduction of visual contrasts (e.g., development) and the associated changes in the human visual experience of the landscape. Visual Impact Assessment (or VIA) is the analysis of the potential visual impacts to the landscape and landscape views resulting from a proposed development or land management action. The document that contains a visual impact analysis is also often referred to as a visual impact assessment or VIA.

Why Do Federal Agencies Conduct VIAs?

Several U.S. federal agency visual resource programs have a VIA process or component, because reducing visual impacts of projects is a key goal of the visual resource programs. This is especially true of agencies that permit development on the lands or waters they administer or agencies that regulate certain types of development, such as highways or dams, that have potentially large visual impacts.

Federal VIA Methodologies Overview

The U.S. Department of the Interior Bureau of Land Management (BLM) has a formal process for assessing the impacts of projects, the Visual Contrast Rating (/assess-simulate/blm/index.cfm). The U.S. Department of Agriculture Forest Service (USFS) does not have a formal process for visual impact assessment, but the USFS Scenery Management System has Landscape Character Goals and Scenic Integrity Objectives (/assess-simulate/usfs/index.cfm) which serve as a baseline for assessing the basic compatibility of a project with the surrounding landscape. The National Park Service does not generally permit new utility-scale energy development on NPS-administered lands, and thus has no formal visual impact assessment process, but does provide guidance on evaluating VIAs (/assess-simulate/nps/index.cfm). The Federal Highway Administration and the U.S. Army Corps of Engineers provide guidance on visual impact

assessment while the Natural Resources Conservation Service does not. The Bureau of Ocean Energy Management is currentluy developing a VIA methodology (see Visual Impact Assessment: Other Federal Agencies (/assess-simulate/other-federal/index.cfm) for more information).

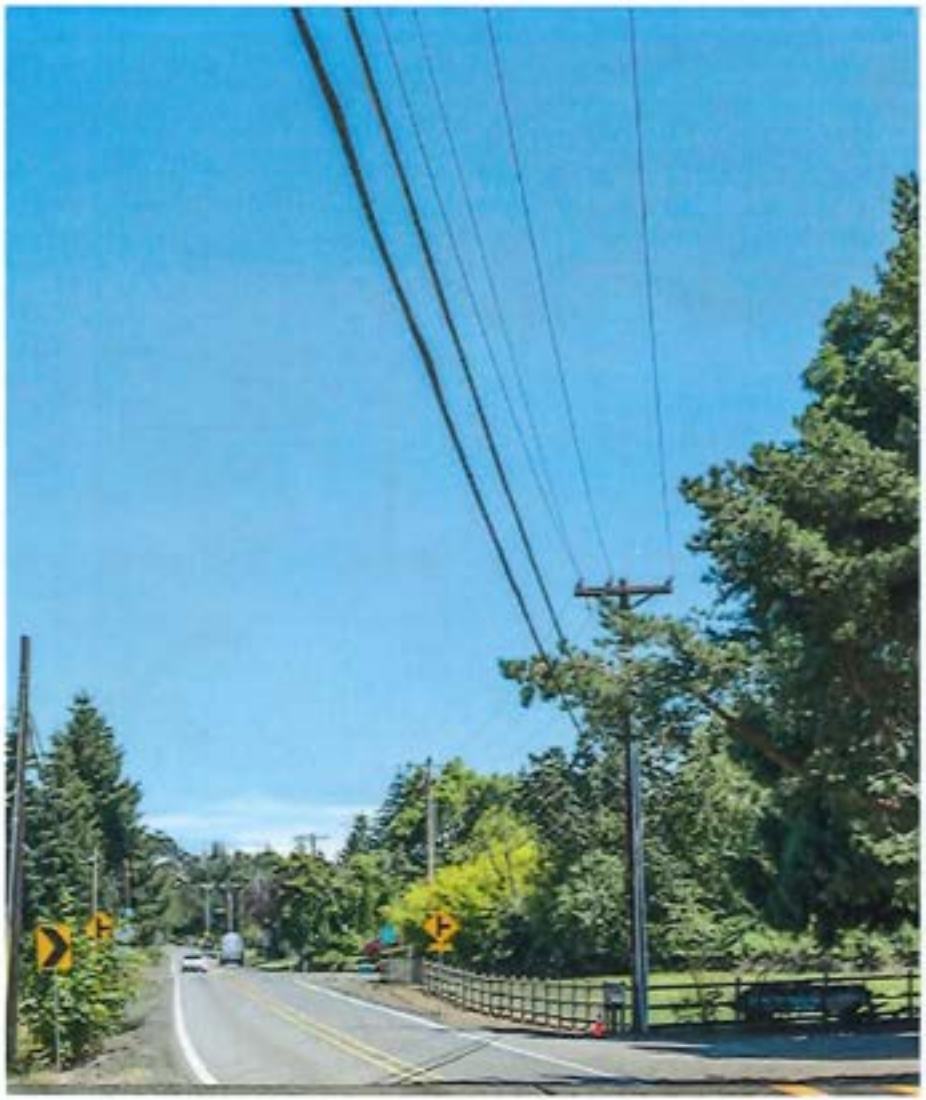
Non-Federal Agencies VIA Methodologies Overview

Some states and other agencies (/assess-simulate/non-federal/index.cfm) have prescribed or recommended VIA methodologies.

Energy Project VIA-Related Research and Technical Reports

A variety of federally-sponsored research and technical reports (/assess-simulate/research-reports/index.cfm) addressing visual impacts of energy facilities and visual impact analysis are also available.

PGE Simulation 16: LOT ID: 3466



38.5 ft Tall

76 ft Tall

EXHIBIT 2

PGE Simulation 14: LOT ID: 3311

38.5 ft Tall

80 ft Tall

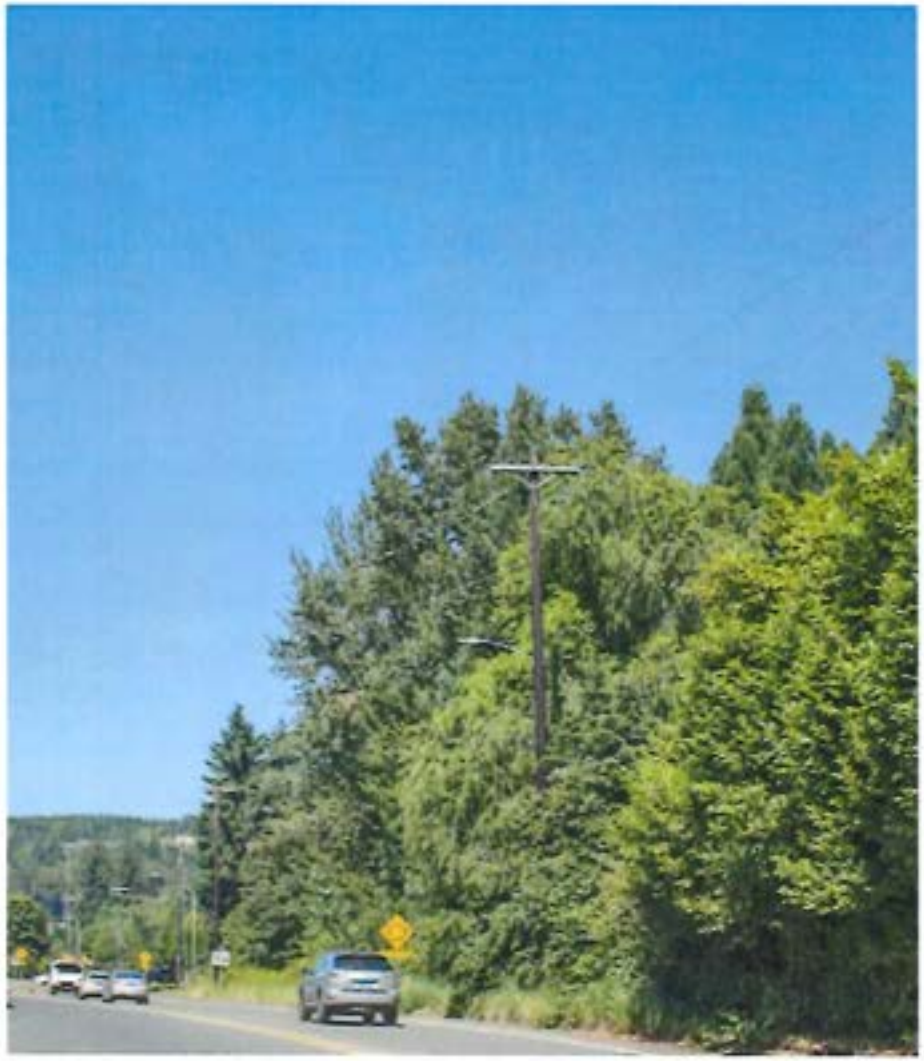
EXHIBIT 3

PGE Simulation 13: LOT ID: 3465

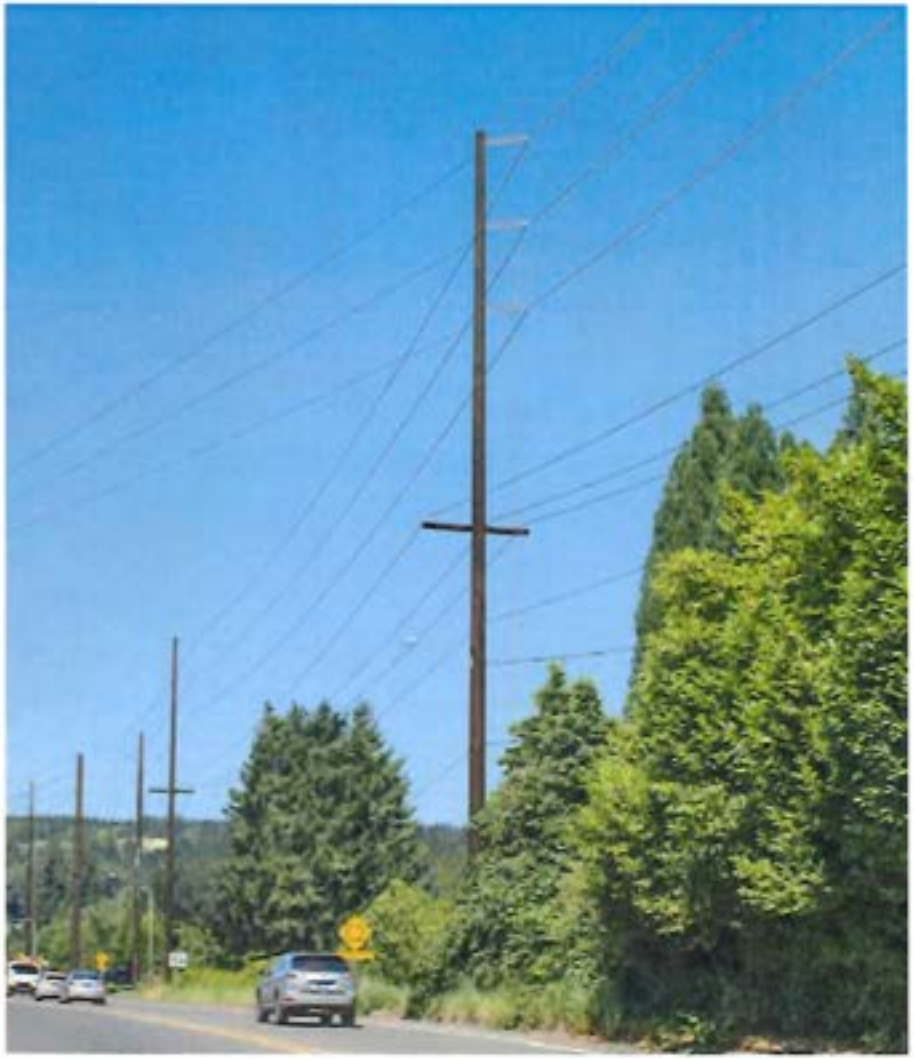
43 ft Tall **89.5 ft Tall**

EXHIBIT 4

PGE Simulation 5: LOT ID: 3427



47.5 ft Tall



79 ft Tall

EXHIBIT 5

PGE Simulation 8: LOT ID: 31

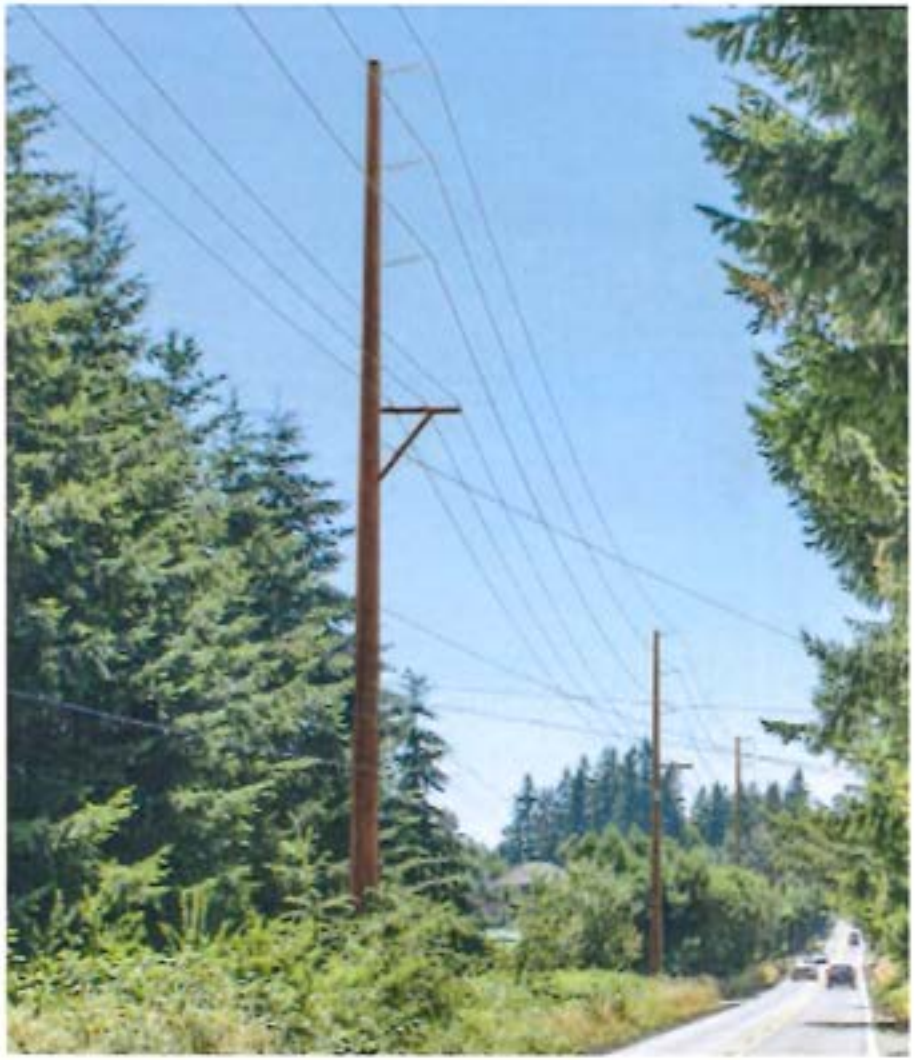
No Current Poles/Lines

98.5 ft Tall New Poles/Lines

EXHIBIT 6

PGE Simulation 18: LOT ID: 3337

34 ft Tall

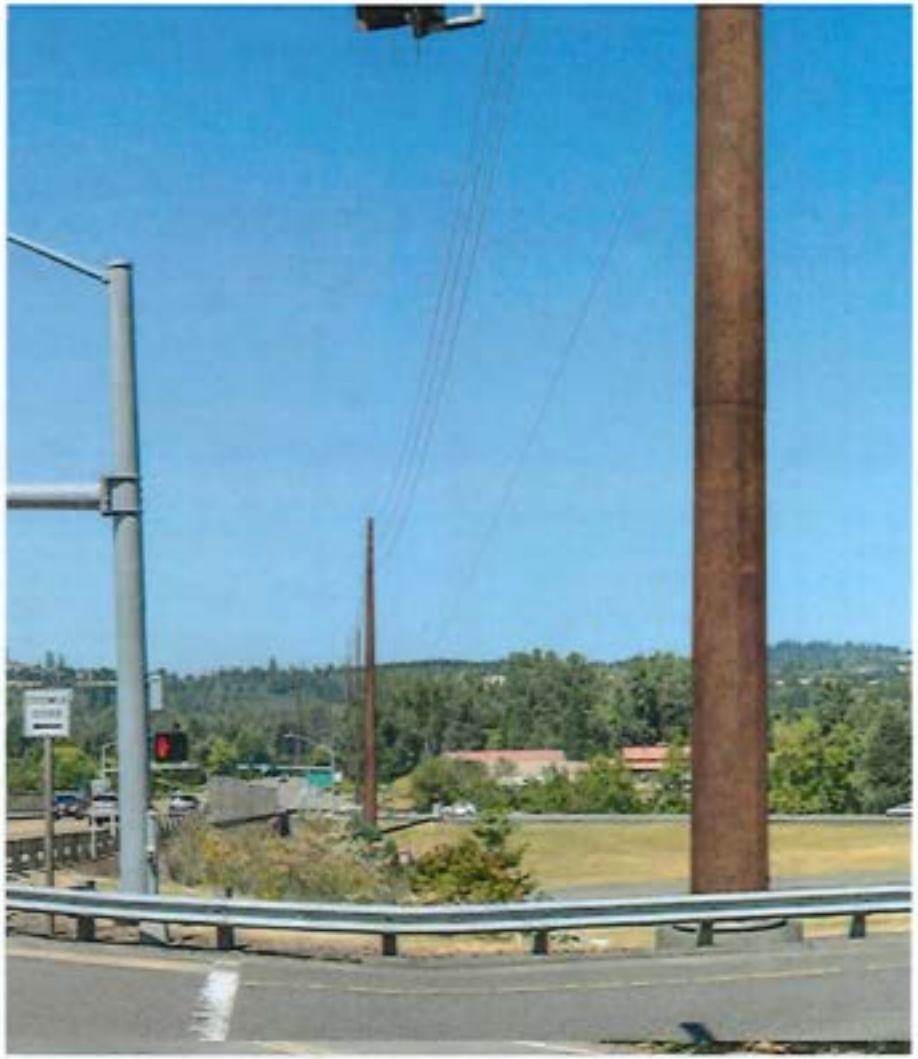


80.5 ft Tall

EXHIBIT 7

PGE Simulation 7: LOT ID: 40

No Current Poles/Lines



120 ft Tall New Poles/Lines

EXHIBIT 8

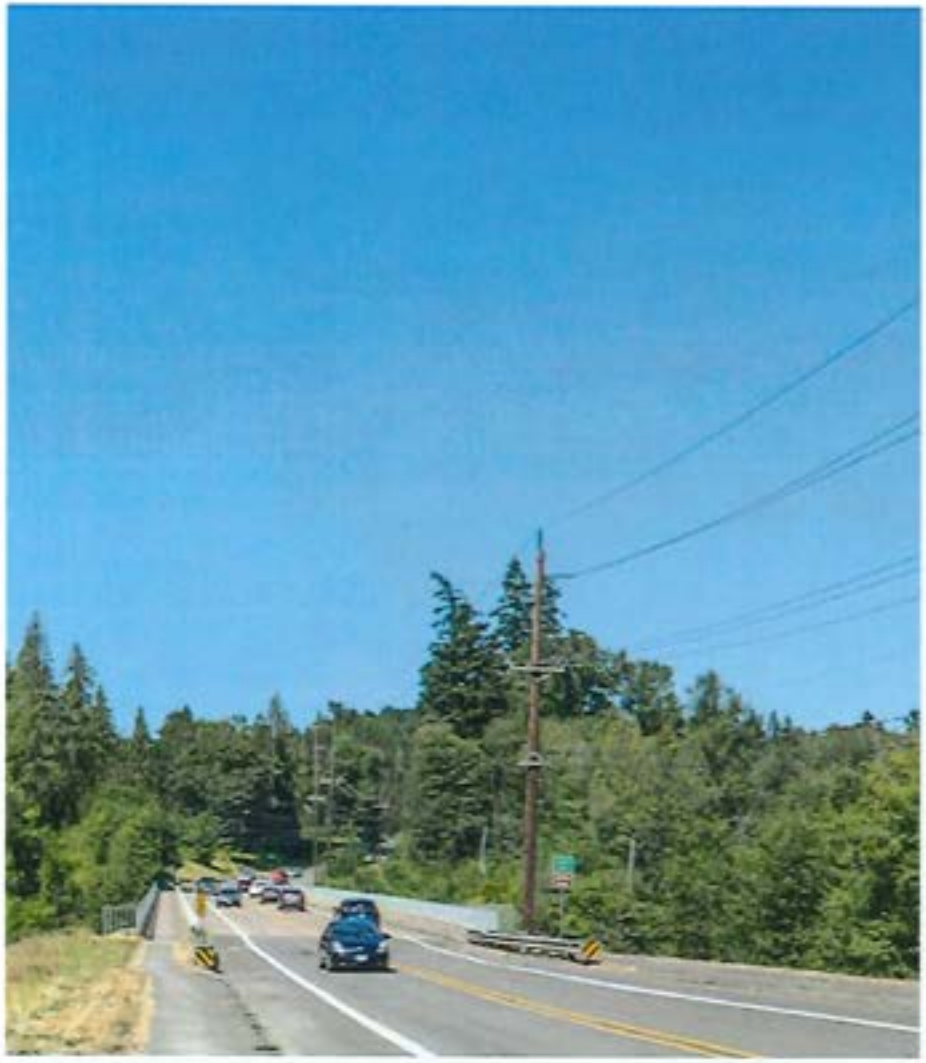
PGE Simulation 17: LOT ID: 3467

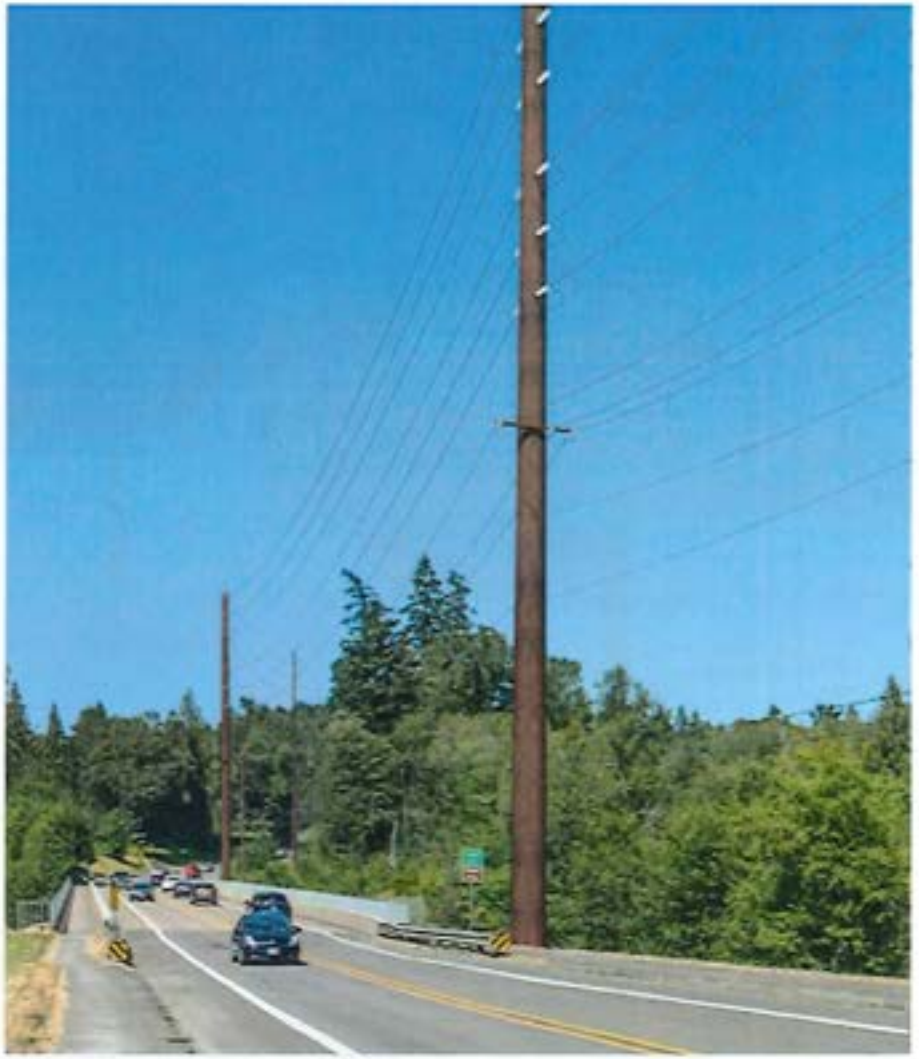
38.5 ft Tall

80 ft Tall

EXHIBIT 9

PGE Simulation 3: LOT ID: 1504

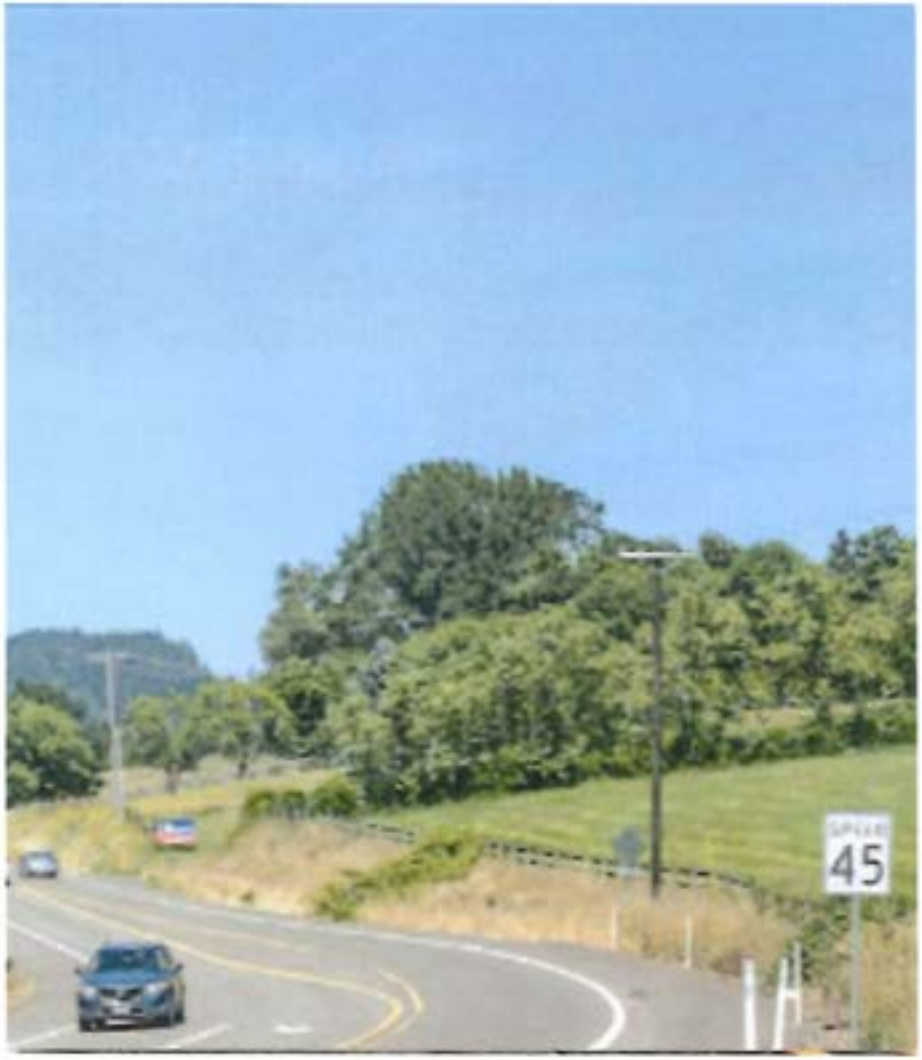




65.5 ft Tall **130 ft Tall**

EXHIBIT 10

PGE Simulation 11: LOT ID: 6428



38.5 ft Tall

85 ft Tall

EXHIBIT 11

PGE Simulation 12: LOT ID: 3973

38.5 ft Tall

94 ft Tall

EXHIBIT 12

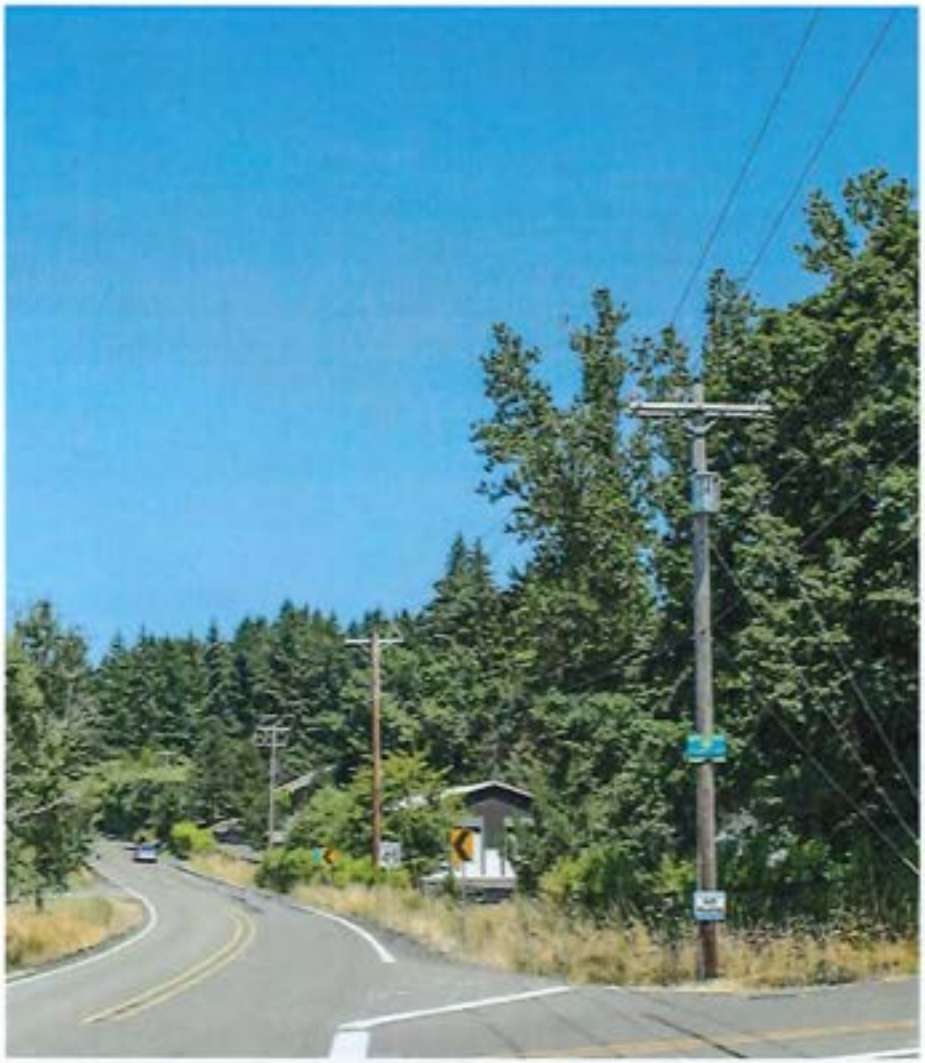
PGE Simulation 15: LOT ID: 65

38.5 ft Tall

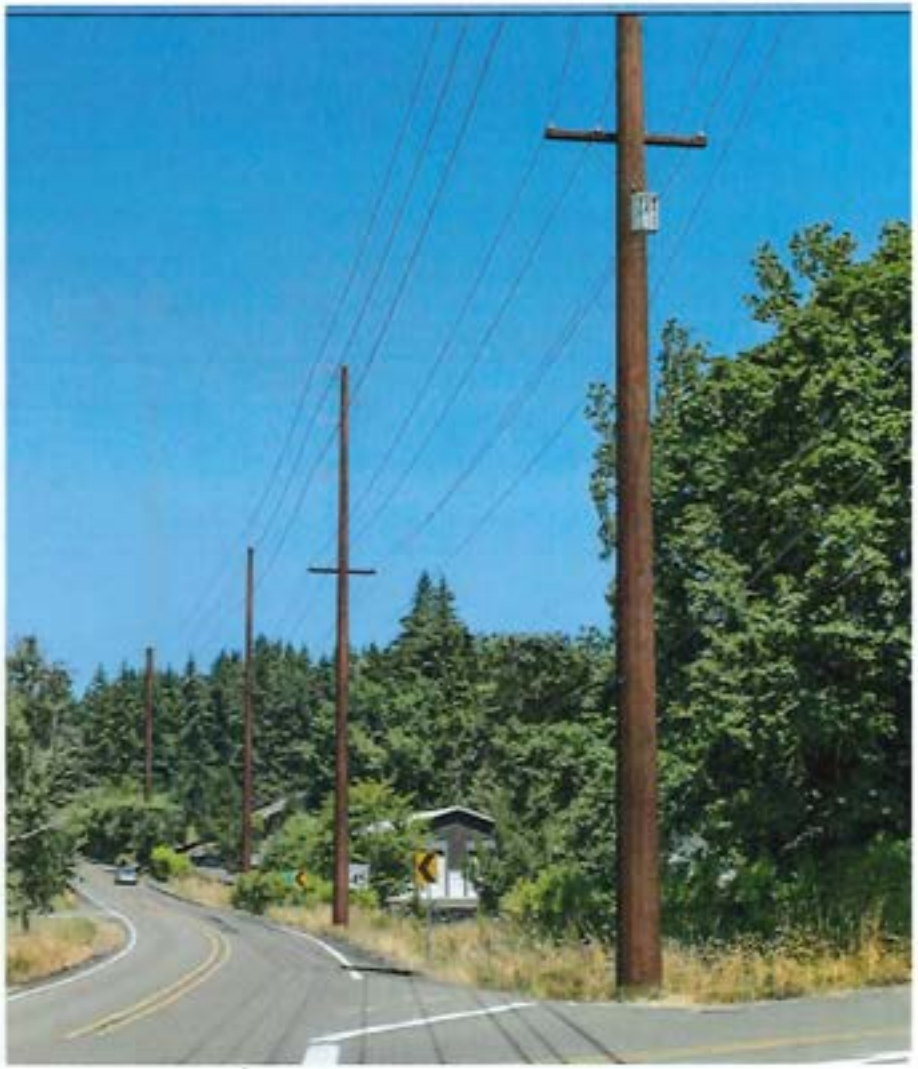
80.5 ft Tall

EXHIBIT 13

PGE Simulation 19: LOT ID: 831



34 ft Tall



85 ft Tall

EXHIBIT 14

PGE Simulation 6: LOT ID: 37

No Current Poles

112 ft Tall
New Poles/Lines

EXHIBIT 15

Your Guide to the Farmlandia Farm Loop

By Matt Wastradowski

The Farmlandia Farm Loop sits at the far northern edge of the Willamette Valley—so far north, in fact, that it butts up against the Portland metro area, offering an unprecedented look at how quickly one can leave the hustle and bustle for a more relaxed pace in the region's farmland.

Explaining the Farmlandia Farm Loop | Location | What to Do

Luscher Farm offers a variety of educational programs on food and farming to children and adults alike. (Photo courtesy of mthoodterritory.com)

The Farmlandia Farm Loop was created as part of the wider Oregon Farm Loop program, which connects visitors with the state's agricultural production through farm visits, family-run markets, welcoming nurseries, inventive eateries, and celebrated wineries.

Best of all, it's easy to get started: Just download a brochure and map from the official Farmlandia Farm Loop website, see what sounds fun, make sure your desired stops will be open when you plan to visit, and head out.

If you need help making plans, we've put together a guide to the Farmlandia Farm Loop—with tips for enjoying your time and a few ideas for getting started.

What is the Farmlandia Farm Loop?

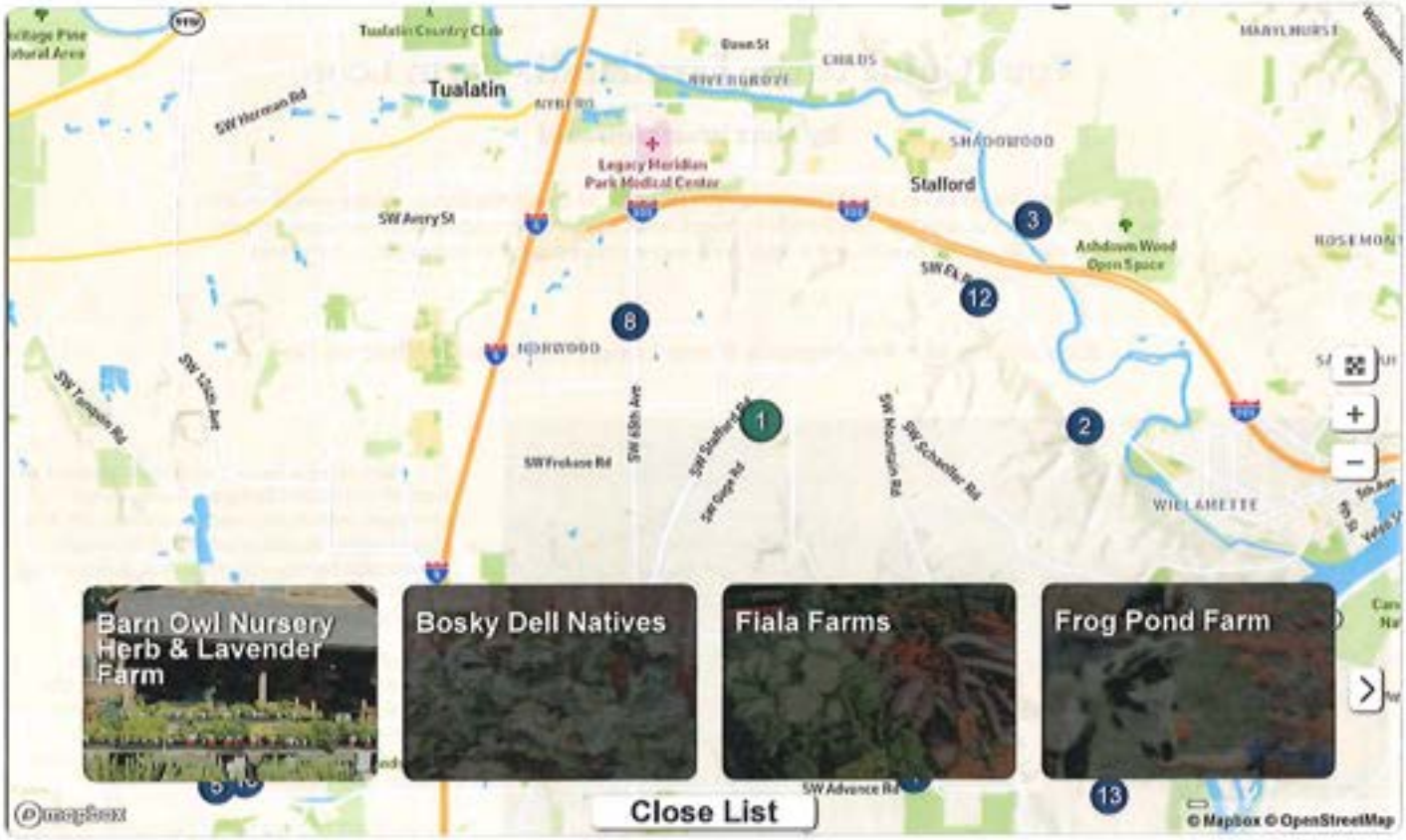
The self-guided **Farmlandia Farm Loop** spans farms, vineyards, nurseries, and more at the far northern edge of the Willamette Valley. Peppers, strawberries, lavender, wine grapes, pumpkins, and Christmas trees are some of the many crops you'll find along the loop.

The Farmlandia Farm Loop spotlights 17 businesses that stretch from the heart of the Willamette Valley and along the Willamette River to the foothills of Mount Hood—so your options for exploring are limited only by your time constraints.

And you're never far from **overnight stays in the Willamette Valley** or Portland suburbs, so it's easy to make a weekend getaway out of it.

Visitors can mingle with llamas, camel, ponies, and more at **Frog Pond Farm Farms**.

Where is the Farmlandia Farm Loop?



Pet miniature donkeys, stroll through a colorful garden, and see what's new at the gift shop at Tollen Farm on the outskirts of Wilsonville. (Photo courtesy of mthoodterritory.com)

The Farmlandia Farm Loop stretches across the northern edge of the Willamette Valley and the foothills of Mount Hood. Wilsonville is the largest community along the loop—and where you'll find many of the loop's 17 stops—but other close-by communities include Oregon City, Milwaukie, Tualatin, and Boring.

Driving between Wilsonville (the westernmost community along the loop) and Boring (the easternmost community) takes about 35 minutes; driving from the trail's northern edge in Milwaukie to its southern border outside of Wilsonville, meanwhile, takes about 25 minutes. All that said, several of the loop's stops are heavily concentrated around Wilsonville and Tualatin, making it possible to visit numerous farms, wineries, and more without spending much time in your vehicle.

What Can You Do Along the Farmlandia Farm Loop?

More than a dozen of the Farmlandia Farm Loop's 17 stops are at working farms, offering visitors an unprecedented look at the many ways these hard-working producers have shaped the Willamette Valley for generations.

Savor the scents of spring and summer at Barn Owl Nursery Herb & Lavender Farm. Since 1982, Barn Owl has grown nearly 100 varieties of lavender—with blooms peaking in June and July; fresh and dried bouquets are available for purchase, as are a variety of lavender products in the farm's gift shop.

Nearby Frog Pond Farm hosts a pumpkin patch and harvest festival, as well as a Christmas tree farm throughout the holiday season; in addition to the seasonal attractions, visitors can get up close to more than 80 animals while enjoying Frog Pond's many activities.

Frog Pond Farm is a popular family stop just outside Wilsonville. (Photo courtesy of mthoodterritory.com)

Triskelee Farm hosts a variety of fun events throughout the spring and summer. (Photo courtesy of mthoodterritory.com)

The family-run Triskelee Farm grows a variety of produce and is home to several animals—including goats, ostriches, sheep, and alpacas. Stop by for some of the farm's special events—like up-close encounters with resident animals, monthly markets with local makers, and farm-based yoga sessions.

Terra Vina Wines, meanwhile, specializes in small-lot red wines, sourced from both the winery's estate and from vineyards throughout the Pacific Northwest. A spot on Terra Vina's spacious lawn, overlooking the winery's vineyard, is one of the area's hottest seats on sunny spring and summer weekends.

If you want to experience the Willamette Valley's love affair with farm-to-table fare up-close, check out The Kitchen at Middleground Farms.

The renowned eatery is housed in a refashioned cattle barn and embraces the idea of "local" in everything it serves: An on-site garden supplies some ingredients, a small herd of goats and more than two-dozen hens supply dairy products and eggs, and nearby growers and producers offer much of the rest.

Make a dinner reservation, sign up for special events, or take a cooking class to learn more about the region's famed culinary scene.

The Kitchen at Middleground Farms hosts beautiful dinners, featuring local wines and fresh farm ingredients.

Willamette Valley

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Should I Buy a House Near Power Lines?

By Kelsey Heath (https://www.fastexpert.com/blog/author/kelsey-heath/)

January 9, 2025 | 13 min read

When searching for that perfect house to call home, one factor that gives some hous hunters pause is the proximity of power lines to the property. They can be viewed as an eye sore, health risk, or even a safety risk. So, if you have the perfect house withir your budget, but it's next to power lines, should you buy it?

If you live in a city, chances are you see power lines and telephone poles everywhere you look. We are desensitized to them. Some cities and regions, like California, are starting to put power lines underground, but historically, they have been above grour as a cost-saving measure.

Power lines crisscross cities, suburbs, and rural areas, bringing electricity to homes and businesses. Their proximity to homes raises questions for homebuyers about the potential drawbacks.

But are these apprehensions warranted when weighing the property's pros and cons Do the real risks justify the stigma surrounding power line proximity? As with most aspects of home buying, the truth lies in balancing perceptions and facts, which we'll explain in this article.

Enter zip code

GET STARTED

Do Power Lines Decrease Property Value?

There are different kinds of power lines, most commonly high-voltage transmission lines and low-voltage lines for local distribution.

Low-voltage power lines, supported by telephone poles, typically don't impact property values because they are everywhere. These pieces of infrastructure are essential to keeping our cities connected and lit. However, high-voltage power lines are different.

The presence of high-voltage power lines near a property often reduces its value, though the impact varies based on location and home specifics. When buying a hous near power lines in an urban area, the effect on property value near power lines may not be as severe as for a rural home.

Proximity is key when buying a house near power lines. The closer a home sits to power lines, the more likely its value will be decreased.

But, a lower value may not be a negative for all buyers. Buyers with limited budgets often see a lower upfront purchase price as a bargain when buying a house near power lines. However, it's important to remember the power lines will remain in place when it comes time to resell.

Power lines are almost always permanent infrastructure fixtures. So, the same lines dragging down the initial purchase price will still affect the property's value at resale.

For example, if you have a beautiful hillside home with fantastic views that are interrupted by power lines, then yes, their presence will likely impact its value. Are they a deal breaker? That depends on the buyer.

Just remember that any initial discount should be weighed against the potential long term hits to resale value. Other factors, like aesthetic issues and health concerns, should also be considered when deciding if proximity to power lines warrants the associated tradeoffs.

How Much Do Power Lines Decrease Property Value?

While proximity is key, several factors influence the extent of property value reductio near power lines.

There's no exact amount by which power lines can decrease a property's value. It depends on the house, the area, and how competitive the real estate market is at the time of sale. If it's a hot seller's market, you may find that power lines have very little impact on the property's value when put up against comparable sales.

Properties that are very close to high-voltage lines (within 150 feet), may see property values decrease by 10 percent to 30 percent or more. The effect lessens as the distance from the lines increases.

For buyers, a lower upfront cost when purchasing near power lines may seem like a good deal. However, the same lines will remain when reselling, hampering value. In extreme cases near high-voltage towers, a study from the ~~Journal of Real Estate Research (https://www.tandfonline.com/doi/abs/10.1080/10835547.2018.12091490)~~ shows nearby property values reduced by 44.' percent.

So, any initial discount should be weighed against potential long-term impacts on resale value. If you want a better understanding of how much a power line will impac your property's value, it's best to talk to your real estate agent.

An experienced agent will understand local buyer preferences and what they are willing (and not willing) to compromise on. Their advice will help you decide whether buy a house near power lines.

Pros of Living Near Power Lines

While high-voltage transmission lines tend to make some homebuyers nervous, proximity to these vital energy conduits can offer certain advantages for the well-informed. Of course, you need to consider potential drawbacks when evaluating homes near power infrastructure.

But there are useful upsides that certain buyers may wish to leverage by overlooking unwarranted fears. Here are a few potential advantages to living near these vital energy conduits:

- Lower Electricity Costs: Homes situated by the power source can benefit from slightly lower electricity bills thanks to shortened transmission distances. Even though the savings may be small, every penny counts for homeowners trying to maximize value. While not a deal-maker on its own, paying a few dollars less eacl month is still welcomed.
- Fewer Power Outages: Living right by the electrical infrastructure allows repair crews to respond quicker when outages occur. This proximity usually results in fewer and shorter disruptions overall. For some, better reliability grants peace of mind, especially during extreme weather when power loss spikes.
- Faster Restoration: Living near power infrastructure means repair crews can reacl downed lines quicker when outages happen. Their fast response helps restore power sooner, limiting disruptions. Outages are inevitable, and in our modern world, few things hamper productivity and convenience more than extended power loss, particularly if you work from home.
- Accessibility to Infrastructure/Services: There's nothing worse than being unable access high-speed internet in a recently purchased home. Telecommunication services are almost always connected through power lines, which means that when they are nearby, you're more likely to have access to your preferred servic Before buying, it's best to check with your service provider to see if they reach your address.
- Renewable Energy Potential: Not all power grids can support large solar systems. Proximity can make initiatives like solar power collection and distribution possible When a home is close to high-voltage power lines, it's more likely the existing infrastructure to feed excess power back to the grid is available.
- Lower HOA Fees: Older neighborhoods typically have power lines. On the flip sid these neighborhoods also tend to have lower homeowners association (HOA) fees. Even small HOA discounts add up, providing more value to homes that are part of associations.
- Less Competition: Some buyers avoid power line properties altogether, meaning slightly less competition for smart buyers; bargaining power increases with fewer prospective purchasers in the mix. Therefore, buying near power lines can be a great way to avoid bidding wars and snag a deal.

So, while there are potential drawbacks, the convenience and marginal perks of locating near power lines can appeal to some homebuyers. If you're unfazed, you ca capitalize on slightly reduced prices and competition.

Cons of Living Near Power Lines

While they enable modern life for homebuyers, the close presence of power lines comes with many cons. If you decide to buy a house close to power lines, you need t understand the financial pros and be fully aware of the cons.

Potential Health Risks

One of the potential homeowners' biggest concerns when purchasing property near power lines is the potential health implications, especially regarding the cancer risk. Power lines produce electromagnetic fields (EMFs), a form of radiation that some hav suspected could increase cancer risk with significant exposure over time.

However, the scientific evidence (https://www.cancercenter.com/community/blog/2023/02/power-lines-and-cancer-is-there-a-connection) so far has been unable to conclusively substantiate health risks from EMF exposure near high-voltage power lines. While power lines produce strong EMFs, many common household items like cell phones, microwaves, and WIFI emit EMF radiation, sometimes at even higher levels than power lines.

For decades, electromagnetic radiation concerns have been raised about whether living near power lines increases cancer risk, but most studies have not found clear evidence of a link. In 2002, a World Health Organization (WHO) working group concluded that EMFs from power lines are "possibly carcinogenic" to humans. At mo collective research has concluded that there is a weak connection between the risk childhood Leukemia (https://www.cancer.net/blog/2022-03/does-living-near-power-lines-increase-my-risk-cancer) and those living closer than 164 feet to a power line.

If you're worried about the health concerns surrounding EMF and power lines, start with your own research, then form your own conclusion.

Potential Fire and Electrocution Hazard

Though installed with safety in mind, power lines bring risks. Extreme weather like hi winds and thunderstorms can compromise lines, creating fire and electrocution hazards. This has been evident in places like California, where downed power lines have ignited major wildfires.

While rare, fires triggered by damaged lines near homes could spread quicker in higl risk areas before crews can respond. Downed neighborhood lines also threaten electrocution from live wires.

If you own a home near power lines, proper maintenance is crucial. Trees and foliage growing too close need removal to prevent wires from being brought down in storms Additionally, it's smart to keep undergrowth cleared to prevent a fire from spreading. Though catastrophic incidents are unlikely, the potential exists.

Homebuyers must be aware of the fire risk associated with power lines so they are prepared to care for their asset.

Impact on Resale Potential

Homes near power lines can be more challenging to sell than houses not impacted b them. Even though these homes may be cheaper when you buy them, many people

want to stay away from power lines, so it can be tough to find buyers. It can take longer for these properties to sell, and they usually generate less demand, resulting i a lower purchase price.

So, weigh any upfront deal against a likely hindered property value growth and sellin speed upon resale. Talk to your agent about how the power lines will impact your ne home. They understand the market and buyer preferences. Their opinion and insight will help you make the right decision.

Aesthetic and Visual Concerns

Power lines can harm a home's visual appeal and spoil the view. Their presence can make a house look less attractive and less desirable, especially in areas where you don't usually see power lines. Many people consider power lines an eyesore, which can negatively affect how appealing a home is and how much the homeowners enjo it.

For homes that rely on sprawling views or scenic surroundings as selling points, having power lines nearby can seriously reduce their marketability and value. From a visual perspective, power lines disrupt the overall look of the house, limit landscapin options, and harm natural settings. For homebuyers who prioritize beauty, these downsides should be carefully considered when looking at properties near power lines.

Buzzing Noise

High-voltage power lines and substations can produce a continuous low hum or buzzing sound. Low-voltage power lines, typically insulated, will produce little to no noise, and they may not pose the same level of noise-related concerns.

This audible buzzing noise from high-voltage power lines can be quite annoying for homes situated nearby and becomes louder in rainy weather. Some claim that the constant background noise contributes to headaches or migraines, adding an unwelcome stressor to daily life.

It can be easy to get caught up in the excitement of a new home purchase, but prospective buyers should pay attention and listen for any bothersome buzz when considering homes near power lines. Not all power lines will generate the same level of sound. If a buzzing noise is present, the property may necessitate noise mitigation and the buyer will need to be able to tolerate the ongoing buzzing noise.

What is a Safe Distance to Live from High Voltage Power Lines?

When house hunting, buyers may ask – how close to power lines is too close? There' no definitive answer, but examining voltage and proximity offers guidance.

Neighborhood distribution lines typically run below 20,000 volts. At this low voltage over short distances, risks are minimal for nearby homes.

High-voltage power lines are more concerning, ranging from 100,000 to 800,000 volts. Their uninsulated tubes emit noise and EMFs, prompting proximity concerns. So high-transmission lines warrant more caution than neighborhood distribution when buying nearby homes.

While no universally accepted safe distance exists, some guidelines suggest:

- Living 700-1000 feet from high-voltage lines is best to limit EMF exposure.
- Each additional 100 feet reduces EMF field strength exponentially.
- Beyond 1300 feet, EMF intensity matches typical background levels.

So, while there's no straightforward safety standard, more distance from high-voltage lines means lower EMF exposure and lower fire risk. How much is enough distance? Well, buyers must weigh their risk tolerance and budget. If you want to be extra cautious, maximize the distance (within reason) that you live from power lines.

Should You Buy a House Near Power Lines?

For some buyers, the advantages may outweigh the drawbacks, while for others, the risks are possible deal breakers. Before deciding, each homebuyer must weigh the pros and cons against their risk tolerance, priorities, and family makeup.

On the risk side, high-voltage lines produce electromagnetic fields that may have health implications. While evidence on cancer and power lines is inconclusive, some studies link close exposure to increased leukemia and cancer rates. More definitively proximity to lines hampers aesthetics, creates noise, and reduces the resale value.

Homes adjoining power lines can lower a home's value by as much as 30%, driven by the stigma surrounding health risks and aesthetics. Properties also generally take longer to sell than comparable listings without power lines nearby.

However, there are also advantages to buying close to power lines, primarily that buyers can get a house for their money. They benefit from marginally lower electricity costs, fewer outages, quicker outage response, lower HOA fees, and less buyer competition. Buyers comfortable accepting the negatives can capitalize on discounted home prices. The cost savings could be exactly what they need to secure their dream home.

In hot real estate markets with low inventory, compromising power line proximity may be an acceptable tradeoff for an otherwise ideal home. For risk-averse buyers, maximizing distance from lines and verifying safe exposure levels may be a higher priority. Informed analysis and research should guide the next steps on any power line property under consideration.

Deciding on a Home Near Power Lines: Seek Expert Insights

When considering a house that's close to power lines, talk to your real estate agent about their impact. They will have the best local insights about how the power lines may impact your lifestyle and resale value. Rather than relying on your own, leverage local expertise.

Your real estate agent can help you objectively weigh the pros and cons. Beyond health and aesthetic concerns, real estate agents help you evaluate impacts on resal potential versus pricing discounts and help find creative noise solutions.

Consult with one of your area's top real estate agents through FastExpert (https://www.fastexpert.com/) today and get insights from a true area expert. With an agent's help, you can make the right call when considering homes near power lines.

Kelsey Heath

Kelsey Heath is a real estate content specialist with an extensive background in residential, industrial, and commercial property. She has been involved in the industry for a decade as a professional and personal investor, gaining a deep understanding of the market and trends. With a passion for written communication, Kelsey loves helping people understand the sometimes-complicated concepts behind real estate and is now a sought-out guest and ghostwriter.

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Mortgage Calculator (https://www.fastexpert.com/mortgage-calculator/)

(https://www.inc.com/profile/fastexpert) (https://www.bbb.org/us/ca/san-marino/profile/real-estate-services/fastexpert-inc-1216-717497)

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OUTDOORS

Downed Wires

- Stay away. Treat all downed wires as if they are live and energized.
- Call 911 and inform the operator there is an electrical emergency.

Overhead Power Lines

- Always be aware of overhead power lines.
  - When working or playing in or around trees, check to make sure you are not close to overhead power lines.
  - Stay at least 10 feet away from overhead power lines and electrical facilities. Contact with electrical wires can cause severe injury or even death – keep all objects away from overhead power lines.

INDOORS

Safe Use of Power Cords

- Remove power cords from outlets by pulling the plug, not the cord.
- Never attach a cord to another surface with nails or staples.
- Never remove the third prong from a three-pronged plug. The third prong grounds the device and protects from faulty electrical devices.
- Never plug a space heater into an extension cord.
  - Always plug it directly into a wall outlet.

SAFETY TIP

Downed wires: Stay away! Call 911. Do not approach or touch the wire or any person or object in contact with the wire

Water and Electricity

- Keep electrical appliances and power tools away from water.
- Never use electrical appliances or tools in or near water, including the shower or bath.
- Dry hands thoroughly before coming into contact with any electrical appliance, outlet, or wall switch.

Electrical Fires

- Call 911.
- If an appliance catches fire, immediately unplug the appliance if safe to do so.
- Use an appropriately rated fire extinguisher (one rated for electrical and grease fires).
  - Baking soda may also be used to extinguish an electrical fire.

OUTAGES

Helpful Tips:

- If you are cold, wear multiple layers of warm clothing.
- Switch off your lights (except one). Also, to prevent damage when the electricity is restored, consider unplugging all electrical equipment.
- Listen to a battery-powered radio for storm or emergency-related updates.
- Keep refrigerator and freezer doors closed. Check food for spoilage before eating.

SAFETY TIP

DO NOT throw water on an electrical fire. You could be electrocuted

SAFETY TIP

Use flashlights instead of candles to avoid a significant fire hazard

The BioInitiative report, prepared by 29 authors from ten countries in 2012 comprises extensive information around the public safety levels for electromagnetic and radiofrequency fields. Written by field experts: ten medical doctors, 21 PhDs, and three MsC, MA or MPHs, three former presidents of the Bioelectromagnetics Society, and five full members of BEMS, a distinguished author is the Chair of the Russian National Committee on Non-Ionizing Radiation, and a Senior Advisor to the European Environmental Agency; the report has been done independent of governments, existing bodies and industry professional societies that have clung to old standards. Precisely because of this, the BioInitiative Report presents a solid scientific and public health policy assessment that is evidence-based .

BioInitiative 2012

A Rationale for Biologically-based Exposure Standards for Low-Intensity Electromagnetic Radiation

BioInitiative Working Group 2012

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PREFACE

The Organizing Committee thanks the participants of the BioInitiative Working Group for their integrity and intellectual courage in dealing with this controversial and important topic; and for devoting the time and energy to produce their chapters. The information and conclusions in each chapter are the responsibilities of the authors of that chapter.

The Group has produced what the authors hope will be a benchmark for good science and public health policy planning. It documents bioeffects, adverse health effects and public health conclusions about impacts of non-ionizing radiation (electromagnetic fields including extremely-low frequency ELF-EMF and radiofrequency/microwave or RF-EMF fields).

Societal decisions about this body of science have global implications. Good public health policy depends on acting soon enough, but not without cause, and with enough information to guide intelligent actions. To a great degree, it is the definition of the standard of evidence used to judge the scientific reports that shapes this debate. Disagreement about when the evidence is sufficient to take action has more to do with the outcome of various reviews and standard-setting proceedings than any other single factor. Whatever "standard of evidence" is selected to assess the strength of the science will deeply influence the outcome of decisions on public policy.

We are at a critical juncture in this world-wide debate. The answers lie not only in the various branches of science; but necessarily depend on the involvement of public health and policy professionals, the regulatory, legal and environmental protection sectors, and the public sector.

This has been a long-term collaboration of international scientists employing a multi-disciplinary approach to problem assessment and solving. Our work has necessarily relied on tools and approaches across the physical, biological and engineering sciences; and those of the environmental scientist and public health professional. Only when taken

together can we see the whole and begin to take steps that can prevent possible harm and protect future generations.

Signed: Signed:

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BIOINITIATIVE 2012 - CONCLUSIONS Table 1-1

Overall, these 1800 or so new studies report abnormal gene transcription (Section 5); genotoxicity and single-and double-strand DNA damage (Section 6); stress proteins because of the fractal RF-antenna like nature of DNA (Section 7); chromatin condensation and loss of DNA repair capacity in human stem cells (Sections 6 and 15); reduction in free-radical scavengers - particularly melatonin (Sections 5, 9, 13, 14, 15, 16 and 17); neurotoxicity in humans and animals (Section 9), carcinogenicity in humans (Sections 11, 12, 13, 14, 15, 16 and 17); serious impacts on human and animal sperm morphology and function (Section 18); effects on offspring behavior (Section 18, 19 and 20); and effects on brain and cranial bone development in the offspring of animals that are exposed to cell phone radiation during pregnancy (Sections 5 and 18). This is only a snapshot of the evidence presented in the BioInitiative 2012 updated report.

BIOEFFECTS ARE CLEARLY ESTABLISHED

Bioeffects are clearly established and occur at very low levels of exposure to electromagnetic fields and radiofrequency radiation. Bioeffects can occur in the first few minutes at levels associated with cell and cordless phone use. Bioeffects can also occur from just minutes of exposure to mobile phone masts (cell towers), WI-FI, and wireless utility 'smart' meters that produce whole-body exposure. Chronic base station level exposures can result in illness.

BIOEFFECTS WITH CHRONIC EXPOSURES CAN REASONABLY BE PRESUMED TO RESULT IN ADVERSE HEALTH EFFECTS

Many of these bioeffects can reasonably be presumed to result in adverse health effects if the exposures are prolonged or chronic. This is because they interfere with normal body processes (disrupt homeostasis), prevent the body from healing damaged DNA, produce immune system imbalances, metabolic disruption and lower resilience to disease across multiple pathways. Essential body processes can eventually be disabled by incessant external stresses (from system-wide electrophysiological interference) and lead to pervasive impairment of metabolic and reproductive functions.

LOW EXPOSURE LEVELS ARE ASSOCIATED WITH BIOEFFECTS AND ADVERSE HEALTH EFFECTS AT CELL TOWER RFR EXPOSURE LEVELS

At least five new cell tower studies are reporting bioeffects in the range of 0.003 to 0.05 μW/cm2 at lower levels than reported in 2007 (0.05 to 0.1 uW/cm2 was the range below which, in 2007, effects were not observed). Researchers report headaches, concentration difficulties and behavioral problems in children and adolescents; and sleep disturbances, headaches and concentration problems in adults. Public safety standards are 1,000 – 10,000 or more times higher than levels now commonly reported in mobile phone base station studies to cause bioeffects.

EVIDENCE FOR FERTILITY AND REPRODUCTION EFFECTS: HUMAN SPERM AND THEIR DNA ARE DAMAGED

Human sperm are damaged by cell phone radiation at very low intensities in the low microwatt and nanowatt/cm2 range (0.00034 – 0.07 uW/cm2). There is a veritable flood of new studies reporting sperm damage in humans and animals, leading to substantial concerns for fertility, reproduction and health of the offspring (unrepaired de novo mutations in sperm). Exposure levels are similar to those resulting from wearing a cell phone on the belt, or in the pants pocket, or using a wireless laptop computer on the lap. Sperm lack the ability to repair DNA damage.

Studies of human sperm show genetic (DNA) damage from cell phones on standby mode and wireless laptop use. Impaired sperm quality, motility and viability occur at exposures of 0.00034 uW/cm2 to 0.07 uW/cm2 with a resultant reduction in human male fertility. Sperm cannot repair DNA damage.

Several international laboratories have replicated studies showing adverse effects on sperm quality, motility and pathology in men who use and particularly those who wear a cell phone, PDA or pager on their belt or in a pocket (Agarwal et al, 2008; Agarwal et al, 2009; Wdowiak et al, 2007; De Iuliis et al, 2009; Fejes et al, 2005; Aitken et al, 2005; Kumar, 2012). Other studies conclude that usage of cell phones, exposure to cell phone radiation, or storage of a mobile phone close to the testes of human males affect sperm counts, motility, viability and structure (Aitken et al, 2004; Agarwal et al, 2007; Erogul et al., 2006). Animal studies have demonstrated oxidative and DNA damage, pathological changes in the testes of animals, decreased sperm mobility and viability, and other measures of deleterious damage to the male germ line (Dasdag et al, 1999; Yan et al, 2007; Otitoloju et al, 2010; Salama et al, 2008; Behari et al, 2006; Kumar et al, 2012). There are fewer animal studies that have studied effects of cell phone radiation on female fertility parameters. Panagopoulous et al. 2012 report decreased ovarian development and size of ovaries, and premature cell death of ovarian follicles and nurse cells in *Drosophila melanogaster*. Gul et al (2009) report rats exposed to stand-by level RFR (phones on but not transmitting calls) caused decrease in the number of ovarian follicles in pups born to these exposed dams. Magras and Xenos (1997) reported irreversible infertility in mice after five (5) generations of exposure to RFR at cell phone tower exposure levels of less than one microwatt per centimeter squared (μW/cm2).

EVIDENCE THAT CHILDREN ARE MORE VULNERABLE

There is good evidence to suggest that many toxic exposures to the fetus and very young child have especially detrimental consequences depending on when they occur during critical phases of growth and development (time windows of critical development), where such exposures may lay the seeds of health harm that develops even decades later. Existing FCC and ICNIRP public safety limits seem to be not sufficiently protective of public health, in particular for the young (embryo, fetus, neonate, very young child).

The Presidential Cancer Panel (2010) found that children '*are at special risk due to their smaller body mass and rapid physical development, both of which magnify their vulnerability to known carcinogens, including radiation.*'

The American Academy of Pediatrics, in a letter to Congressman Dennis Kucinich dated 12 December 2012 states "*Children are disproportionately affected by environmental exposures, including cell phone radiation. The differences in bone density and the amount of fluid in a child's brain compared to an adult's brain could allow children to absorb greater quantities of RF energy deeper into their brains than adults. It is essential that any new standards for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure thay are safeguarded through their lifetimes.*"

FETAL AND NEONATAL EFFECTS OF EMF

Fetal (*in-utero*) and early childhood exposures to cell phone radiation and wireless technologies in general may be a risk factor for hyperactivity, learning disorders and behavioral problems in school.

Fetal Development Studies: Effects on the developing fetus from *in-utero* exposure to cell phone radiation have been observed in both human and animal studies since 2006. Divan et al (2008) found that children born of mothers who used cell phones during pregnancy develop more behavioral problems by the time they have reached school age than children whose mothers did not use cell phones during pregnancy. Children whose mothers used cell phones during pregnancy had 25% more emotional problems, 35% more hyperactivity, 49% more conduct problems and 34% more peer problems
(Divan et al., 2008).

Common sense measures to limit both ELF-EMF and RF EMF in these populations is needed, especially with respect to avoidable exposures like incubators that can be modified; and where education of the pregnant mother with respect to laptop computers, mobile phones and other sources of ELF-EMF and RF EMF are easily instituted.

Sources of fetal and neonatal exposures of concern include cell phone radiation (both paternal use of wireless devices worn on the body and maternal use of wireless phones during pregnancy). Exposure to whole-body RFR from base stations and WI-FI, use of wireless laptops, use of incubators for newborns with excessively high ELF-EMF levels resulting in altered heart rate variability and reduced melatonin levels in newborns, fetal exposures to MRI of the pregnant mother, and greater susceptibility to leukemia and asthma in the child where there have been maternal exposures to ELF-EMF.

A precautionary approach may provide the frame for decision-making where remediation actions have to be realized to prevent high exposures of children and pregnant woman.

(Bellieni and Pinto, 2012 – Section 19)

EMF/RFR AS A PLAUSIBLE BIOLGICAL MECHANISM FOR AUTISM (ASD)

- Children with existing neurological problems that include cognitive, learning, attention, memory, or behavioral problems should as much as possible be provided with wired (not wireless) learning, living and sleeping environments,
- Special education classrooms should observe 'no wireless' conditions to reduce avoidable stressors that may impede social, academic and behavioral progress.
- All children should reasonably be protected from the physiological stressor of significantly elevated EMF/RFR (wireless in classrooms, or home environments).
- School districts that are now considering all-wireless learning environments should be strongly cautioned that wired environments are likely to provide better learning and teaching environments, and prevent possible adverse health consequences for both students and faculty in the long-term.
- Monitoring of the impacts of wireless technology in learning and care environments should be performed with sophisticated measurement and data analysis techniques that are cognizant of the non-linear impacts of EMF/RFR and of data techniques most appropriate for discerning these impacts.
- There is sufficient scientific evidence to warrant the selection of wired internet, wired classrooms and wired learning devices, rather than making an expensive and potentially health-harming commitment to wireless devices that may have to be substituted out later, and
- Wired classrooms should reasonably be provided to all students who opt-out of wireless environments. (Herbert and Sage, 2012 – Section 20)

Many disrupted physiological processes and impaired behaviors in people with ASDs closely resemble those related to biological and health effects of EMF/RFR exposure. Biomarkers and indicators of disease and their clinical symptoms have striking similarities. Broadly speaking, these types of phenomena can fall into one or more of several classes: a) alteration of genes or gene expression, b) induction of change in brain or organismic development, c) alteration of phenomena modulating systemic and brain function on an ongoing basis throughout the life course (which can include systemic pathophysiology as well as brain-based changes), and d) evidence of functional alteration in domains such as behavior, social interaction and attention known to be challenged in ASD.

Several thousand scientific studies over four decades point to serious biological effects and health harm from EMF and RFR. These studies report genotoxicity, single-and double-strand DNA damage, chromatin condensation, loss of DNA repair capacity in human stem cells, reduction in free-radical scavengers (particularly melatonin), abnormal gene transcription, neurotoxicity, carcinogenicity, damage to sperm morphology and function, effects on behavior, and effects on brain development in the fetus of human mothers that use cell phones during pregnancy. Cell phone exposure has been linked to altered fetal brain development and ADHD-like behavior in the offspring of pregnant mice.

Reducing life-long health risks begins in the earliest stages of embryonic and fetal development, is accelerated for the infant and very young child compared to adults, and is not complete in young people (as far as brain and nervous system maturation) until the early 20's. Windows of critical development mean that risk factors once laid down in the cells, or in epigenetic changes in the genome may have grave and life-long consequences for health or illness for every individual.

All relevant environmental conditions, including EMF and RFR, which can degrade the human genome, and impair normal health and development of species including homo sapiens, should be given weight in defining and implementing prudent, precautionary actions to protect public health.

Allostatic load in autism and autistic decompensation - we may be at a tipping point that can be pushed back by removing unnecessary stressors like EMF/RFR and building resilience.

The consequence of ignoring clear evidence of large-scale health risks to global populations, when the risk factors are largely avoidable or preventable is too high a risk to take. With the epidemic of autism (ASD) putting the welfare of children, and their families in peril at a rate of one family in 88, the rate still increasing annually, we cannot afford to ignore this body of evidence. The public needs to know that these risks exist, that transition to wireless should not be presumed safe, and that it is very much worth the effort to minimize exposures that still provide the benefits of technology in learning, but without the threat of health risk and development impairments to learning and behavior in the classroom.

(Herbert and Sage, 2010 – Section 20)

THE BLOOD-BRAIN BARRIER IS AT RISK

The BBB is a protective barrier that prevents the flow of toxins into sensitive brain tissue. Increased permeability of the BBB caused by cell phone RFR may result in neuronal damage. Many research studies show that very low intensity exposures to RFR can affect the blood-brain barrier (BBB) (mostly animal studies). Summing up the research, it is more probable than unlikely that non-thermal EMF from cell phones and base stations do have effects upon biology. A single 2-hr exposure to cell phone radiation can result in increased leakage of the BBB, and 50 days after exposure, neuronal damage can be seen, and at the later time point also albumin leakage is demonstrated. *The levels of RFR needed to affect the BBB have been shown to be as low as 0.001 W/kg, or less than holding a mobile phone at arm's length. The US FCC standard is 1.6 W/kg; the ICNIRP standard is 2 W/kg of energy (SAR) into brain tissue from cell/cordless phone use. Thus, BBB effects occur at about 1000 times lower RFR exposure levels than the US and ICNIRP limits allow.* (Salford, 2012 - Section 10)

If the blood-brain barrier is vulnerable to serious and on-going damage from wireless exposures, then we should perhaps also be looking at the blood-ocular barrier (that protects the eyes), the blood-placenta barrier (that protects the developing fetus) and the blood-gut barrier (that protects proper digestion and nutrition), and the blood-testes barrier (that protects developing sperm) to see if they too can be damaged by RFR.

EPIDEMIOLOGICAL STUDIES CONSISTENTLY SHOW ELEVATIONS IN RISK OF BRAIN CANCERS

Brain Tumors: There is a consistent pattern of increased risk of glioma and acoustic neuroma associated with use of mobile phones and cordless phones.

"Based on epidemiological studies there is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of mobile phones and cordless phones. The evidence comes mainly from two study centres, the Hardell group in Sweden and the Interphone Study Group. No consistent pattern of an increased risk is seen for meningioma. A systematic bias in the studies that explains the results would also have been the case for meningioma. The different risk pattern for tumor type strengthens the findings regarding glioma and acoustic neuroma. Meta-analyses of the Hardell group and Interphone studies show an increased risk for glioma and acoustic neuroma. Supportive evidence comes also from anatomical localisation of the tumor to the most exposed area of the brain, cumulative exposure in hours and latency time that all add to the biological relevance of an increased risk. In addition risk calculations based on estimated absorbed dose give strength to the findings. (Hardell, 2012 – Section 11)

"There is reasonable basis to conclude that RF-EMFs are bioactive and have a potential to cause health impacts. There is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of wireless phones (mobile phones and cordless phones) mainly based on results from case-control studies from the Hardell group and Interphone Final Study results. Epidemiological evidence gives that RF-EMF should be classified as a human carcinogen.

Based on our own research and review of other evidence the existing FCC/IEE and ICNIRP public safety limits and reference levels are not adequate to protect public health. New public health standards and limits are needed.

EVIDENCE FOR GENETIC EFFECTS

Eighty six (86) new papers on genotoxic effects of RFR published between 2007 and mid-2012 are profiled. Of these, 54 (63%) showed effects and 32 (37%) showed no effects.

Forty three (43) new ELF-EMF papers and two static magnetic field papers that report on genotoxic effects of ELF-EMF published between 2007 and mid-2012 are profiled. Of these, 35 (81%) show effects and 8 (19%) show no effect.

EVIDENCE FOR NEUROLOGICAL EFFECTS

One hundred fifty five (155) new papers that report on neurological effects of RFR published between 2007 and mid-2012 are profiled. Of these, 98 (63%) showed effects and 57 (37%) showed no effects.

Sixty nine (69) new ELF-EMF papers (including two static field papers) that report on genotoxic effects of ELF-EMF published between 2007 and mid-2012 are profiled. Of these, 64 (93%) show effects and 5 (7%) show no effect.

EVIDENCE FOR CHILDHOOD CANCERS (LEUKEMIA)

With overall 42 epidemiological studies published to date power frequency EMFs are among the most comprehensively studied environmental factors. Except ionizing radiation no other environmental factor has been as firmly established to increase the risk of childhood leukemia.

Sufficient evidence from epidemiological studies of an increased risk from exposure to EMF (power frequency magnetic fields) that cannot be attributed to chance, bias or confounding. Therefore, according to the rules of IARC such exposures can be classified as a **Group 1 carcinogen (Known Carcinogen).**

There is no other risk factor identified so far for which such unlikely conditions have been put forward to postpone or deny the necessity to take steps towards exposure reduction. As one step in the direction of precaution, measures should be implemented to guarantee that exposure due to transmission and distribution lines is below an average of about 1 mG. This value is arbitrary at present and only supported by the fact that in many studies this level has been chosen as a reference.

Base-station level RFR at levels ranging from less than 0.001 uW/cm2 to 0.05 uW/cm2. In 5 new studies since 2007, researchers report headaches, concentration difficulties and behavioral problems in children and adolescents; and sleep disturbances, headaches and concentration problems in adults.

MELATONIN, BREAST CANCER AND ALZHEIMER'S DISEASE

MELATONIN AND BREAST CANCER

Conclusion: Eleven (11) of the 13 published epidemiologic residential and occupational studies are considered to provide (positive) evidence that high ELF MF exposure can result in decreased melatonin production. The two negative studies had important deficiencies that may certainly have biased the results. There is sufficient evidence to conclude that long-term relatively high ELF MF exposure can result in a decrease in melatonin production. It has not been determined to what extent personal characteristics, e.g., medications, interact with ELF MF exposure in decreasing melatonin production

Conclusion: New research indicates that ELF MF exposure, in vitro, can significantly decrease melatonin activity through effects on MT1, an important melatonin receptor.

ALZHEIMER'S DISEASE

There is strong epidemiologic evidence that exposure to ELF MF is a risk factor for AD. There are now twelve (12) studies of ELF MF exposure and AD or dementia which. Nine (9) of these studies are considered positive and three (3) are considered negative. The three negative studies have serious deficiencies in ELF MF exposure classification that results in subjects with rather low exposure being considered as having significant exposure. There are insufficient studies to formulate an opinion as to whether radiofrequency MF exposure is a risk or protective factor for AD.

There is now evidence that (i) high levels of peripheral amyloid beta are a risk factor for AD and (ii) medium to high ELF MF exposure can increase peripheral amyloid beta. High brain levels of amyloid beta are also a risk factor for AD and medium to high ELF MF exposure to brain cells likely also increases these cells' production of amyloid beta.

There is considerable in vitro and animal evidence that melatonin protects against AD. Therefore it is certainly possible that low levels of melatonin production are associated with an increase in the risk of AD.
(Davanipour and Sobel, 2012 – Section 13)

STRESS PROTEINS AND DNA AS A FRACTAL ANTENNA FOR RFR

DNA acts as a 'fractal antenna' for EMF and RFR.

The coiled-coil structure of DNA in the nucleus makes the molecule react like a fractal antenna to a wide range of frequencies.

The structure makes DNA particularly vulnerable to EMF damage.

The mechanism involves direct interaction of EMF with the DNA molecule (claims that there are no known mechanisms of interaction are patently false)

Many EMF frequencies in the environment can and do cause DNA changes.

The EMF-activated cellular stress response is an effective protective mechanism for cells exposed to a wide range of EMF frequencies.

EMF stimulates stress proteins (indicating an assault on the cell).

EMF efficiently harms cells at a billion times lower levels than conventional heating.

Safety standards based on heating are irrelevant to protect against EMF-levels of exposure. There is an urgent need to revise EMF exposure standards. Research has shown thresholds are very low (safety standards must be reduced to limit biological responses). Biologically-based EMF safety standards could be developed from the research on the stress response.

EVIDENCE FOR DISRUPTION OF THE MODULATING SIGNAL
HUMAN STEM CELL DNA DOES NOT ADAPT OR REPAIR

Human stem cells do not adapt to chronic exposures to non-thermal microwave (cannot repair damaged DNA), and damage to DNA in genes in other cells generally do not repair as efficiently.

Non-thermal effects of microwaves depend on variety of biological and physical parameters that should be taken into account in setting the safety standards. Emerging evidence suggests that the SAR concept, which has been widely adopted for safety standards, is not useful alone for the evaluation of health risks from non-thermal microwave of mobile communication. Other parameters of exposure, such as frequency, modulation, duration, and dose should be taken into account.

Lower intensities are not always less harmful; they may be more harmful.

Intensity windows exist, where bioeffects are much more powerful.

A linear, dose-response relationship test is probably invalid for testing of RFR and EMF (as is done in chemicals testing for toxicity).

Resonant frequencies may result in biological effects at very low intensities comparable to base station (cell tower) and other microwave sources used in mobile communications. These exposures can cause health risk. The current safety standards are insufficient to protect from non-thermal microwave effects.

The data about the effects of microwave at super-low intensities and significant role of duration of exposure in these effects along with the data showing that adverse effects of non-thermal microwave from GSM/UMTS mobile phones depend on carrier frequency and type of the microwave signal suggest that microwave from base-stations/masts, wireless routers, WI-FI and other wireless devices and exposures in common use today can also produce adverse effects at prolonged durations of exposure.

Most of the real signals that are in use in mobile communication have not been tested so far. Very little research has been done with real signals and for durations and intermittences of exposure that are relevant to chronic exposures from mobile communication. In some studies, so-called "mobile communication-like" signals were investigated that in fact were different from the real exposures in such important aspects as intensity, carrier frequency, modulation, polarization, duration and intermittence.

New standards should be developed based on knowledge of mechanisms of non-thermal effects. Importantly, because the signals of mobile communication are completely replaced by other signals faster then once per 10 years, duration comparable with latent period, epidemiologic studies cannot provide basement for cancer risk assessment from upcoming new signals.

In many cases, because of ELF modulation and additional ELF fields created by the microwave sources, for example by mobile phones, it is difficult to distinguish the effects of exposures to ELF and microwave. Therefore, these combined exposures and their possible cancer risks should be considered in combination.

As far as different types of microwave signals (carrier frequency, modulation, polarization, far and near field, intermittence, coherence, *etc.*) may produce different effects, cancer risks should ideally be estimated for each microwave signal separately.

The Precautionary Principle should be implemented while new standards are in progress.

It should be anticipated that some part of the human population, such as children, pregnant women and groups of hypersensitive persons could be especially sensitive to the non-thermal microwave exposures.

N. EFFECTS OF WEAK-FIELD INTERACTIONS ON NON-LINEAR BIOLOGICAL OSCILLATORS AND SYNCHRONIZED NEURAL ACTIVITY

A unifying hypothesis for a plausible biological mechanism to account for very weak field EMF bioeffects other than cancer may lie with weak field interactions of pulsed RFR and ELF-modulated RFR as disrupters of synchronized neural activity. Electrical rhythms in our brains can be influenced by external signals. This is consistent with established weak field effects on coupled biological oscillators in living tissues. Biological systems of the heart, brain and gut are dependent on the cooperative actions of cells that function according to principles of non-linear, coupled biological oscillations for their synchrony, and are dependent on exquisitely timed cues from the environment at vanishingly small levels (Buzsaki, 2006; Strogatz, 2003). The key to synchronization is the joint actions of cells that co-operate electrically - linking populations of biological oscillators that couple together in large arrays and synchronize spontaneously. Synchronous biological oscillations in cells (pacemaker cells) can be disrupted by artificial, exogenous environmental signals, resulting in desynchronization of neural activity that regulates critical functions (including metabolism) in the brain, gut and heart and circadian rhythms governing sleep and hormone cycles (Strogatz, 1987). The brain contains a population of oscillators with distributed natural frequencies, which pull one another into synchrony (the circadian pacemaker cells). Strogatz has addressed the unifying mathematics of biological cycles and external factors disrupt these cycles (Strogatz, 2001, 2003). *"Rhythms can be altered by a wide variety of agents and that these perturbations must seriously alter brain performance"* (Buzsaki, 2006).

"Organisms are biochemically dynamic. They are continuously subjected to time-varying conditions in the form of both extrinsic driving from the environment and intrinsic rhythms generated by specialized cellular clocks within the organism itself. Relevant examples of the latter are the cardiac pacemaker located at the sinoatrial node in mammalian hearts (1) and the circadian clock residing at the suprachiasmatic nuclei in mammalian brains (2). These rhythm generators are composed of thousands of clock cells that are intrinsically diverse but nevertheless manage to function in a coherent oscillatory state. This is the case, for instance, of the circadian oscillations exhibited by the suprachiasmatic nuclei, the period of which is known to be determined by the mean period of the individual neurons making up the circadian clock (3–7). The mechanisms by which this collective behavior arises remain to be understood." (Strogatz, 2001; Strogatz, 2003)

Synchronous biological oscillations in cells (pacemaker cells) can be disrupted by artificial, exogenous environmental signals, resulting in desynchronization of neural activity that regulates critical functions (including metabolism) in the brain, gut and heart and circadian rhythms governing sleep and hormone cycles. The brain contains a population of oscillators with distributed natural frequencies, which pull one another into synchrony (the circadian pacemaker cells). Strogatz has addressed the unifying mathematics of biological cycles and external factors disrupt these cycles.

EMF AND RFR MAKE CHEMICAL TOXINS MORE HARMFUL

EMF acts on the body like other environmental toxicants do (heavy metals, organic chemicals and pesticides). Both toxic chemicals and EMF may generate free radicals, produce stress proteins and cause indirect damage to DNA. Where there is combined exposure the damages may add or even synergistically interact, and result in worse damage to genes.

EMF IS SUCCESSFULLY USED IN HEALING AND DISEASE TREATMENTS

"The potential application of the up-regulation of the HSP70 gene by both ELF-EMF and nanosecond PEMF in clinical practice would include trauma, surgery, peripheral nerve damage, orthopedic fracture, and vascular graft support, among others. Regardless of pulse design, EMF technology has been shown to be effective in bone healing [5], wound repair [11] and neural regeneration [31,36,48,49,51,63,64,65,66]. In terms of clinical applica- tion, EMF-induction of elevated levels of hsp70 protein also confers protection against hypoxia [61] and aid myocardial function and survival [20,22]. Given these results, we are particularly interested in the translational significance of effect vs. efficacy which is not usually reported by designers or investigators of EMF devices. More precise description of EM pulse and sine wave parameters, including the specific EM output sector, will provide consistency and "scientific basis" in reporting findings."

"The degree of electromagnetic field-effects on biological systems is known to be dependent on a number of criteria in the waveform pattern of the exposure system used; these include frequency, duration, wave shape, and relative orientation of the fields [6,29,32,33,39,40]. In some cases pulsed fields have demonstrated increased efficacy over static designs [19,21] in both medical and experimental settings."
(Madkan et al, 2009)

ELF-EMF AND RFR ARE CLASSIFIED AS POSSIBLE CANCER-CAUSING AGENTS – WHY ARE GOVERNMENTS NOT ACTING?

The World Health Organization International Agency for Research on Cancer has classified wireless radiofrequency as a Possible Human Carcinogen (May, 2011)*. The designation applies to low-intensity RFR in general, covering all RFR-emitting devices and exposure sources (cell and cordless phones, WI-FI, wireless laptops, wireless hotspots, electronic baby monitors, wireless classroom access points, wireless antenna facilities, etc). The IARC Panel could have chosen to classify RFR as a Group 4 – Not A Carcinogen if the evidence was clear that RFR is not a cancer-causing agent. It could also have found a Group 3 designation was a good interim choice (Insufficient Evidence). IARC did neither.

NEW SAFETY LIMITS MUST BE ESTABLISHED - HEALTH AGENCIES SHOULD ACT NOW

Existing public safety limits (FCC and ICNIRP public safety limits) do not sufficiently protect public health against chronic exposure from very low-intensity exposures. If no mid-course corrections are made to existing and outdated safety limits, such delay will magnify the public health impacts with even more applications of wireless-enabled technologies exposing even greater populations around the world in daily life.

SCIENTIFIC BENCHMARKS FOR HARM PLUS SAFETY MARGIN = NEW SAFETY LIMITS THAT ARE VALID

Health agencies and regulatory agencies that set public safety standards for ELF-EMF and RFR should act now to adopt new, biologically-relevant safety limits that key to the lowest scientific benchmarks for harm coming from the recent studies, plus a lower safety margin. Existing public safety limits are too high by several orders of magnitude, if prevention of bioeffects and minimization or elimination of resulting adverse human health effects. Most safety standards are a thousand times or more too high to protect healthy populations, and even less effective in protecting sensitive subpopulations.

SENSITIVE POPULATIONS MUST BE PROTECTED

Safety standards for sensitive populations will more likely need to be set at lower levels than for healthy adult populations. Sensitive populations include the developing fetus, the infant, children, the elderly, those with pre-existing chronic diseases, and those with developed electrical sensitivity (EHS).

PROTECTING NEW LIFE - INFANTS AND CHILDREN

Strong precautionary action and clear public health warnings are warranted immediately to help prevent a global epidemic of brain tumors resulting from the use of wireless devices (mobile phones and cordless phones). Common sense measures to limit both ELF-EMF and RFR in the fetus and newborn infant (sensitive populations) are needed, especially with respect to avoidable exposures like baby monitors in the crib and baby isolettes (incubators) in hospitals that can be modified; and where education of the pregnant mother with respect to laptop computers, mobile phones and other sources of ELF-EMF and RFR are easily instituted.

Wireless laptops and other wireless devices should be strongly discouraged in schools for children of all ages.

STANDARD OF EVIDENCE FOR JUDGING THE SCIENCE

The standard of evidence for judging the scientific evidence should be based on good public health principles rather than demanding scientific certainty before actions are taken.

WIRELESS WARNINGS FOR ALL

The continued rollout of wireless technologies and devices puts global public health at risk from unrestricted wireless commerce unless new, and far lower exposure limits and strong precautionary warnings for their use are implemented.

EMF AND RFR ARE PREVENTABLE TOXIC EXPOSURES

We have the knowledge and means to save global populations from multi-generational adverse health consequences by reducing both ELF and RFR exposures. Proactive and immediate measures to reduce unnecessary EMF exposures will lower disease burden and rates of premature death.

DEFINING A NEW 'EFFECT LEVEL' FOR RFR

On a precautionary public health basis, a reduction from the BioInitiative 2007 recommendation of 0.1 uW/cm2 (or one-tenth of a microwatt per square centimeter) for cumulative outdoor RFR down to something three orders of magnitude lower (in the low nanowatt per square centimeter range) is justified.

A scientific benchmark of 0.003 uW/cm2 or three nanowatts per centimeter squared for 'lowest observed effect level' for RFR is based on mobile phone base station-level studies. Applying a ten-fold reduction to compensate for the lack of long-term exposure (to provide a safety buffer for chronic exposure, if needed) or for children as a sensitive subpopulation yields a 300 to 600 picowatts per square centimeter precautionary action level. This equates to a 0.3 nanowatts to 0.6 nanowatts per square centimeter as a reasonable, precautionary action level for chronic exposure to pulsed RFR.

These levels may need to change in the future, as new and better studies are completed. We leave room for future studies that may lower or raise today's observed 'effects levels' and should be prepared to accept new information as a guide for new precautionary actions.

Review of the Literature Regarding the Health Effects of Electromagnetic Radiation

Prepared for the
Holistic Veterinary Medicine Association
January 1996

By Lawrence J. Gust

Human Epidemiological Studies of ELF EMR

An Epidemiological study compares the rate of disease in a group of people (animals) exposed to a certain variable to a control group that was not exposed to the variable in question. The results will show if an association exist between the variable and the disease. This type of study can not determine cause and effect.

The results are usually reported in the form of an Odds Ratio (OR) or Risk Ratio (RR). This refers to ratio of incidence of disease found in the exposed group versus the incidence in an unexposed group. Such studies should be controlled for confounding variables. For example in a study of the increased risk of brain cancer from EMF exposure, the study would be controlled for risk factors such as smoking and exposure to cancer causing chemicals.

A compendium of peer reviewed EMF epidemiological studies was compiled by National Library of Medicine, Bethesda, MD. for use in testimony to the Nebraska State legislature (National Library of Medicine, 1995).

The majority of these studies (8 out of 11) show that children living in homes near high voltage transmission lines and near high current carrying local distribution lines show a statistically significant risk of developing cancer. These cancers are mostly leukemia, brain cancer, and lymphoma. The RR in these studies were generally in the range of 1.3 to 4 (Brodeur, 1995). The results for adults in similar situations are less clear. Although it is not possible to review all of these studies there several are of interest

The pioneering study examined the effect on cancer rates from childhood exposure to high current local distribution lines that run through Denver neighborhoods (Wertheimer, 1979). Compared to controls, children exposed to 3 milligauss (3/1000 Gauss) fields had an increased risk of contracting childhood cancers at a statistically significant level. The RR (OR) was 2.35 for leukemia and 2.22 for all other cancers (Kosta, 1995). At the time this finding was surprising as a 3 milligauss AC field is many times weaker than the Earth's steady state (DC) magnetic field of about 500 milligauss. Therefore, the study was met with much criticism on the grounds there was no *known* physical link between these extremely weak 60 Hertz fields and biological life.

In 1988 the Wertheimer study was duplicated (with resources enormously larger) as part of The New York State Power Lines project. This five year project was expected to disprove the results of the Wertheimer study, instead it confirmed them. Additional evidence was reported that power frequency fields had significant behavioral and central nervous system effects (Savitz, 1988) .

Although not part of the National Library of Medicine list, the next three studies are of interest from the behavioral standpoint: A British study found a statistically significant higher incidence of mental disturbance and suicide in patients living near electric power lines in a rural U.K. area (Reichmanis, 1979).

The US Navy in 1973, completed a study to assess the effects of the 45 or 70 Hertz magnetic fields which would be produced by the proposed buried communications antenna for the SANGUINE Project. This antenna was to be buried in Wisconsin and upper Michigan to communicate with submarines around the world.

Among the significant findings was evidence showing nine out of ten volunteer seamen exposed in a lab to the SANGUINE type radiation developed elevated serum triglycerides levels. A study of personnel at The Clam Lake, Wisconsin experimental SANGUINE facility showed similar elevated level in all personnel. Serum triglycerides level is elevated by stress (SANGUINE, 1973). The frequency of the 60 Hz US electric power system was right in the middle of the two possible SANGUINE frequencies. The magnetic field level of the SANGUINE signal was one million times *less* than the average 100 milligauss field found at the edge of a 345,000 volt transmission line (0.1 milligauss). SANGUINE was not built. Today, the Navy denies that the study ever took place (Becker, 1990).

Studies were done in U.K. with people housed in underground bunkers relatively free of EMR. Their wake-sleep cycles gradually shifted to 25-26 hours. When they were subjected to EMR they shifted to a 23 hour cycle showing a

shift in the circadian rhythm. Other work showed a pulsating low intensity EMR (such as 60 Hertz EMR) will cause the release of noradrenaline in most people within 15 minutes (Jones, 1992).

Another epidemiological study on the National Library of Medicine list was conducted in Sweden. In the early 1980's 716 children who had died of cancer were compared with controls. The results showed that brain cancer occurred 3.7 (RR= 3.7) times as often as expected in children living within sight of a high voltage transmission line (Tomenius, 1986).

A landmark EMR epidemiological study was conducted by Ahlbom and Feychting. This study was significant because of the number of people involved (500,000), the efficiency of the Swedish Cancer Registry, and better knowledge about the magnetic fields levels produced by the 200 kilovolt and 400 kilovolt transmission lines in question (Microwave News, 1992).

This study found statistically significant RRs for leukemia in children as follows: For average 50 Hertz magnetic field exposures greater than 1 milligauss the risk ration was 2. For exposures greater than 2 milligauss the risk ration was 2.7. And for exposures over 3 milligauss the risk ration was 3.8 (Feychting, 1993).

Residential epidemiological studies have produced less clear results for adults. However, the majority of peer reviewed, occupational epidemiological studies (24 out of 30) show that exposed occupations have a significantly higher risk of cancer. In these occupations workers develop leukemia, lymphoma and brain cancer far more readily than less exposed workers. These are occupations like Utility linemen, electricans, electrical engineers, Phone Company linemen, subway operators and so forth. The RR in these studies were generally in the range of 2 to 10 (Brodeur, 1995). Magnetic field level in occupational exposures is sometimes, but not always higher than that seen in homes (Gust, 1995).

Controversy Surrounding Human Epidemiological Studies

There is criticism of the results of such studies on the grounds that the risk ratios found are not sufficiently large. These people wish to see an RR of 5 or greater. (Kosta,, 1995). Others state that there are as many studies showing no association as showing an association. However, most of the studies which are presented as contradicting a positive association are not peer reviewed and tend to be funded and presented by vested interests such as utility industry or bodies funded by the utility industry (Brodeur, 1995).

Animal Studies with ELF EMR

John Reif, DVM, Colorado State University College of Veterinary Medicine and a team study the home magnetic field conditions of 93 cases of canine lymphoma and 137 controls over a four year period. The study showed dogs with lymphoma were six times more likely to have lived in homes with wire coded fields in excess of 2 milligauss, and three times more likely to have lived in homes with moderately magnetic field levels of 0.5 to 2.0 milligauss (Reif, 1995)

Phillips reported at a recent Washington, DC. seminar entitled *How Animals Perceive Weak Magnetic Fields*, sponsored by the EPA that "...birds, bees, newts, turtles and sharks have been shown to be exquisitely sensitive to such fields". Phillips also reported that recent research "suggests mechanisms based on radical pair formation which may also trigger melatonin changes observed in rodent exposed to magnetic fields". Weak EMR depresses output of melatonin which normally cycles lower during the day and higher at night (Litigation, 1996).

As Part of the New York State Power Lines Project Sulzman and Murrish studied the relationship between power line fields and behavioral changes associated with the circadian rhythms in monkeys. The monkeys were exposed to both electric and magnetic fields and observed for both acute and chronic changes. The circadian rhythms were altered by field exposure (Sulzman, 1987)

In the same project Wolpaw studied monkey brain function during exposure to a weak 60 Hertz magnetic field. He measure the neurohormones in the spinal fluid in monkeys exposed for three weeks. He found that the levels of

serotonin and dopamine were significantly depressed immediately following exposure. Only dopamine returned to a normal level. Serotonin remained depressed for several months (Wolpaw, 1987).

Also as part of this project Salzinger exposed rats to 60 Hertz fields during gestation and for a few week after birth. These rats and controls were then trained in various routines. The exposed rats made more mistakes and learned the routines more slowly than the controls (Salzinger, 1987).

The Battelle Pacific Northwest Laboratories, in a study funded by the Electric Power Research Institute (a research arm of the electric utility industry), examined several generations of minipigs exposed to power line EMR (Battelle, 1987). The study focused on developmental abnormalities. Several month into the experiment an epidemic struck the pigs and the experiment had to be started again. All of the pigs in the exposed group died while significantly fewer in the control group died. Becker suggests that the exposed pigs' immune systems had been compromised by the exposure (Becker, 1990)..

The study was redone, but Battelle claimed no evidence of harm was found. However, the original director of the study, listed these findings: A marked reduction in night time melatonin production by the pineal gland after three weeks exposure. A significant loss in serum testosterone in males exposed for three months. Changes in the neuromuscular system after a one month exposure. An increased incidence of fetal malformations after chronic exposure for two generations (Phillips, 1988). These findings differ from the official Battelle version.

The effect of 'stray voltage' on dairy animals is also instructive. Dairy operators have been plagued over the last 50 years with problems associated with the electrification of farms. The problems encountered are spontaneous abortion, increased mastitis, lower milk production, extreme nervousness, sudden death, high somatic cell count, breeding problems, early peaking of milk production, swollen legs and joints (Dahlberg, 1995).

After 50 years of research and corrective measures the problem still exists. The term stray voltage exists because the problem was originally pinned on the difference in potential between metal barn components and the floor of the barn resulting in a shock to livestock when they connected these metal parts to the floor via their hooves. The voltage potential issue has been largely resolved and control measures proved beneficial on about 30% of the farms. For the other 70% it was not, and in many cases made the situation worse.

Current thinking has turned to the ambient magnetic field created by current flow in the ground. Approximately 65% of the current supplied by the utility returns to the generating station via the earth. This situation is true everywhere in the U.S. Current flow in the soil produces a magnetic field which appears to come from nowhere. It is higher in urban areas where power demand is concentrated, but it certainly exists in the suburbs as well. Soil conditions affect the density of current flow as do the number of points in an area where the utility has grounded the neutral. Normally this occurs at every power pole. In urban areas background 60 Hertz magnetic fields can be 0.5 to even 1.0 milligauss. In suburban areas 0.2 to 0.5 milligauss based on personal measurements.

You will recall that the study done for the Navy SANGUINE Project showed stress induced elevation in serum triglycerides levels for a magnetic field one millionth that by a 345 kilovolt power line right of way. This is approximately 0.1 milligauss.

Smith, mentions that among the interesting research on animal effects was a US Navy study which found that a buried high voltage transmission line radically disturbed the earth worms in the area and affected the aeration of the soil. Bees subjected to ELF EMR stopped making honey and sealed their hives, thereby committing communal suicide. Other bees kept under a high voltage transmission line became savage and unproductive. When move, they resumed making honey. In another case, high voltage lines near a bird sanctuary disoriented the birds. The effect of a low level magnetic field on Escherichia coli bacteria was to cause changes at the cellular level (Jones, 1992).

Delgado, known for research on brain behavioral mechanisms and their control by electrical stimulation, exposed chick embryos to very weak (as low as 1 milligauss) ELF EMR at 10, 100 and 1000 Hertz. Embryonic malformations resulted at all three frequencies with the largest number at 100 Hertz (Delgado, 1982).

In 1986 the US Navy set up Project Hen House in six different labs, all with the same equipment, in an effort to duplicate Degado's results. It was reported at a meeting of the Bioelectromagnetics Society that in five of the six labs "apparently very low level VLF, pulsed magnetic fields contribute to increased abnormality incidences in early embryonic chicks" (Navy, 1986).

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EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses

Europaem = European Academy for Environmental Medicine

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Abstract: Chronic diseases and illnesses associated with non-specific symptoms are on the rise. In addition to chronic stress in social and work environments, physical and chemical exposures at home, at work, and during leisure activities are causal or contributing environmental stressors that deserve attention by the general practitioner as well as by all other members of the health care community. It seems necessary now to take "new exposures" like electromagnetic fields (EMF) into account. Physicians are increasingly confronted with health problems from unidentified causes. Studies, empirical observations, and patient reports clearly indicate interactions between EMF exposure and health problems. Individual susceptibility and environmental factors are frequently neglected. New wireless technologies and applications have been introduced without any certainty about their health effects, raising new challenges for medicine and society. For instance, the issue of so-called non-thermal effects and potential long-term effects of low-dose exposure were scarcely investigated prior to the introduction of these technologies. Common electromagnetic field or EMF sources: Radio-frequency radiation (RF) (3 MHz to 300 GHz) is emitted from radio and TV broadcast antennas, Wi-Fi access points, routers, and clients (e.g. smartphones, tablets), cordless and mobile phones including their base stations, and Bluetooth devices. Extremely low frequency electric (ELF EF) and magnetic fields (ELF MF) (3 Hz to 3 kHz) are emitted from electrical wiring, lamps, and appliances. Very low frequency electric (VLF EF) and magnetic fields (VLF MF) (3 kHz to 3 MHz) are emitted, due to harmonic voltage and current distortions, from electrical wiring, lamps (e.g. compact fluorescent lamps), and electronic devices. On the one hand, there is strong evidence that long-term exposure to certain EMFs is a risk factor for diseases such as certain cancers, Alzheimer's disease, and male infertility. On the other hand, the emerging electromagnetic hypersensitivity (EHS) is more and more recognized by health authorities, disability administrators and case workers, politicians, as well

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as courts of law. We recommend treating EHS clinically as part of the group of chronic multisystem illnesses (CMI), but still recognizing that the underlying cause remains the environment. In the beginning, EHS symptoms occur only occasionally, but over time they may increase in frequency and severity. Common EHS symptoms include headaches, concentration difficulties, sleep problems, depression, a lack of energy, fatigue, and flu-like symptoms. A comprehensive medical history, which should include all symptoms and their occurrences in spatial and temporal terms and in the context of EMF exposures, is the key to making the diagnosis. The EMF exposure is usually assessed by EMF measurements at home and at work. Certain types of EMF exposure can be assessed by asking about common EMF sources. It is very important to take the individual susceptibility into account. The primary method of treatment should mainly focus on the prevention or reduction of EMF exposure, that is, reducing or eliminating all sources of high EMF exposure at home and at the workplace. The reduction of EMF exposure should also be extended to public spaces such as schools, hospitals, public transport, and libraries to enable persons with EHS an unhindered use (accessibility measure). If a detrimental EMF exposure is reduced sufficiently, the body has a chance to recover and EHS symptoms will be reduced or even disappear. Many examples have shown that such measures can prove effective. To increase the effectiveness of the treatment, the broad range of other environmental factors that contribute to the total body burden should also be addressed. Anything that supports homeostasis will increase a person's resilience against disease and thus against the adverse effects of EMF exposure. There is increasing evidence that EMF exposure has a major impact on the oxidative and nitrosative regulation capacity in affected individuals. This concept also may explain why the level of susceptibility to EMF can change and why the range of symptoms reported in the context of EMF exposures is so large. Based on our current understanding, a treatment approach that minimizes the adverse effects of peroxynitrite – as has been increasingly used in the treatment of multisystem illnesses – works best. This EMF Guideline gives an overview of the current knowledge regarding EMF-related health risks and provides recommendations for the diagnosis, treatment and accessibility measures of EHS to improve and restore individual health outcomes as well as for the development of strategies for prevention.

Keywords: accessibility measures; Alzheimer's disease; cancer; chronic multisystem illnesses (CMI); diagnosis; electric; electromagnetic field (EMF); electromagnetic hypersensitivity (EHS); infertility; leukemia; magnetic; medical guideline; nitrosative stress; non-ionizing; oxidative stress; peroxynitrite; prevention; radiation; static; therapy; treatment.

Current state of the scientific and political debate about EMF-related health problems from a medical perspective

Introduction

The Environmental Burden of Disease Project assessed the influence of nine environmental stressors (benzene, dioxins including furans and dioxin-like PCBs, second-hand smoke, formaldehyde, lead, noise, ozone, particulate matter and radon) on the health of the population of six countries (Belgium, Finland, France, Germany, Italy, and the Netherlands). Those nine environmental stressors caused 3%–7% of the annual burden of disease in the six European countries (1).

The Bundespsychotherapeutenkammer (BPtK) study in Germany showed that mental disorders had increased further and especially burnout as a reason of inability to work increased seven-fold from 2004 to 2011 (2). In Germany, 42% of early retirements in 2012 were caused by mental disorders, depression being the leading diagnosis (3). In Germany, psychotropic drugs are in third place for the prescriptions of all drugs (4).

The consumption of methylphenidate (Ritalin, Medikinet, Concerta), a psychotropic drug prescribed as a treatment for attention deficit hyperactivity disorder (ADHD) especially for young children and adolescents, has increased alarmingly since the early 1990s. According to statistics of the German Federal Institute for Drugs and Medical Devices (Bundesinstitut für Arzneimittel und Medizinprodukte), prescriptions have increased even more dramatically since 2000 and reached a climax in 2012. In 2013, only a slight decline in the number of prescriptions was observed (5). Interestingly, the rapid increase in the use of methylphenidate coincides with the enormous expansion of mobile telecommunication and other related technologies, posing an open research question.

In Germany, work disability cases and absence days due to mental health disorders more than doubled from 1994 to 2011 (6). In the Organization for Economic Co-operation and Development (OECD) countries, a huge

variability in the prescription of antidepressants has occurred and generally an increasing trend has been observed. Socioeconomic status and therapeutic standards cannot fully explain these observations (7). Functional disturbances like chronic inflammation and changes of neurotransmitter functions caused by environmental influences have hardly been investigated.

A steady increase in the prevalence of allergic/asthmatic diseases globally has occurred, with about 30%–40% of the world population now being affected by one or more allergic/asthmatic conditions (8).

It is suspected that environmental conditions such as the increasing exposure of the population to electromagnetic fields (EMFs) play a causal role for EMF-related health effects (9–12), including exposure to radio-frequency radiation (RF), which emanates from, e.g. cordless phones (DECT), mobile phone base stations, and mobile phones (GSM, GPRS, UMTS, LTE), especially smartphones, data cards for laptop and notebook computers, wireless LAN (Wi-Fi), wireless and powerline communication-based smart meters, but also exposure to extremely low frequency (ELF) electric fields (EF) and magnetic fields (MF) including "dirty electricity", which emanate from disturbances on electric wiring, power lines, electric devices, and other equipment. For the society and the medical community, all of this raises new challenges.

While biophysical and biochemical mechanisms of biological effects of EMF at low-intensity levels are not exactly known, significant progress has been achieved in the last decades, and there are numerous data indicating that these mechanisms may overlap for ELF and RF effects (13–18). In the following sections, we provide some background information on important aspects of EMF biological effects. However, this must not be misunderstood as a full review of the evidence. We do not always strictly differentiate between RF and ELF fields because of the above mentioned overlap in biological mechanisms. It should also be mentioned here that very specific exposure conditions may trigger biological responses in one individual, but not in others. Anecdotal reports, however, indicate that such individual responsiveness or susceptibility does expand over time and the intolerance then extends over a broad range of exposure conditions.

Chronic diseases and illnesses associated with unspecific symptoms are on the rise. In addition to chronic stress in social and work environments, physical and chemical exposures at home, at work, and during leisure activities are causal or contributing environmental stressors that deserve attention by the general practitioner as well as by all other members of the health care community. It seems certainly necessary now to take "new exposures" like EMF into account, or as stated by Hedendahl et al. (19): *"It is time to consider ELF EMF and RF EMF as environmental pollutants that need to be controlled"*.

Worldwide statements of organizations regarding EMF

The recommendations of the World Health Organization (WHO) regarding ELF electric and magnetic fields and RF radiation, compiled by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (20, 21), are based on currents induced in the body (ELF) and thermal effects (RF).

Thermal effects are defined as effects that originate in elevated temperatures from the absorption of electromagnetic energy. The specific absorption rate (SAR) is defined as the rate of absorption of electromagnetic energy in a unit mass of biological tissue. It is proportional to the incremental temperature increase in that tissue. Indeed while a significant temperature increase must be avoided as it can be of immediate adverse health consequences (tissue necrosis, cardiac stress, etc.) exposures can be without (measureable) temperature increase either because of heat dissipation or because the exposure is too low to be associated with relevant heating. The latter type of exposure is termed non-thermal. Biological and health-relevant effects at non-thermal levels have been shown and discussed by many research groups all over the world (9, 10, 22–24).

The ICNIRP recommendations were adopted by the EU in its Council Recommendation of 1999, without considering long-term non-thermal effects. However, it should be stressed that at an international EMF conference in London (2008), Professor Paolo Vecchia, ICNIRP Chairman from 2004 to 2012, said about the exposure guidelines "What they are not": *"They are not mandatory prescriptions for safety"*, *"They are not the' 'last word' on the issue"*, and *"They are not defensive walls for industry or others"* (25).

For all RF-based non-thermal EMF effects, SAR estimates are not an appropriate exposure metric, but instead either the field intensity or power density (PD) in combination with exposure duration should be used in safety standards (26, 14, 27). In contrast to the ICNIRP guidelines, the Russian safety standards, are based on non-thermal RF effects, which were obtained by several research institutes in the former Soviet Union during decades of studies on chronic exposures to RF (28, 29).

In contrast to the WHO headquarter in Geneva, the International Agency for Research on Cancer (IARC), a WHO-affiliated specialized agency in Lyon, classified

extremely low frequency magnetic fields (ELF MF) as possibly carcinogenic to humans (Group 2B) in 2002 (30) and radio-frequency radiation in 2011 (24).

It should be noted that, during the last 20 years, more than 20 position papers and resolutions regarding EMF and health have been adopted by EMF researchers and physicians. These include the Vienna EMF Resolution, Austria, 1998; Stewart Report, UK, 2000; Salzburg Resolution, Austria, 2000; Freiburg Appeal, Germany, 2002; Catania Resolution, Italy, 2002; Irish Doctors' Environmental Association Statement, Ireland, 2005; Helsinki Appeal, Finland, 2005; Benevento Resolution, Italy, 2006; Venice Resolution, Italy, 2008; Porto Alegre Resolution, Brazil, 2009; Russian National Committee on Non-Ionizing Radiation Protection Resolution, Russia, 2001; International Doctors' Appeal, Europe, 2012; and the Report of the Standing Committee on Health, Canada, 2015 (31–34).

In August 2007 and December 2012, the BioInitiative Working Group, an international group of 29 experts with different competences, published two groundbreaking reports "BioInitiative 2007/resp. 2012 – A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)" edited by Cindy Sage and David O. Carpenter, calling for preventive measures against EMF exposure based on the available scientific evidence (9, 10). The BioInitiative reports are global milestones with respect to a comprehensive review of biological effects and health effects of low-intensity electromagnetic radiation as well as the conclusions and recommendations given for the public. The BioInitiative report 2012 includes sections on the evidence for effects on: gene and protein expression, DNA, immune function, neurology and behavior, blood-brain barrier, brain tumors and acoustic neuromas, childhood leukemia, melatonin, Alzheimer's disease, breast cancer, fertility and reproduction, fetal and neonatal disorders, autism, disruption by the modulating signal, EMF medical therapeutics, as well as sections on: statement of the problem, the existing public exposure standards, evidence for inadequacy of the standards, the precautionary principle, global public health examples, key scientific evidence and public health recommendations, and summary for the public and conclusions.

As it is mostly neglected as a health hazard, the European Environment Agency compared the risks of non-ionizing radiation (EMF) to other environmental hazards such as asbestos, benzene, and tobacco, urgently recommending to implement a precautionary approach regarding EMF (35). This position was confirmed and elaborated more comprehensibly in further publications in 2011 and 2013 (36, 37).

In September 2008, a statement of the European Parliament called for a review of the EMF limits set out in the EU Council Recommendation of 1999, which was based on the ICNIRP guidelines, with reference to the BioInitiative Report (38). This was further strengthened in the European Parliament resolution of April 2009 (39).

At the meeting in November 2009 in Seletun, Norway, a scientific panel adopted a Consensus Agreement that recommends preventative and precautionary actions that are warranted now, given the existing evidence for potential global health risks from EMF exposure (40). Besides general and specific recommendations, e.g. for mobile and cordless phone use, the panel recommended exposure limits for ELF magnetic fields and radio-frequency radiation. It was stated by the panel: "Numeric limits recommended here do not yet take into account sensitive populations (EHS, immune-compromised, the fetus, developing children, the elderly, people on medications, etc.). Another safety margin is, thus, likely justified further below the numeric limits for EMF exposure recommended here".

Since 2007 the Highest Health Council of the Ministry of Health in Austria has recommended to take preventive action by reducing exposure levels from RF devices which may lead to long-term human exposure of at least a factor of 100 below the guideline levels of the European Commission and by issuing rules on how to reduce one's individual exposure to RF radiation from mobile phones (41).

In May 2011, the Parliamentary Assembly of the Council of Europe adopted the report "The Potential Dangers of Electromagnetic Fields and their Effects on the Environment" (42). The Assembly recommended many preventive measures for the member states of the Council of Europe with the aim to protect humans and the environment, especially from high-frequency electromagnetic fields such as: *"Take all reasonable measures to reduce exposure to electromagnetic fields, especially to radiofrequencies from mobile phones, and particularly the exposure of children and young people who seem to be most at risk from head tumors"*, or *"Pay particular attention to 'electrosensitive' people who suffer from a syndrome of intolerance to electromagnetic fields and introduce special measures to protect them, including the creation of wave-free areas not covered by the wireless network"*.

Recognizing that patients are being adversely affected by EMF exposure, the American Academy of Environmental Medicine (AAEM) published recommendations regarding EMF exposure in July 2012. The AAEM called for physicians to consider electromagnetic exposure in diagnosis and treatment and to recognize that EMF exposure *"may be an underlying cause of the patient's disease process"* (43).

Since 2014, the Belgian government has prohibited the advertising of mobile phones for children under the age of

7 and has required the specific absorption rate (SAR) of mobile phones be listed. Furthermore, at the point of sale, well-marked warnings must be posted that instruct users to use headsets and to minimize their exposure (44).

In January 2015, the French parliament adopted a comprehensive law that protects the general public from excessive exposure to electromagnetic waves. Among other things, it was passed to ban Wi-Fi in nurseries for children under the age of 3 and to enable Wi-Fi at primary schools with children under the age of 11 only when used specifically for lessons. Public places offering Wi-Fi must clearly advertise this fact on a sign. At the point of sale of mobile phones, the SAR value must be clearly shown. In the future, any mobile phone advertisement must include recommendations on how users can reduce RF radiation exposure to the head such as the use of headsets. Data on local EMF exposure levels shall be made more easily accessible to the general public, among others, through country-wide transmitter maps. Also, the French government will have to submit a report on electromagnetic hypersensitivity to the parliament within a year (45).

As of February 2016, 220 scientists from 42 countries have signed an international Appeal, directed to the United Nations (UN) and WHO, calling for protection from non-ionizing electromagnetic field exposure. The appeal addresses the scientifically proven effects on health and the inadequate international guidelines (ICNIRP) to date and their use by the WHO. In addition, nine requests were made, including that: *"the public be fully informed about the potential health risks from electromagnetic energy and taught harm reduction strategies"* and that *"medical professionals be educated about the biological effects of electromagnetic energy and be provided training on treatment of patients with electromagnetic sensitivity"* (46).

In September 2015 an International Scientific Declaration on Electromagnetic Hypersensitivity and Multiple Chemical Sensitivity was published by the Scientific Committee following the 5th Paris Appeal Congress, which took place on 18 May 2015 at the Royal Academy of Medicine, Brussels, Belgium. It calls upon national and international agencies and organizations to recognize EHS and multiple chemical sensitivity as a disease and urges particularly the WHO to include EHS and MCS in the International Classification of Diseases. It also asks national and international agencies and organizations to adopt simple precautionary measures of prevention, to inform the public, and to appoint truly independent expert groups to evaluate these health risks based on scientific objectivity, which is not the case today (47).

EMF and cancer

Except for a few investigations in occupational settings, epidemiological research of EMF started in 1979 when Wertheimer and Leeper published their study about the relationship between the proximity to so-called power line poles (ELF MF) with "service drop" wires and the occurrence of childhood cancer (specifically leukemia and brain tumors) (48). At the same time Robinette et al. studied mortality in a cohort of Korean War veterans having been trained on military radars (RF) in the early 1950s (49). Both studies found indications of increased risks and initiated a new era of studying health-relevant effects from exposure to EMFs.

ELF MF

In the following years, a large number of investigations about the relationship between childhood leukemia and extremely low frequency magnetic fields (ELF MF) have been published. However, the results seemed inconsistent until in 2000 two pooled analyses (50, 51) were conducted, providing little indication of inconsistency and demonstrating an increase of leukemia risk with increasing average exposure levels that was significant for levels above 0.3 or 0.4 μT relative to averages below 0.1 μT but without indication of a threshold. Based on these findings, the International Agency for Research on Cancer (IARC) classified ELF MF in 2002 as a Group 2B (possible) carcinogen (30). To this category belong, e.g. lead, DDT, welding fumes, and carbon tetrachloride.

Since then additional epidemiological studies have been conducted that gave essentially the same results (52, 53). The only study to date on the gene-environment interaction in relation to power-frequency MF reported a significant effect enhancement in children with a polymorphism in a DNA-repair gene (54). In a review on childhood leukemia and ELF MF, Kundi concluded that there is sufficient evidence from epidemiological studies of an increased risk for childhood leukemia from exposure to power-frequency MF that cannot be attributed to chance, bias, or confounding. Therefore, according to the rules of IARC, such exposures ought to be classified as a Group 1 (definitive) carcinogen (55).

The BioInitiative Report 2012 (56) stated: *"Children who have leukemia and are in recovery have poorer survival rates if their ELF exposure at home (or where they are recovering) is between 1mG [0.1 μT] and 2 mG [0.2 μT] in one study; over 3 mG [0.3 μT] in another study"* (56).

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RF

There were several mechanisms identified which might be responsible for carcinogenic effects of RF (23). Epidemiological studies of RF before the general rise in exposure to mobile telecommunication devices was very restricted and only a few studies had been conducted in the vicinity of radio transmitters, radar stations, for occupational exposures, and in radio amateurs. After the introduction of digital mobile telephony, the number of users of mobile phones increased dramatically and it was recommended in the 1990s to perform epidemiological studies with a focus on intracranial tumors. Since the first publication in 1999 by the Swedish group of Prof. Lennart Hardell (57), about 40 studies have been published. The majority of these studies investigated brain tumors, but salivary gland tumors, uveal melanoma, malignant melanoma of the skin, nerve sheath tumors, testicular cancer, and lymphoma were also studied. Many of these studies are inconclusive because exposure durations are too short; however, two series of investigations, the international Interphone Study conducted in 13 countries and the Swedish studies of the Hardell group, had a significant proportion of long-term mobile phone users and could in principle be used for risk assessment. In 2011, IARC classified radio-frequency electromagnetic fields (RF) as a Group 2B carcinogen based on evidence from epidemiological studies and animal experiments (24). Since then, additional studies have corroborated the assumption of a causal relationship between mobile phone use and cancer (58–60). Hardell and Carlberg (61) concluded that RF EMF ought to be classified as a definitive human carcinogen (IARC Group 1). The evidence for a causal relationship between long-term mobile and cordless phone use and the risk of glioma has increased further: in 2014, a study by Carlberg and Hardell (62) showed significantly decreased survival rates in patients with glioblastoma multiforme (astrocytoma grade IV) and the use of wireless phones and, in 2015, another pooled case-control study by Hardell and Carlberg (63) including latency periods of >25 years.

That also other tumors might be related to EMF exposure is exemplified by the observation in women who have worn their mobile phone in their bra for prolonged periods of time and later developed breast cancer at that site (64).

The Italian Supreme Court confirmed a previous decision by the Civil Court of Appeals of Brescia (no. 614 of 10 December 2009) that ruled that the National Institute for Workmen's Compensation (INAIL) must compensate a worker who had developed a tumor in the head due to long-term, heavy use of mobile phones while on the job. The case was an ipsilateral neuroma of the trigeminal nerve in a subject who had occupational exposure for >10 years, with >15,000 h on mobile and cordless phones. The court recognized that *"it is likely (qualified probability) that RF have a role which is at least contributory in the development of the origin of the tumor suffered by the subject"* (65).

Many modern devices emit EMF of different frequency ranges simultaneously. For example, mobile phones create EMF in RF, VLF, and ELF frequency ranges and also a static magnetic field; for a review see (23). Therefore, it is important to consider combined exposures for the assessment of health effects.

Genotoxic effects

Genotoxic effects of EMF dealing with DNA damage, mutations, chromatin structure, and DNA repair have recently been reviewed by Henry Lai in the Bioinitiative Report (66) and by the IARC Working Group in the assessment of RF carcinogenicity (24). In general, about half of the available studies found genotoxicity (positive reports), although other studies did not (negative reports) (23). Of note, a similar ratio of positive and negative RF studies was reported for other biological endpoints (67–69). The evident reason for this eventual inconsistency is strong dependence of the EMF effects on a number of physical and biological parameters, which significantly varied between studies. These dependencies were established for both ELF (70–72) and RF effects (24, 27).

Among other parameters, in human lymphocytes, an individual variability in chromatin response to ELF has been reported, which might suggest a stronger response in cells from EHS individuals (72). The same research group performed comparative studies on genotoxicity with cells from EHS and carefully matched control subjects (73–75). The response of lymphocytes to RF from GSM mobile phones (915 MHz) and power-frequency magnetic fields (50 Hz) was investigated (73). The 53BP1 protein, which participates in the formation of DNA repair foci at the location of DNA double-strand breaks (DSB), was analyzed by immunostaining in situ. Exposure to either 915 MHz or 50 Hz significantly condensed chromatin and inhibited the formation of DNA repair foci. The EMF-induced responses in lymphocytes from healthy and hypersensitive donors were similar but not identical to the stress response induced by heat shock. The effects of GSM on chromatin and DNA repair foci in lymphocytes from EHS were further confirmed (74, 75). Although individual variability was observed, effects of RF from mobile phones strongly

depended on the carrier frequency/frequency channel (74–77). Regardless of the cell type (human lymphocytes, fibroblasts, or stem cells), the effects at the 905 MHz/GSM channel 74 on DNA repair foci and chromatin were consistently lower as compared to the effects at the 915 MHz/GSM channel 124. The data also indicated stronger effects of exposure to RF from UMTS mobile phone radiation at the frequency of 1947.4 MHz. These data provided evidence that different frequency channels of different types of mobile communications technologies should be tested separately in provocation studies with EHS. While some minor differences were detected, very similar ELF/RF effects were observed in cells from EHS and matched control subjects. It is likely that compensatory reactions at a more complex level of biological organization such as reactions of tissues, organs, and organ systems are less efficient in persons with EHS, thereby providing a stronger connection of the EMF cellular response with symptoms of hypersensitivity.

Neurological effects of EMF

Neurological and behavioral effects were among the earliest topics of research on potential adverse effects of ELF as well as RF EMFs (78, 79). Concerning epidemiological evidence, more than a decade before the seminal publication of Wertheimer and Leeper (48), Haynal and Regli reported in 1965 an approximately four-fold higher prevalence of a history of electrical engineering jobs in patients with amyotrophic lateral sclerosis (ALS) than in control subjects (80).

Functional, morphological, and biochemical changes at the cellular, tissue, and organism level, as well as behavioral changes have been studied under experimental conditions, and epidemiology has assessed the association between occupational and residential exposure to EMFs and neurodegenerative diseases as well as neurological symptoms.

Research has shown that EMFs (RF and ELF) have deleterious effects on brain neurons and brain functioning (81). Epidemiological research has also shown an increased risk for Alzheimer's and dementia from occupational and residential exposure to ELF.

Neurological effects of radio-frequency radiation

Early studies of RF are difficult to assess because the descriptions of exposure conditions are often insufficient to derive the relevant dosimetric quantities. As early as 1932, Schliephake (82) reported effects that he considered to be non-thermal: *„Es treten Erscheinungen auf, wie wir sie bei Neurasthenikern zu sehen gewohnt sind: starke Mattigkeit am Tag, dafür in der Nacht unruhiger Schlaf, zunächst ein eigenartig ziehendes Gefühl in der Stirn und Kopfhaut, dann Kopfschmerzen, die sich immer mehr steigern, bis zur Unerträglichkeit. Dazu Neigung zu depressiver Stimmung und Aufgeregtheit."* [*"Phenomena occur that we are accustomed to seeing in neurasthenics: pronounced fatigue during the day, however, restless sleep at night, in the beginning, a peculiar pulling sensation on the forehead and scalp, and then headaches that increase beyond the limit of tolerance. In addition, a tendency to depressive moods and agitation".*] Such symptoms, not unlike those later summarized as microwave or radio wave sickness syndrome, have been found in a substantial percentage of exposed workers in the Soviet Union (83) and also in individuals presenting as electrohypersensitive (see below).

Experimental research in humans was scarce before the advent of digital mobile telephony. Since the earliest studies (84, 85) on brain electrical activity, a large evidence base has been compiled that indicates subtle changes in CNS function after and during short-term exposure to different types of RF. Experimental investigations were predominantly about effects on EEG power spectra (e.g. 86–96), event related potentials (e.g. 97–104), sleep (e.g. 105–119) and cognitive function (e.g. 120–131). A few investigations were about effects on glucose metabolism (132, 133) and regional cerebral blood flow (134, 135), applying PET scan imaging. Animal studies covered a wide variety of behavioral aspects, ranging from learning and memory (e.g. 136–141) to anxiety-related behavior (142).

The reaction of the CNS to RF is not restricted to the presence of the exposure but persists for some time after the exposure, making short-term cross-over studies uninformative. The location of exposure could be of relevance under certain circumstances, but often effects are bilateral after unilateral exposure, suggesting involvement of subcortical structures. Effects on sleep may depend on individual characteristics, which led to the conclusion that conflicting results are not strong evidence against an effect (113). Pulsed RF is more effective than continuous waves, but there is some evidence of the importance of exposure characteristics including the site of coupling of the RF field and its modulation.

In the 2012 update of the BioInitiative Report, Henry Lai summarized the experimental evidence as follows (143): *"Almost all the animal studies reported effects, whereas more human studies reported no effects than effects. This may be caused by several possible factors:* (a) *Humans are less susceptible to the effects of RFR than*

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are rodents. (b) *It may be more difficult to do human than animal experiments, since it is, in general, easier to control the variables and confounding factors in an animal experiment.* (c) *In the animal studies, the cumulative exposure duration was generally longer and studies were carried out after exposure, whereas in the human studies, the exposure was generally one time and testing was done during exposure. This raises the question of whether the effects of RFR are cumulative".*

Neurological effects of extremely low frequency electromagnetic fields (ELF EMF)

Neurophysiological investigations of ELF EMFs were already conducted in the 1970s. Studies of chick and cat brain tissue (e.g. 144–146) revealed effects of weak ELF EMFs and ELF modulated RF fields that depended on intensity and frequency (so-called window effects). Adey proposed in 1981 (147) that effects are due to a primary interaction of EMFs at the cell membrane surface inducing a cascade of intracellular processes. This early insight has been corroborated by recent studies on various transmitter receptors in the brain such as N-methyl-D-aspartate receptors, dopamine and serotonin receptors (e.g. 148–151). Some of these more recent studies also reported frequency window effects as well as intensity window effects on the neurodevelopment in the rat (152).

Behavioral effects of ELF EMF have been studied at rather high levels in the 1970s and 1980s (e.g. 153, 154), while recent studies include low-level exposures and support effects on behavior at different levels of complexity. These include: changes in locomotor activity (e.g. 148, 149, 155, 156), anxiety (e.g. 157–159) and depression-like behavior (160, 161). *"Since different behavioral effects have been observed in different exposure conditions, species of animals, and testing paradigms, they provide the strongest evidence that exposure to ELF EMF can affect the nervous system".* (Lai, 2012, BioInitiative Report, section 9, Evidence for effects on neurology and behavior effects, 143). Also in humans, effects were reported at low levels (e.g. 162–164).

Neurodegenerative diseases

The most prevalent of neurodegenerative diseases is Alzheimer's disease with an estimated 45 million patients worldwide for 2015, followed by Parkinson's disease, Huntington's disease, amyothrophic lateral sclerosis (ALS), and other motoneuron diseases (MND). To date, the pathophysiology of these diseases is incompletely understood. In many of these diseases, atypical protein assemblies, mitochondrial dysfunction, and programmed cell death play a role and some genetic changes have been detected. As some such changes could be a consequence of oxidative stress (see below), disruption of calcium homoeostasis, and disturbance of intracellular signaling pathways, there is a theoretical possibility that EMFs could contribute to the risk of these diseases. Since the 1980s, more than 30 epidemiological studies assessing the potential relationship between exposure to ELF EMFs and neurodegenerative diseases have been conducted. In the last years, several meta-analyses have been published. Concerning Parkinson's disease, there is little evidence of an association (165). Concerning ALS, Zhou et al. (166) summarize their results as follows: *"Although there are potential limitations from study selection bias, exposure misclassification, and the confounding effect of individual studies in this meta-analysis, our data suggest a slight but significant ALS risk increase among those with job titles related to relatively high levels of ELF EMF exposure".* A review by Vergara et al. came to another conclusion (167): *"Our results do not support MF [magnetic fields] as the explanation for observed associations between occupational titles and MND".* This discrepancy can be resolved by discriminating between different methods of endpoint assessment (incidence, prevalence or mortality data) and the potential for misclassification due to various sources of exposure data used. If these factors are considered, there is a consistent relationship between ELF EMF from occupational exposure and ALS/MND, and also the few studies about residential exposure are in line with an increased risk from exposure to MF (168).

Blood-brain barrier

All exchanges between blood and brain are strictly regulated by the blood-brain barrier (BBB). The BBB prevents the passage of various molecules from the blood into the brain and vice versa. An increase in a normally low BBB permeability for hydrophilic and charged molecules could potentially be detrimental. While the data on ELF effects are very sparse, several research groups investigated whether RF affects the BBB. These data have recently been reviewed (169–171). Although some BBB studies reported negative data, other studies, including replicated studies with rats from the Swedish group of Leif Salford and Bertil Persson, suggested that RF from mobile phones may affect the BBB under specific exposure conditions (171). More recent studies showing EMF effects at specific conditions of

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exposure (150, 172, 173) and not showing effects on the BBB under other conditions (174) are in line with this suggestion.

EMF and infertility and reproduction

Infertility and reproduction disorders are on the rise. Based on the BioInitiative Report (175), it should be concluded that men who use – and particularly those who wear a mobile phone, personal digital assistant (PDA) or pager on their belt or in a pocket – show adverse effects on sperm quality, motility, and pathology. The usage of mobile phones, the exposure to mobile phone radiation, or the storage of a mobile phone close to the testes of human males affects sperm count, motility, viability, and structure (176–184). Animal studies have demonstrated oxidative and DNA damage, pathological changes in the testes of animals, decreased sperm mobility and viability, and other measures of deleterious damage to the male germ line (182, 185–188).

There are also some studies of adverse birth outcomes in EMF-exposed women. A case-control study (189) and a population-based prospective cohort study (190) from California showed an association between miscarriage and the maximum value measured by a 24-h body-worn magnetic field dosimeter.

Electromagnetic hypersensitivity (EHS)

An increasing number of humans are continuously exposed in their daily life to increasing levels of a combination of static, ELF and VLF (very low frequencies, in general terms from 3 kHz to 3 MHz, in detailed terms from 3 kHz to 30 kHz) electric and magnetic fields and RF electromagnetic fields. These exposures are of different signal patterns, intensities, and technical applications for varying periods of time. All these fields are summarized as EMF, colloquially referred to as "electrosmog".

Some historical examples of EHS from as early as 1932 (82, 83) are given in the chapter "Neurological effects of radio-frequency radiation".

In a questionnaire survey in Switzerland in 2001, which was addressed to persons attributing specific health problems to EMF exposure, of the 394 respondents 58% suffered from sleep problems or disorders, 41% from headaches, 19% from nervousness, 18% from fatigue, and 16% from difficulties with concentration. The respondents attributed their symptoms to, e.g. mobile phone base stations (74%), mobile phones (36%), cordless phones (29%), and high-voltage power lines (27%). Two thirds of the respondents had taken measures to reduce their symptoms, the most frequent one being to avoid exposure (191).

In 2001, 63 persons who attributed health problems to environmental exposure were counseled in an interdisciplinary environmental medicine pilot project in Basel. An interdisciplinary expert team assessed the individual symptoms by a medical psychological-psychiatric and environmental examination, including visits and environmental measurements at home. With respect to the 25 persons with EHS, the expert team attested to the fact that in one third of them at least one symptom was plausibly related to electrosmog, although the EMF exposure was within the Swiss limits. They concluded that patients with EHS should be advised medically, psychologically, and environmentally (192, 193).

A questionnaire study of Finns (n=206), who describe themselves as suffering from electromagnetic hypersensitivity (EHS), revealed that the most common symptoms were related to the nervous system: stress (60%), sleeping disorders (59%) and fatigue (57%). The sources that were most often reported to have triggered EHS were: personal computers (51%) and mobile phones (47%). For 76% of the participants the reduction or avoidance of electromagnetic fields (EMF) helped in their full or partial recovery (194).

A representative telephone survey (n=2048; age>14 years) carried out in Switzerland in 2004 yielded a frequency of 5% (95% CI 4% to 6%) for having symptoms attributed to electrosmog, so-called EHS. In n=107 EHS persons, the most common symptoms being sleep problems (43%), headache (34%), and concentration difficulties (10%). Remarkably, only 13% consulted their family doctor. Individuals with a past history of symptoms attributable to EMF gave "turned off the source" as the answer to measures taken three times as often as the ones who still had symptoms (195).

In a Swiss questionnaire study of GPs in 2005, two-thirds of the doctors were consulted at least once a year because of symptoms attributed to EMF. Fifty-four percent of the doctors assessed a relation as possible. The doctors in this questionnaire asked for more general information about EMF and health and instructions on how to deal with patients with EHS (196).

In another questionnaire study, also mandated by the Swiss Federal Government and performed by the University of Bern in 2004, Swiss doctors working with complementary diagnostic and therapeutic tools reported that 71% of their consultations related to EMF. Remarkably, not only the patients but even more so the doctors suspected a possible relation between illness and EMF. The reduction or elimination of environmental sources was the main

therapeutic instrument in treating symptoms related to EMF (197).

A questionnaire study of Austrian doctors yielded similar results. In this study, the discrepancy between the physicians' opinions and established national and international health risk assessments was remarkable, considering that 96% of the physicians believed to some degree in or were totally convinced of a health-relevant role of environmental electromagnetic fields (198).

In a survey conducted 2009 in a Japanese EHS and multiple chemical sensitivity (MCS) self-help group (n = 75), 45% of the respondents had EHS as a medical diagnosis and 49% considered themselves EHS. Every second respondent had medically diagnosed MCS (49%) and 27% had self-diagnosed MCS. The main EHS-related symptoms were fatigue, headache, concentration problems, sleep disorders, and dizziness. The most frequent causes included base stations, other persons' mobile phones, PC, power lines, television, own mobile phone, public transportation, cordless phones, air conditioner, and car. Suspected EMF source of EHS onset were: mobile phone base stations, PC, electric home appliances, medical equipment, mobile phones, power lines, and induction cookers (199).

In 2010, Khurana et al. reported that eight out of ten epidemiological studies that assessed health effects of mobile phone base stations reported an increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances within 500 m from base stations. None of the studies reported exposure levels above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations (200).

Carpenter reported in 2015 (201) a series of healthy people that developed EHS after a brief, high-intensity microwave radiation exposure. Typical symptoms included, for example, chronic headaches, irritability, and emotional lability, decreased libido, and memory problems, which in some patients, lasted for years.

Hedendahl et al. (19) reported two 15-year-old male students and one 47-year-old female teacher who experienced health effects like headaches, difficulties concentrating, tachycardia, poor memory, or dizziness when exposed to Wi-Fi in school. This example is mentioned to point specifically to the potential health impacts from increasing RF exposure of students and teachers by Wi-Fi.

The question, whether EHS is causally associated with EMF exposure is controversially discussed. On the one hand, physicians judge a causal association between EMF exposures as plausible based on case reports, on the other hand, national and international health risk assessments mostly claim that there is no such causal association, because provocation studies under controlled blinded conditions mostly failed to show effects. However, these studies have severe shortcomings that must be addressed: sequences of exposure conditions were often contiguous neglecting aftereffects of exposure; the exposure duration and the examined effects were short-term; the sham exposure was frequently under conditions that could provoke arousal in sensitive individuals; the time frame neglected the temporal conditions of symptom occurrence and disappearance, and/or the recruitment of persons with EHS was not medically assessed.

The WHO does not consider EHS as a diagnosis and recommends to medical doctors that the treatment of affected individuals should focus on the health symptoms and the clinical picture, and not on a person's perceived need for reducing or eliminating EMF in the workplace or at home (202). Based on the existing evidence and practical knowledge this view ignores a causal approach; see also (203).

The paper "Electromagnetic hypersensitivity: fact or fiction" by Genuis and Lipp (204) offers an instructive review of studies of the last decades concerning EHS, including historical milestones, reviews, pathogenesis, biochemical markers, therapeutic management, as well as the debate about the legitimacy of EHS.

In facial skin samples of electrohypersensitive persons, a profound increase of mast cells has been found (205). From this and other earlier studies when EHS manifested itself often during exposure to EMFs from cathode ray tubes (CRT), it became clear that the number of mast cells in the upper dermis is increased in the EHS group. A different pattern of mast cell distribution also occurred in the EHS group. Finally, in the EHS group, the cytoplasmic granules were more densely distributed and more strongly stained than in the control group, and the size of the infiltrating mast cells was generally found to be larger in the EHS group as well. It should be noted that increases of a similar nature were later demonstrated in an experimental situation, employing normal healthy volunteers in front of CRT monitors, including ordinary household television sets (206).

A French research group headed by Belpomme (207) investigated prospectively, since 2009, self-reported cases of EHS and/or MCS clinically and biologically in an attempt to establish objective diagnostic criteria and to elucidate the pathophysiological aspects of these two disorders. Based on 727 evaluable cases, the investigation showed a number of new and important insights such as:

(a) None of the biomarkers so far identified in the study are specific for EHS and/or MCS.
(b) Several biomarkers like histamine, nitrotyrosine, and circulating antibodies against O-myelin were

increased. The 24-h urine melatonin/creatinine ratio was decreased.

(c) EHS and MCS are genuine somatic pathological entities.

(d) Under the influence of EMFs and/or chemicals a cerebral hypoperfusion/hypoxia-related neuroinflammation may occur.

(e) EHS and/or MCS patients might be potentially at risk of chronic neurodegenerative diseases and cancer.

While a 2006 study by Regel et al. (208) described no exposure effects, two provocation studies on exposure of "electrosensitive" individuals and control subjects to mobile phone base station signals (GSM, UMTS, or both) found a significant decline in well-being after UMTS exposure in the individuals reporting sensitivity (209, 210). Most so-called provocation studies with EHS show no effects. However, all these studies used a very limited number of exposure conditions and most have methodological weaknesses. Taking in account the strong dependence of EMF effects on a variety of physical and biological variables (27), available provocation studies are scientifically difficult to interpret and, in fact, are not suitable to disprove causality.

There is increasing evidence in the scientific literature of various subjective and objective physiological alterations, e.g. heart-rate variability (HRV) as apparent in some persons with EHS claiming to suffer after exposure to certain frequencies of RF like DECT or Wi-Fi (211–215). Analysis of the data available on the exposure of people living near mobile phone base stations has yielded clear indications of adverse health effects like fatigue, depression, difficulty in concentrating, headaches, dizziness, etc. (216–220). A synopsis of 30 studies on mobile phone base stations is given in the document "Leitfaden Senderbau" (221).

Residential EMF exposures in the VLF frequency range are often due to "dirty power"/"dirty electricity" originating from voltage and/or current perturbations from diverse sources like electronic power supplies for TVs, monitors, PCs, motor drives, inverters, dimmers, compact fluorescent lamps (CFLs), phase-angle control devices, as well as sparking and arcing from switching operations and from electric motors with brushes. The kHz waves/transients travel along the electric wiring and grounding systems (conducted emissions) and radiate electric and/or magnetic fields into free space (radiated emissions), leading to human exposures in the vicinity.

First epidemiological evidence links dirty electricity to most of the diseases of civilization including cancer, cardiovascular disease, diabetes, suicide, and attention deficit hyperactivity disorder in humans (222).

While the dependence of ELF effects on the local magnetic field has been reported by many research groups (13, 223), there are also a few studies which suggest that the RF effects are also dependent on slight changes in the local static magnetic field. In the review by Belyaev (224), a physical mechanism has been suggested to account for such effects (225). Slight changes in the local static magnetic field within 10 μT, which are usually observed within offices and homes due to ferromagnetic objects, were reported to induce biological effects that corresponded well to the predictions following from the mechanism of ion interference developed by Binhi (226).

On July 8, 2015, a court in Toulouse, France, ruled in favor of a woman with the diagnosis "syndrome of hypersensitivity to electromagnetic radiation" and determined her disability to be 85% with substantial and lasting restrictions on access to employment (227).

In France, the first low-EMF zone has been established at Drôme in July 2009 (228). In Austria, the construction of a multi-family house has been planned for 2015, which was designed by a team of architects, building biology professionals, and environmental medicine health care professionals to provide a sustainable healthy living environment. Both the outdoor and indoor environments were explicitly chosen and designed to meet low-EMF requirements (229). The implementation of low-EMF zones for electrosensitive individuals is pursued in numerous countries. The realization of such projects greatly depends on the understanding, knowledge, and tolerance of the members of the chosen community.

Possible mechanism of EHS

Based on the scientific literature on interactions of EMF with biological systems, several mechanisms of interaction are possible (14, 13, 22, 26). A plausible mechanism at the intracellular and intercellular level, for instance, is an interaction via the formation of free radicals or oxidative and nitrosative stress (230–238). It has been shown in many reports reviewed by Georgiu (15) that reactive oxygen species (ROS) may be involved in radical pair reactions; thus, radical pairs may be considered as one of the mechanisms of transduction able to initiate EMF-induced oxidative stress. Furthermore, many of the changes observed in RF-exposed cells were prevented by (pre)treatment with antioxidants and radical scavengers (24). While the data from different studies should be interpreted with care in view of variations in physical and biological parameters, a majority of the studies have shown effects of ELF and RF on the oxidative stress (239).

The IARC monograph states: *"even small effects on radical concentration could potentially affect multiple biological functions"*, page 103 (24).

Yakymenko et al. (238) have summarized the current evidence: *"Analysis of the currently available peer-reviewed scientific literature reveals molecular effects induced by low-intensity RFR in living cells; this includes significant activation of key pathways generating reactive oxygen species (ROS), activation of peroxidation, oxidative damage of DNA and changes in the activity of antioxidant enzymes. It indicates that among 100 currently available peer-reviewed studies dealing with oxidative effects of low-intensity RFR, in general, 93 confirmed that RFR induces oxidative effects in biological systems. A wide pathogenic potential of the induced ROS and their involvement in cell signaling pathways explains a range of biological/health effects of low-intensity RFR, which include both cancer and non-cancer pathologies"*.

Reviews by Pall (12, 16, 240) provide evidence for a direct interaction between static and time-varying electric fields, static and time-varying magnetic fields and electromagnetic radiation with voltage-gated calcium channels (VGCCs). The increased intracellular Ca^{2+} produced by such VGCC activation may lead to multiple regulatory responses, including increased nitric oxide levels produced through the action of the two Ca^{2+}/calmodulin-dependent nitric oxide synthases, nNOS and eNOS. In most pathophysiological contexts, nitric oxide reacts with superoxide to form peroxynitrite, a potent non-radical oxidant, which can produce radical products, including hydroxyl and NO_2 radicals.

Peroxynitrite is by far the most damaging molecule that occurs during metabolism in our body. Although not a free radical, peroxynitrite is much more reactive than its parent molecules NO and O_2^-. The half-life of peroxynitrite is comparatively long (10–20 ms), sufficient to cross biological membranes, diffuse one to two cell diameters, and allow significant interactions with most critical biomolecules and structures (cell membranes, nucleus DNA, mitochondrial DNA, cell organelles), and a large number of essential metabolic processes (225). Elevated nitrogen monoxide, formation of peroxynitrite, and induction of oxidative stress can be associated with chronic inflammation, damage of mitochondrial function and structure, as well as loss of energy, e.g. via the reduction of adenosine triphosphate (ATP).

A significant increase of 3-nitrotyrosine was observed in the liver of Wistar rats exposed to ELF, suggesting a deteriorative effect on cellular proteins due to possible formation of peroxynitrite (241). Nitrotyrosin was found to be increased (>0.9 µg/mL) in 30% of the 259 tested EHS individuals (207).

A study by De Luca et al., in 2014 on 153 EHS and 132 controls showed metabolic pro-oxidant/pro-inflammatory alterations in EHS like decreased erythrocyte glutathione S-transferase (GST) activity, decreased reduced glutathione (GSH) levels, increased erythrocyte glutathione peroxidase (GPX) activity, an increased ratio of oxidized-CoQ10/total-CoQ10 in plasma, and a 10-fold increased risk associated with EHS for the detoxifying enzymes glutathione S transferase haplotype (null) GSTT1+(null) GSTM1 variants (242).

The importance of ATP has been shown for chronic fatigue syndrome (CFS) (243) and for stress control (244). Those patients describe the same symptoms as those suffering from CMI. This could indicate similarities in their pathomechanisms. Similar disturbances in neurotransmitter expression has been described both with chronic exposure to EMF (245) and in CMI patients (232, 246).

A study (247) proposed to investigate a possible association between RF exposure and myelin integrity via classical immunohistochemical markers for healthy and degenerated myelin, respectively, and for Schwann cells in general.

Complaints in chronic fatigue syndrome (CFS), fibromyalgia (FM), multiple chemical sensitivity (MCS), post-traumatic stress disorder (PTSD), and Gulf War syndrome (GWS) are almost the same. Meanwhile, they are summarized as chronic multisystem illnesses (CMI) (246). In all of them, various disturbances of functional cycles have been shown: activation of nitrogen oxide and peroxynitrite, chronic inflammation by activation of NF-kB, IFN-γ, IL-1, IL-6, and interaction with neurotransmitter expression (232, 246, 248). We recommend classifying EHS as part of CMI (232, 249), but still recognizing that the underlying cause remains the environment (see Figure 1).

Other diseases that require attention with respect to EMF

Based on interactions between EMF exposure and biological responses that, e.g. lead to a disturbance of the oxidative/nitrosative homeostasis, a variety of diseases are possible and even expected to occur. Some examples are given here.

Havas reported in 2008 (250): *"Transient electromagnetic fields (dirty electricity), in the kilohertz range on electrical wiring, may be contributing to elevated blood sugar levels among diabetics and prediabetics. By closely following plasma glucose levels in four Type 1 and Type 2 diabetics, we find that they responded directly to the amount of dirty electricity in their environment. In an electromagnetically*

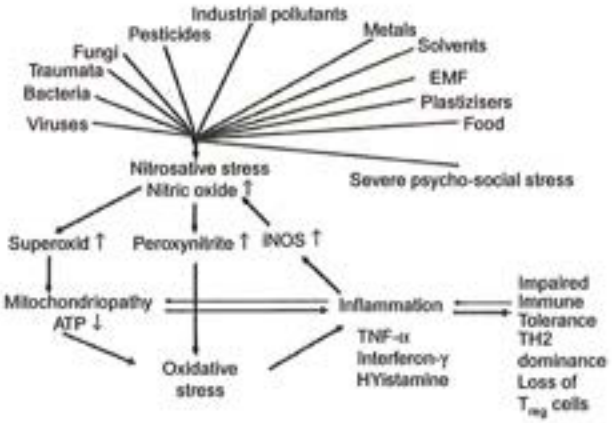

Figure 1: Pathogenesis of inflammation, mitochondriopathy, and nitrosative stress as a result of the exposure to trigger factors (248).

clean environment, Type 1 diabetics require less insulin and Type 2 diabetics have lower levels of plasma glucose. Dirty electricity, generated by electronic equipment and wireless devices, is ubiquitous in the environment. Exercise on a treadmill, which produces dirty electricity, increases plasma glucose. These findings may explain why brittle diabetics have difficulty regulating blood sugar. Based on estimates of people who suffer from symptoms of electrical hypersensitivity (3%–35%), as many as 5–60 million diabetics worldwide may be affected".

With respect to fetal and early childhood exposures to EMF, Sage in the BioInitiative Report 2012 (56) pointed out: *"Fetal (in-utero) and early childhood exposures to cell phone radiation and wireless technologies in general may be a risk factor for hyperactivity, learning disorders and behavioral problems in school." [&] "Common sense measures to limit both ELF EMF and RF EMF in these populations is needed, especially with respect to avoidable exposures like incubators that can be modified; and where education of the pregnant mother with respect to laptop computers, mobile phones and other sources of ELF EMF and RF EMF are easily instituted".*

In a 2013 review, Herbert and Sage (251, 252) reported remarkable similarities between pathophysiological phenomena found in autism spectrum conditions (ASCs) and the physiological impacts of ELF MF/RF, such as oxidative stress, free radical damage, malfunctioning membranes, mitochondrial dysfunction, inflammatory issues, neuropathological disruption and electrophysiological dysregulation, cellular stress proteins and deficiencies of antioxidants such as glutathione.

In a 6-year study, certain blood hormone levels were monitored in volunteers. Mobile phone use as well as close distances to mobile phone base stations were associated with decreased testosterone levels in males, as well as decreased ACTH, cortisol, T3 and T4 levels in males and females (253).

Recommendations for action

EUROPAEM has developed guidelines for differential diagnosis and potential treatment of EMF-related health problems with the aim to improve/restore individual health outcomes and to propose strategies for prevention. These recommendations are further outlined below.

These recommendations are preliminary and in large parts, although related to the whole body of evidence rooted in the experience of the team, cannot in every detail be strictly considered evidence-based.

Evidence of treatment strategies for EMF-related illness including EHS

There are only a few studies assessing therapeutic approaches to EHS. The interdisciplinary based assessing and counseling of EHS in the Swiss Environmental Pilot Project performed in 2001 showed, in an evaluation interview half a year after counseling, that 45% of the persons with EHS had benefitted from realizing certain advice, e.g. changing the bedroom (192, 193).

In the 2005 Swiss questionnaire study of physicians working with complementary therapeutic tools, two-thirds chose exposure reduction as a principal tool, whereas complementary therapeutics were only chosen as a supplement (197).

Since 2008, the Swiss Society of Doctors for the Environment has run a small interdisciplinary environmental medicine counseling structure for patients with EHS, which is embedded in everyday practice with a central coordination and consultation office as well as a network of general practitioners interested in environmental medicine who perform environmental medical assessments and consultations based on a standard protocol. If necessary, environmental experts are consulted and home inspections are conducted. The aim of the assessments is to detect or rule out common diseases and to analyze the impact of suspected environmental burdens on the complaints in order to find individual therapeutic approaches. The main instrument of the assessment is an extensive medical and psycho-social history with an additional environmental history, including a systematic questionnaire and environmental key questions.

In the first years, the project was scientifically assessed. In a questionnaire 1 year after counseling, 70% of the persons recommended the interdisciplinary based counseling structure and 32% of them considered the counseling as being helpful. Therefore, a model based on such an interdisciplinary concept, embedded in the family doctor's holistic and lasting concept of treatment, seems to be promising for a better therapeutic approach to EHS, also including accessibility measures targeted at the actual environment (254).

In Finland, psychotherapy is the officially recommended therapy for EHS. In a questionnaire study of EHS people in Finland, symptoms, perceived sources and treatments, the perceived efficacy of medical and complementary alternative treatments (CAM) in regards to EHS were evaluated by multiple choice questions. According to 76% of the 157 respondents, the reduction or avoidance of EMF helped in their full or partial recovery. The best treatments for EHS were given as weighted effects: dietary change (69.4%), nutritional supplements (67.8%), and increased physical exercise (61.6%). The official treatment recommendations of psychotherapy (2.6%) were not significantly helpful, or for medication (−4.2%) even detrimental. The avoidance of electromagnetic radiation and fields effectively removed or lessened the symptoms in persons with EHS (194, 255).

Response of physicians to this development

In cases of unspecific health problems (see Questionnaire) for which no clearly identifiable cause can be found – besides other factors like chemicals, non-physiological metals, molds – EMF exposure should, in principle, be taken into consideration as a potential cause or cofactor, especially if the person presumes it.

A central approach for a causal attribution of symptoms is the assessment of variation in health problems depending on time and location and individual susceptibility, which is particularly relevant for environmental causes such as EMF exposure.

Regarding such disorders as male infertility, miscarriage, Alzheimer's, ALS, blood sugar fluctuations, diabetes, cancer, hyperactivity, learning disorders and behavioral problems in school, it would be important to consider a possible link with EMF exposure. Some people with EHS might be misdiagnosed with multiple sclerosis (MS) since many of the symptoms are similar. This offers an opportunity to causally influence the course of the disease.

How to proceed if EMF-related health problems are suspected

The recommended approach to diagnosis and treatment is intended as an aid and should, of course, be modified to meet the needs of each individual case (see Figure 2).

1. History of health problems and EMF exposure
2. Medical examinations and findings
3. Measurement of EMF exposure
4. Reduction and prevention of EMF exposure
5. Diagnosis
6. Treatment of the patient including the environment

History of health problems and EMF exposure

In order to put later findings into a larger context, a general medical history is necessary. Part of this history should include:

- Electrical trauma: multiple shocks, electrocution, struck by lightning.
- Chemical trauma: exposure to pesticides, metals, chlorinated hydrocarbons (PCBs, DDT, etc.)

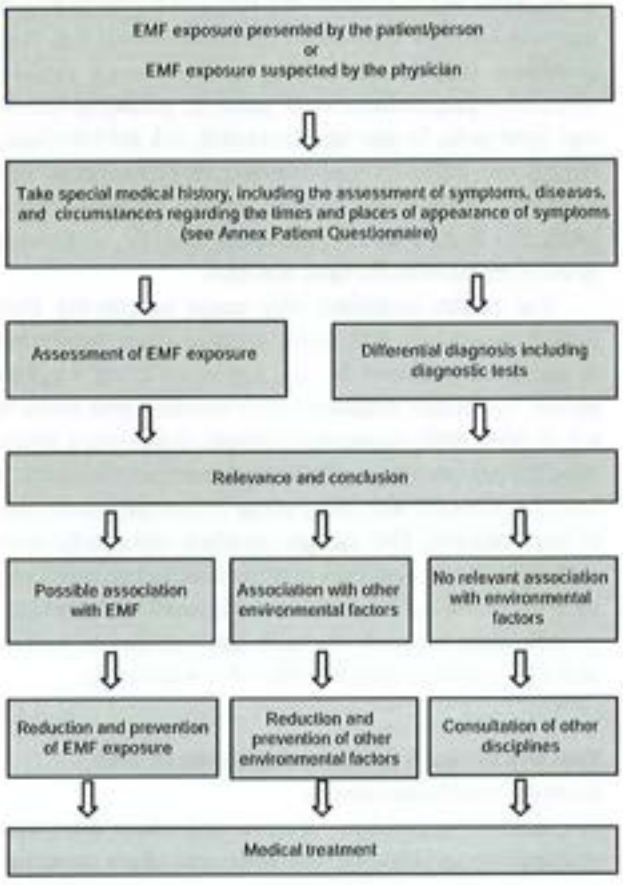

Figure 2: Flowchart for the handling of EMF-related health problems.

- Biological trauma in the form of a large load of parasites, fungal infections, viral infections, etc.
- Physical trauma to the central nervous system in the form of whiplash, other accidents, spinal problems
- Autoimmune disorders

In the next steps, we focus only on EMF-related health effects.

A questionnaire to take a systematic history of health problems and EMF exposure, compiled by the EUROPAEM EMF Working Group, is available in the Annex of this EMF Guideline.

The questionnaire consists of three sections:

(a) List of symptoms
(b) Variation of health problems depending on time, location, and circumstances
(c) Assessment of certain EMF exposures that can be evaluated by questionnaire

The list of symptoms in the questionnaire serves to systematically quantify health problems regardless of their causes. It also includes questions as to when the health problems first occurred. Most EMF-related symptoms are nonspecific and fall within the scope of health problems due to inadequate regulation (decompensation), e.g. sleep problems, fatigue, exhaustion, lack of energy, restlessness, heart palpitations, blood pressure problems, muscle and joint pain, headaches, increased risk for infections, depression, difficulty concentrating, disturbances of coordination, forgetfulness, anxiety, urinary urgency, anomia (difficulty finding words), dizziness, tinnitus, and sensations of pressure in the head and ears.

The health problems may range in severity from benign, temporary symptoms, such as slight headaches or paresthesia around the ear, e.g. when using a mobile phone, or flu-like symptoms after maybe some hours of whole-body EMF exposure, to severe, debilitating symptoms that drastically impair physical and mental health. It has to be stressed that, depending on the individual state of susceptibility, EHS symptoms often occur only occasionally, but over time they may increase in frequency and severity. On the other hand, if a detrimental EMF exposure is sufficiently reduced, the body has a chance to recover and EHS symptoms will be reduced or will vanish.

Variation of health problems depending on time, location, and circumstances

The answers to questions of when and where the health problems occur or recede, and when and where the symptoms increase or are particularly evident, provide only indications. They must be interpreted by the investigator (e.g. regarding the correct attribution between location/EMF sources and health problems). Special attention should be drawn to sleeping areas, because of the duration of influence and the vital role of sleep for regeneration.

Assessment of certain EMF exposures that can be evaluated by questionnaire

The assessment of EMF exposure usually starts with certain questions of usual EMF sources. Regardless of whether or not the patient suspects EMF exposure as a cause, these questions should be used to assess the existing exposure level, at least as a rough estimate. It is important to note that only certain types of EMF exposure can be assessed by means of questions, such as the use of compact fluorescent lamps, mobile phones, and cordless phones. Detection of other types of EMF exposure, e.g. due to RF transmitter sites or the electric or magnetic fields from electric wiring, generally requires measurements. In principle, questions should be asked to assess EMF exposure at home and at work and when on holidays and so on, keeping in mind that the degree of EMF exposure may vary at different times.

Medical examinations and findings

We do not have any clinical findings yet that are specific to EMF, which makes diagnosis and differential diagnosis a considerable challenge.

A method that has proven useful is to use stress-associated findings for diagnosis and follow-up and to evaluate them synoptically. Basic diagnostic tests should be carried out as a first step, followed by measurements of EMF exposure as a second step. The core diagnosis should focus on investigations of nitric oxide production (nitrotyrosine), mitochondriopathy (intracellular ATP), oxidative stress-lipid peroxidation (MDA-LDL), inflammation [TNF-alpha, IFN-gamma-inducible protein 10 (IP-10), IL-1b, histamine], and the melatonin status (24 h urine melatonin/creatinine ratio).

Then additional diagnostic tests can be considered. Due to the differences in normal ranges between labs and different practices as to the units of measurement in different countries, we do not provide levels to be considered relevant in EHS. It is recommended to interpret them in context, focusing not only on out-of-range values. For example, when several parameters are simultaneously close to the border of the normal ranges, this could be instructive for forming a therapeutic or diagnostic opinion.

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Functional tests

Basic diagnostic tests

- Blood pressure and heart rate (in all cases resting heart rate in the morning while still in bed), including self-monitoring, possibly several times a day, e.g. at different locations and with journaling of subjective well-being for a week.

Additional diagnostic tests

- 24-h blood pressure monitoring (absence of nighttime decline)
- 24-h ECG (heart rhythm diagnosis)
- 24-h heart rate variability (HRV) (autonomous nervous system diagnosis)
- Ergometry under physical stress
- Sleep EEG at home

Laboratory tests

Basic diagnostic tests

- Blood
  - ACTH
  - Bilirubin
  - Blood count and differential blood count
  - BUN
  - Cholesterol, LDL, HDL, triglycerides
  - Coenzyme-Q10 ratio for oxidized-CoQ10/total-CoQ10
  - Creatinine kinases (CK-MB, CK-MM)
  - High-sensitivity C-reactive protein (hs-CRP)
  - Cystatin C (glomerular filtration rate)
  - Electrolytes
  - Fasting blood glucose
  - Ferritin
  - Glutathione S-transferase (GST)
  - Reduced glutathione (GSH)
  - Glutathione peroxidase (GPX)
  - HBA_{1c}
  - Histamine and diaminoxidase (DAO)
  - IFN-gamma-inducible protein 10 (IP-10)
  - Interleukin-1 (e.g. IL-1a, IL-1b)
  - Intracellular ATP
  - Liver enzymes (e.g. ALT, AST, GGT, LDH, AP)
  - Magnesium (whole blood)
  - Malondialdehyde (MDA)-LDL
  - Nitrotyrosine (NTT)
  - Potassium (whole blood)
  - Prolactin
  - Selenium (whole blood)
  - Testosterone
  - TSH
  - T3, T4
  - Tumor necrosis factor alpha (TNFα)
  - Vitamin D3
  - Zinc (whole blood)
- Standard urine
  - Leucocytes, erythrocytes, albumin, urobilinogen, pH, bacteria, glucose, microalbumin
- Second morning urine
  - Adrenaline
  - Dopamine
  - Noradrenaline
  - Noradrenaline/adrenaline ratio
  - Serotonin
  - Beta-phenylethyleamine (PEA)
- 24-h urine
  - 6-OH melatonin sulfate
  - Creatinine
  - 6-OH melatonin sulfate/creatinine ratio
- Saliva
  - Cortisol (8 a.m., 12 a.m., and 8 p.m.)

Additional diagnostic tests

- Urine
  - Metals (depending on case history, e.g. mercury, cadmium, lead, arsenic, aluminum)
- Second morning urine
  - Gamma-aminobutyric acid (GABA)
  - Glutamate
  - Cryptopyrrole
- Saliva
  - Dehydroepiandrosterone DHEA (8 a.m. and 8 p.m.)
  - Alpha-amylase
- Blood
  - 8-Hydroxydeoxyguanosine (DNA oxidation)
  - Biotin
  - Differential lipid profile
  - Folate
  - Holotranscobolamin
  - Homocysteine
  - Interferon-gamma (IFN-γ)
  - Interleukin-10 (IL-10)
  - Interleukin-17 (IL-17)
  - Interleukin-6 (IL-6)
  - Interleukin-8 (IL-8)
  - Intracellular glutathione (redox balance)
  - Lactate, pyruvate incl. ratio
  - Lipase
  - NF-kappa B
  - Vitamin B6 (whole blood)

Provocation tests

Special facilities with the use of a variety of signals, e.g. DECT or Wi-Fi exposure (e.g. 20–60 min, depending on

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the individual regulation capacity, susceptibility, and observed response)

- Heart rate variability (HRV) (autonomous nervous system diagnosis)
- Microcirculation
- Oxidative stress (lipid peroxidation, malondialdehyde, oxo-LDL)
- For diabetics, plasma glucose
- Live blood analysis (red blood cell aggregation in the form of rouleaux, blood viscosity, macrophage activity, lysis of red blood cell membrane)
- For people with neurological problems and problems with fine or gross motor coordination, a video of them walking before and after provocation and a photograph taken of a sample of handwriting before and after provocation.

Individual susceptibility

- Blood (genetic parameters and actual function)
  - Glutathione S transferase M1 (GSTM1) – detoxification
  - Glutathione S transferase T1 (GSTT1) – detoxification
  - Superoxide dismutase 2 (SOD2) – protection of mitochondria
  - Catechol-O-methyltransferase (COMT) – stress control

Measurement of EMF exposure

The evolutionary development of the human species took place under the presence of the natural electromagnetic spectrum (Earth's magnetic field, Earth's electric field, spherics, Schumann resonance). Those influences have been part of our biosphere like the oxygen content in the air or the visible light spectrum, and they have been integrated into the biological functions (14).

By now, nearly all non-ionizing parts of the electromagnetic spectrum are filled with artificial, technical EMF sources due to electrification and (wireless) communication technologies, but are very rarely found in nature (see Figure 3). EMF measurements and/or exposure damages are usually not covered by statutory health care insurance.

In general, a wide variety of EMF exposure types (static fields, ELF, VLF, and RF) should be considered.

- ELF magnetic fields may originate from, e.g. 12 V transformers, transformer stations, net currents on the electric wiring, water pipes, and other conductive materials, infrared heaters, heating blankets and different types of power lines.
- ELF electric fields may originate from, e.g. electrical wiring, lamps, and appliances.
- VLF magnetic fields ("dirty power") and/or VLF electric fields ("dirty electricity") may be emitted from electronic

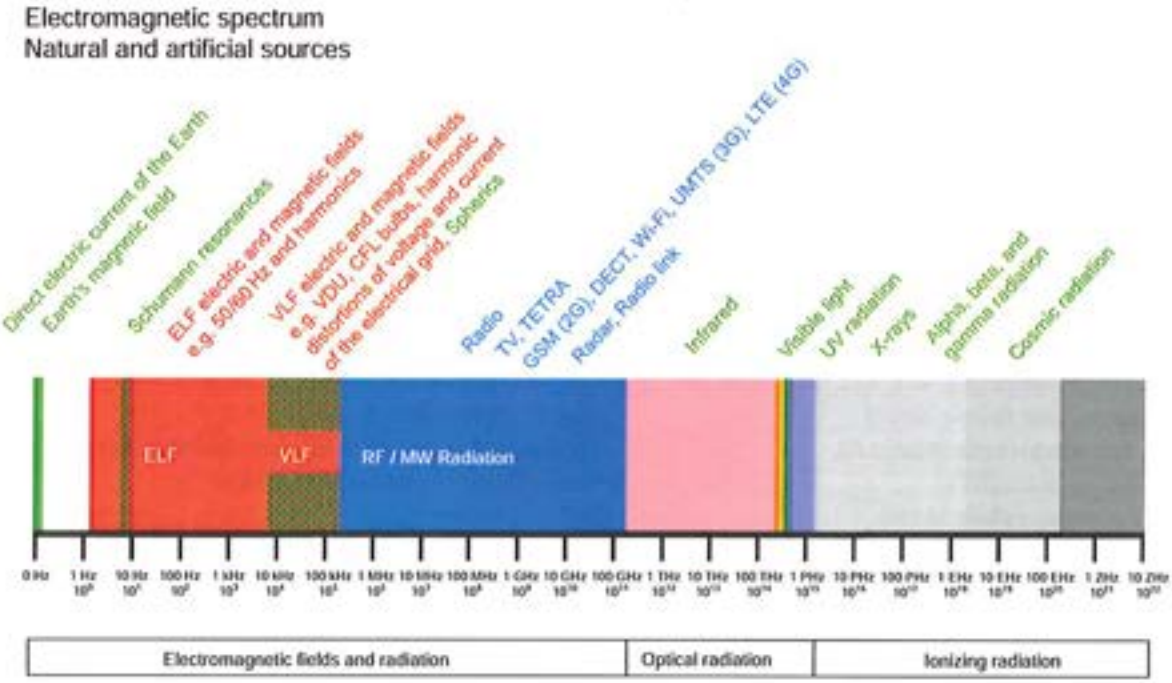

Figure 3: Examples of natural (green) and artificial (red and blue) EMF sources along the electromagnetic spectrum (256).

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devices like energy-efficient lighting, electronic transformers, induction cooker, variable speed frequency drives, light dimmer switches, power line communication (PLC) connected to the electrical grid. These devices use current and/or voltage in short pulses that might produce harmonics and VLF transients on the electrical circuits, earthed materials and the ground.
- Typical RF radiation sources include, e.g. cordless phones (DECT), wireless Internet access (Wi-Fi), mobile phones and their base stations, radio and TV broadcast antennas, radar (military, airport, marine, and weather), Bluetooth, and the microwave ovens.

In the sleeping area, the most important exposure point is the head and trunk region followed by all other points with chronic or high exposure.

EMF measurements should be planned and carried out by specially trained and experienced testing specialists and always in accordance with relevant standards, e.g. the VDB Guidelines of the German Association of Building Biology Professionals (257). In addition to the measurement results, the measurement report should also include suggestions on how to possibly reduce the EMF exposure.

To clarify certain issues, personal dosimeters with a data logging function are available to measure ELF magnetic fields and radio-frequency radiation.

After the measurements have been commissioned by the person and carried out, the results should be discussed with a physician familiar with the EMF issue.

EMF guidance values

In each case, the following aspects should be individually taken into account when evaluating EMF measurement results (27, 26):
- A person's individual susceptibility, which, e.g. may be based on previous history of trauma (electrical, chemical, biological and physical).
- A person's individual total body burden (e.g. exposure to noise, chemicals like neurotoxins)
- Duration of EMF exposure
- EMF exposure during the night and day
- Multiple exposure to different EMF sources
- Signal intensity: watt/m² (W/m²), volt/m (V/m), ampere/m (A/m)
- Signal characteristics were taken into account in the EMF guidance values – see Supplement 3 (258)
  - Frequency
  - Risetime (ΔT) of bursts, transients, etc.
  - Frequency and periodicity of bursts, e.g. certain GSM base stations (8.3 Hz), Wi-Fi networks (10 Hz), DECT cordless phones (100 Hz)
  - Type of modulation (frequency modulation, amplitude modulation, phase modulation)

Regardless of the ICNIRP recommendations for specific acute effects, the following guidance values (Tables 1–3, 5 and 6) apply to sensitive locations with long-term exposure of more than 20 h per week (259). They are based on epidemiological studies (9, 10, 27, 221, 260–262), empirical observations, and measurements relevant in practice (258, 263), as well as recommendations by the Seletun Statement (40) and the Parliamentary Assembly of the Council of Europe (42). The proposed guidance values are based on scientific data including a preventive component and aim to help restore health and well-being in already compromised patients. All levels provided are for incident intensities and whole-body exposure.

ELF magnetic fields (extremely low frequency) (ELF MF)

Measurement specifications

Frequency range: 50/60 Hz mains electricity, up to 2 kHz. 16.7 Hz railroad systems in Austria, Germany, Switzerland, Sweden, and Norway, 400 Hz on airplanes
Type of measurement: Magnetic induction or flux density [T; mT; µT; nT]
Field probe: Isotropic magnetic field probe (three orthogonal axes)
Detector mode: RMS (root mean square)
Measurement volume: Bed: Short-term measurements across entire sleeping area. Workplace: Short-term measurements across entire work area (e.g. sitting position). Long-term measurements: e.g. point close to the head/trunk in bed or at workplace
Measurement period: Short-term measurements to identify field sources. Long-term measurements during sleep and work shift
Basis for evaluation: Long-term measurements: maximum (MAX) and arithmetic mean (AVG)

Precautionary guidance values Magnetic

In areas where people spend extended periods of time (>4 h per day), minimize exposure to ELF magnetic fields to levels as low as possible or below the precautionary guidance values specified below.

Table 1: Precautionary guidance values for ELF magnetic fields.

ELF magnetic field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	100 nT (1 mG)[1,2,3]	100 nT (1 mG)[1,2,3]	30 nT (0.3 mG)[1]
Maximum (MAX)	1000 nT (10 mG)[3,4]	1000 nT (10 mG)[3,4]	300 nT (3 mG)[1]

Based on: [1]BioInitiative (9, 10); [2]Oberfeld (262); [3]Seletun Statement (40), [4]NISV (264); [5]Precautionary approach by a factor of 3 (field strength). See also IARC 2002 (30), Blank and Goodman (17), and TCO Development (265).

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Evaluation guidelines specifically for sleeping areas

Higher frequencies than the mains electricity at 50/60 Hz and distinct harmonics should be evaluated more critically. See also the precautionary guidance values for the VLF frequency range further below. If applicable, mains current (50/60 Hz) and traction current (16.7 Hz) should be assessed separately but added (squared average). Long-term measurements should be carried out especially at nighttime, but at least for 24 h.

ELF electric fields (extremely low frequency) (ELF EF) Measurement specifications

Frequency range: 50/60 Hz mains electricity, up to 2 kHz.16.7 Hz railroad systems in Austria, Germany, Switzerland, Sweden, and Norway
Type of measurement: Electric field [V/m] without ground reference (potential-free)
Field probe: Isotropic electric field probe (three orthogonal axes)
Detector mode: RMS (root mean square)
Measurement volume: Bed: Nine points across sleeping area. Workplace: Across entire work area (e.g. sitting position three or six points)
Measurement period: Spot measurements to assess the exposure as well as to identify field sources. Since electric field exposure levels in the ELF frequency range usually do not change, long-term measurements are not needed.
Basis for evaluation: Spot measurements (maximum) at relevant points of exposure

Precautionary guidance values ELF Electric

In areas where people spend extended periods of time (> 4 h per day), minimize exposure to ELF electric fields to levels as low as possible or below the precautionary guidance values specified below.

Table 2: Precautionary guidance values for ELF electric fields.

ELF electric field	Daytime exposure	Nighttime exposure	Sensitive populations
Maximum (MAX)	10 V/m[B, a]	1 V/m[b]	0.3 V/m[b]

Based on: [a]NCRP Draft Recommendations on EMF Exposure Guidelines: Option 2, 1995 (261); [B]Oberfeld (262); [b]Precautionary approach by a factor of 3 (field strength). See also TCO Development (265).

Evaluation guidelines specifically for sleeping areas

Higher frequencies than the mains electricity at 50/60 Hz and distinct harmonics should be evaluated more critically. See also the precautionary guidance values for the VLF frequency range further below.

Radio-frequency radiation (RF) Measurement specifications

Frequency range: Radio and TV broadcast antennas, mobile phone base stations, e.g. TETRA (400 MHz),GSM (900 and 1800 MHz), UMTS (2100 MHz),LTE (800, 900, 1800, 2500–2700 MHz), cordless phone base stations, e.g. DECT (1900), Wi-Fi access points and clients (2450 and 5600 MHz), WiMAX (3400–3600 MHz). Above frequencies in MHz refer to European networks.
Type of measurement: Usually electric field [V/m] -> calculated power density [W/m²; mW/m²; µW/m²]; for conversion units see Table 4.
Field probe: Isotropic, biconical or logarithmic-periodic antennas
Detector mode: Peak detector with max hold
Measurement volume: Point of exposure across bed and workplace
Measurement period: Usually short-term measurements to identify RF field sources (e.g. acoustic analysis) and peak readings
Basis for evaluation: Band-specific or frequency-specific spot measurements (peak detector with max hold) of common signals at relevant points of exposure (e.g. with spectrum analyzer or at least band-specific RF meter)

Precautionary guidance values for selected RF sources

In areas where people spend extended periods of time (>4 h per day), minimize exposure to radio-frequency radiation to levels as low as possible or below the precautionary guidance values specified below. Frequencies to be measured should be adapted to each individual case. The specific guidance values take the signal characteristics of risetime (ΔT) and periodic ELF "pulsing" into account (258). Note: Rectangular signals show short risetimes and consist of a broad spectrum of frequencies. The current density induced in the human body increases with increasing frequency in an approximately linear relationship (266). RF

Table 3: Precautionary guidance values for radio-frequency radiation.

RF source Max Peak/ Peak Hold	Daytime exposure	Nighttime exposure	Sensitive populations[b]
Radio broadcast (FM)	10,000 µW/m²	1000 µW/m²	100 µW/m²
TETRA	1000 µW/m²	100 µW/m²	10 µW/m²
DVBT	1000 µW/m²	100 µW/m²	10 µW/m²
GSM (2G) 900/1800 MHz	100 µW/m²	10 µW/m²	1 µW/m²
DECT (cordless phone)	100 µW/m²	10 µW/m²	1 µW/m²
UMTS (3G)	100 µW/m²	10 µW/m²	1 µW/m²
LTE (4G)	100 µW/m²	10 µW/m²	1 µW/m²
GPRS (2.5G) with PTCCH* (8.33 Hz pulsing)	10 µW/m²	1 µW/m²	0.1 µW/m²
DAB+ (10.4 Hz pulsing)	10 µW/m²	1 µW/m²	0.1 µW/m²
Wi-Fi 2.4/5.6 GHz (10 Hz pulsing)	10 µW/m²	1 µW/m²	0.1 µW/m²

*PTCCH, packet timing advance control channel.

Based on: BioInitiative (9, 10); Kundi and Hutter (260); Leitfaden Senderbau (221); PACE (42); Seletun Statement (40). [b]Precautionary approach by a factor of 3 (field strength)= a factor of 10 (power density). See also IARC 2013 (24) and Margaritis et al. (267).

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Table 4: Conversion of radio-frequency radiation measurement units.

Conversion of RF Measurement units	mW/m²	10	1	0.1	0.01	0.001	0.0001
	µW/m²	10,000	1000	100	10	1	0.1
	µW/cm²	1	0.1	0.01	0.001	0.0001	0.00001
	V/m	1.9	0.6	0.19	0.06	0.019	0.006

Magnetic fields in the VLF range (VLF MF) Measurement specifications

Frequency range: 3 kHz–3 MHz. Frequency-specific measurements (spectrum analyzer/EMF meter), e.g. "dirty power", powerline communication (PLC), radio-frequency identification transmitters (RFID), compact fluorescent lamps (CFL)

Type of measurement: Magnetic field [A/m] – > calculated magnetic induction [T; mT; µT; nT]

Field probe: Isotropic or anisotropic magnetic field probe

Detector mode: RMS (root mean square)

Measurement volume: Point of exposure across bed and workplace

Measurement period: Short-term measurements to identify field sources. Long-term measurements during sleep and work shift

Basis for evaluation: Long-term measurements: RMS detector, arithmetic mean and maximum at relevant points of exposure

Note: If an elevated exposure is detected, power quality analyzers and oscilloscopes can be used on the actual wiring to trace the source of the dirty power.

Precautionary guidance values VLF Magnetic

In areas where people spend extended periods of time (>4 h per day), minimize exposure to VLF magnetic fields to levels as low as possible or below the precautionary guidance values specified below.

Table 5: Precautionary guidance values for VLF magnetic fields.

VLF magnetic field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	1 nT (0.01 mG)[1]	1 nT (0.01 mG)[1]	0.3 nT (0.003 mG)[2]
Maximum (MAX)	10 nT (0.1 mG)[1]	10 nT (0.1 mG)[1]	3 nT (0.03 mG)[2]

Based on: [1]The current density induced in the human body increases with increasing frequency in an approximately linear relationship (266). Therefore, the guidance value of the magnetic field in the VLF frequency range should be lower than the one of the 50/60 Hz magnetic field, e.g. for 100 nT RMS/100=1 nT. For the rationale of 100 nT (avg) and 1 µT (max), see section ELF magnetic fields. [2]Precautionary approach by a factor of 3 (field strength). See also TCO Development (265).

Electric fields in the VLF range (VLF EF) Measurement specifications

Frequency range: 3 kHz–3 MHz. Frequency-specific measurements (spectrum analyzer/EMF meter), e.g. "dirty electricity", powerline communication (PLC), radio-frequency identification transmitters (RFID), compact fluorescent lamps (CFL)

Type of measurement: Electric field [V/m]

Field probe: Isotropic, biconical, logarithmic-periodic electric field probe

Detector mode: RMS arithmetic mean

Measurement volume: Point of exposure across bed and workplace

Measurement period: Short-term measurements to identify field sources. Long-term measurements during sleep and work shift

Basis for evaluation: Long-term measurements: arithmetic mean at relevant points of exposure

Note: If an elevated exposure is detected, power quality analyzers and oscilloscopes can be used on the actual wiring to trace the source of the dirty power.

Precautionary guidance values VLF Electric

In areas where people spend extended periods of time (>4 h per day), minimize exposure to VLF electric fields to levels as low as possible or below the precautionary guidance values specified below.

Table 6: Precautionary guidance values for VLF electric fields.

VLF electric field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	0.1 V/m[1]	0.01 V/m[1]	0.003 V/m[2]

Based on: [1]The current density induced in the human body increases with increasing frequency in an approximately linear relationship (266). Therefore, the guidance value of the electric field in the VLF frequency range should be lower than the one of the 50/60 Hz electric field, e.g. for 10 V/m/100 = 0.1 V/m. For the rationale of 10 V/m and 1 V/m, see section ELF electric fields. [2]Precautionary approach by a factor of 3 (field strength). See also TCO Development (265).

Reduction and prevention of EMF exposure

Preventing or reducing EMF exposure after consulting a testing specialist is advantageous for several reasons:

(a) To prevent and reduce risks to individual and public health,
(b) To identify any links to health problems,
(c) To causally treat the EMF-related health problems.

There are numerous potential causes of relevant EMF exposures, and this EMF guideline can only give a few examples. Further information can be found, for instance, in the document "Options to Minimize EMF/ RF/Static Field Exposures in Office Environments" (268) and "Elektrosmog im Alltag"

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(269). For detailed information on physics, properties, and measurement of EMF, see Virnich (270); regarding reduction of radio-frequency radiation (RF) in homes and offices, see Pauli and Moldan (271).

In most cases, it will be necessary to consult an expert (e.g. qualified EMF/RF engineer/ consultant) and/or electrician who will advise the person on what measures could be taken to reduce EMF exposure.

EMF exposure reduction – first steps

As a first step, recommendations are given (also as preventive measures) to eliminate or reduce typical EMF exposures, which may help alleviate health problems within days or weeks. The following actions may be suggested:

Preventing exposure to radio-frequency radiation (RF)

- Keep mobile phone/smartphone and cordless phone calls short; use the speakerphone function or a hands-free kit.
- Avoid wearing the mobile phone/smartphone close to the body.
- Deactivate all non-essential wireless mobile phone apps, which cause periodic radiation exposure.
- Keep mobile phones/smartphones in "airplane mode" whenever possible or deactivate mobile data, Wi-Fi, Bluetooth and near field communication (NFC) in the smartphone settings.
- Disconnect (unplug) the power supply of all DECT cordless phone base stations. So called "ECO Mode" or "zero-emission" DECT phones are only conditionally recommended because the exposure by the handset is still present. A "traditional" corded phone is recommended instead.
- Disconnect (unplug) the power supply to all Wi-Fi access points or Wi-Fi routers. Many LAN routers now come equipped with additional Wi-Fi. Call the provider of the LAN router and ask to have the Wi-Fi deactivated. It is usually also possible to do so online by following the provider's instructions.
- In case of external RF radiation sources, rooms – especially bedrooms – facing away from the source should be chosen.
- Avoid powerline communication for Internet access (dLAN) and instead use a hardwired Ethernet cable (LAN).
- Avoid exposure to RF radiation (e.g. wireless devices like, home entertainment, headsets, baby monitors, computer games, printers, keyboards, mouse, home surveillance systems) at home, in offices, and in cars.
- Avoid exposure to energy-efficient lighting (compact fluorescent lamps as well as some LEDs generate high frequency transients). These types of lamps can be replaced with incandescent or line-voltage halogen incandescent lamps until good-quality lighting energy-efficient lamps become commercially available.

Preventing exposure to ELF electric and magnetic fields

- Move the bed or desk away from the wiring in the walls and power cords. A minimum distance of 30 cm (1 ft) from the wall is recommended.
- As magnetic fields can pass through walls, make certain that there are no magnetic sources immediately beneath or above a bed or in an adjacent room.
- Another simple complementary action is to disconnect the power supply to the bedroom (turn off circuit breaker or fuse) for the nighttime while sleeping; try it for a test phase of, e.g. 2 weeks. In general, this measure is not always successful because circuits of adjacent rooms contribute to the electric field levels. ELF electric field measurements are required to know exactly which circuit breakers need to be disconnected. The benefits should be weighed against the potential risk of accidents; therefore, the use of a flashlight for the test phase should be recommended.
- Disconnect the power supply to all non-essential electric circuits, possibly in the entire apartment or house. (N.B. See note above.)
- Avoid using an electric blanket during sleep; not only turn it off, but also disconnect it.
- Avoid extended exposures close to running electric motors. As a first step, keep a minimum distance of 1.5 m (5 ft). As a second step, establish a safe distance based on magnetic field measurements.

Preventing exposure to static magnetic/static electric fields

- Sleep in a bed and mattress without metal.
- Avoid sleeping close to iron materials (radiator, steel, etc.)
- Wearing synthetic clothing and, e.g. rubber-soled shoes and not regularly being in contact with the earth can result in build up of static electricity. Cotton clothing and leather-soled shoes will help avoid static electricity.

EMF exposure reduction – second steps

As a second step, EMF measurements and mitigation measures should be carried out. Typical examples are:

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- Measure the ELF electric field in the bed. Based on the measurement results, install automatic demand switches in those circuits that increase the exposure.
- Measure the ELF electric field at all other places that are used for extended periods at home and at work. If necessary, choose lamps used close to the body with a shielded electric cable and a grounded lamp fixture (metal). Especially in lightweight construction (wood, gypsum board), electrical wiring without grounding (two-slot outlets) might have to be replaced with grounded electrical wiring or shielded electrical wiring. In special cases, shielded wiring and shielded outlets may have to be installed in the whole building.
- Measure the ELF magnetic field close to the bed, e.g. for 24 h. If net currents are detected, the electrical wiring and grounding system of the building must be corrected to reduce the magnetic fields.
- Install a residual current device (RCD) or ground-fault circuit interrupter (GFCI) to prevent electric shocks (safety measure).
- Measure radio-frequency radiation and mitigate high exposure levels by installing certain RF shielding materials for the affected walls, windows, doors, ceilings, and floors. For example, in a multiunit setting (condominiums or highrise apartments, townhomes), proximity to neighbors can contribute to inhome exposure.
- Measure dirty electricity/dirty power (electric and magnetic fields in the VLF frequency range) and identify the sources in order to remove them. If this is not possible, appropriate power filters in line with the source may be used.

Diagnosis

We will have to distinguish between EHS and other EMF-related health problems like certain cancers, Alzheimer's, ALS, male infertility, etc. that might have been induced, promoted, or aggravated by EMF exposure. An investigation of EHS and other EMF-related health problems will largely be based on a comprehensive case history, focusing, in particular, on correlations between health problems and times, places, and circumstances of EMF exposure, as well as the progression of symptoms over time and the individual susceptibility. In addition, measurements of EMF exposure and the results of additional diagnostic tests (laboratory tests, cardiovascular system) serve to support the diagnosis. Moreover, all other potential causes should be excluded as far as possible.

In 2000 the Nordic Council of Ministers (Finland, Sweden, and Norway) adopted the following unspecific ICD-10 code for EHS: Chapter XVIII, Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, code R68.8 "Other specified general symptoms and signs" (Nordic ICD-10 Adaptation, 2000) (272).

Regarding the current International Classification of Diseases (ICD), ICD-10-WHO 2015, we recommend at the moment:

(a) Electromagnetic hypersensitivity (EHS): to use the existing diagnostic codes for the different symptoms **plus** code R68.8 "Other specified general symptoms and signs" **plus** code Z58.4 "Exposure to radiation" and/or Z57.1 "Occupational exposure to radiation."
(b) EMF-related health problems (except EHS): to use the existing diagnostic codes for the different diseases/symptoms **plus code** Z58.4 "Exposure to radiation" and/or Z57.1 "Occupational exposure to radiation."

Regarding the next ICD update to be published in 2018 (ICD-11 WHO), we recommend:

(a) To create ICD codes for all environmentally induced chronic multisystem illnesses (CMI) like multiple chemical sensitivity (MCS), chronic fatigue syndrome (CFS), fibromyalgia (FM), and electromagnetic hypersensitivity (EHS) on the basis of their clinical and pathological description (187, 192).
(b) To expand chapter XIX, Injury, Poisoning and Certain Other Consequences of External Causes (T66-T78), to include/distinguish effects of EMF (static magnetic field, static electric field, ELF magnetic field, ELF electric field, VLF magnetic field, VLF electric field, radio-frequency radiation), infrared radiation, visible light, UV radiation and ionizing radiation.
(c) To expand chapter XXI, Factors Influencing Health Status and Contact with Health Services (Z00-Z99), to include/distinguish factors as EMF (static magnetic field, static electric field, ELF magnetic field, ELF electric field, VLF magnetic field, VLF electric field, radio-frequency radiation), infrared radiation, visible light, UV radiation, and ionizing radiation.

Treatment of the patient including the environment

The primary method of treatment should mainly focus on the prevention or reduction of EMF exposure that is reducing or eliminating all sources of EMF at home and in the workplace. The reduction of EMF exposure should also be extended to schools, hospitals, public transport, public places like libraries, etc. in order to enable EHS persons an unhindered use (accessibility measure). Many examples have shown that such measures can prove effective.

With respect to total body load of other environmental influences, they must also be regarded.

Beside EMF reduction, other measures can and must be considered. These include a balanced homeostasis in order to increase the "resistance" to EMF. There is increasing evidence that a main effect of EMF on humans is the reduction of their oxidative and nitrosative regulation capacity. This hypothesis also explains observations of changing EMF sensitivity and the large number of symptoms reported in the context of EMF exposure. Based on currently available knowledge it appears useful to recommend a treatment approach, as those gaining ground for multisystem illnesses, that aims at minimizing adverse peroxynitrite effects. Measures that enhance the immune system and reduce stress in combination with detoxification will promote EHS recovery.

It should be stressed, that psychotherapy has the same significance as in other diseases. Products that are offered in the form of plaques and the like to "neutralize" or "harmonize" electrosmog should be evaluated with great restraint. Psychological stress generated by a lack of understanding or support by family, friends and physicians can exacerbate the symptoms of EHS as can stressing about exposure. For rapid recovery, the treatments need to apply to the body, mind and spirit of the individual.

In summary, the following treatment and accessibility measures appear advantageous, depending on the individual case:

Reduction of EMF exposure

This should include all types of EMF exposures relevant to the person, especially during sleep and at work – see Chapter "Reduction of EMF Exposure". For more information, see e.g. "Options to Minimize EMF/RF/Static Field Exposures in Office Environment" (268) and "Elektrosmog im Alltag" (269).

Environmental medicine treatments

Until now, no specific treatment of EHS has been established. The following paragraphs are recommendations based on the combined experience of the team. They can be considered either as an attempt to restore the full regulative capacity of the patients, as general advice for healthy living (that could and should be adapted to the cultural and individual situation of the patient), or as a more targeted approach to address the specific problems of EHS individuals according to the experience of the team.

Controlled clinical trials would be necessary to assess optimal treatment and accessibility measures. Actual data indicate that the functional deficits, which can be found in patients with EHS, correspond to those we can find in CMI such as MCS, CFS, and FM. The target of the therapy is the regulation of the physiological dysfunction detected by diagnostic steps (see chapter 2 "Examination and Findings"). The main therapeutic target includes both general and adjuvant procedures and specific treatments. The latter are challenging and need special knowledge and experience in clinical environmental medicine treatments. Main therapeutic targets include:

- **Control of total body burden**
  Besides the reduction of EMF exposure, the reduction of the total body burden by various environmental pollutants (home, workplace, school, hobby), food additives, and dental materials is indicated.
- **Reduction of oxidative and/or nitrosative stress**
  Reactive oxygen species (ROS) and reactive nitrogen species (RNS) are free radicals naturally produced in cells. Scavengers guarantee the balance between the production of free radicals and the rate of their removal. Many biologically important compounds with antioxidant (AO) function have been identified as endogenous and exogenous scavengers. Among the endogenous AO, we distinguish between enzymatic AO (catalase, glutathione peroxidase, glutathione reductase, superoxide dismutase) and non-enzymatic AO [bilirubin, ferritin, melatonin, glutathione, metallothionin, N-acetyl cysteine (NAC), NADH, NADPH, thioredoxin, 1,4,-bezoquinine, ubiquinone, uric acid]. They interact with exogenous dietary and/or synthetic AO (carotenoids, retinoids, flavonoids, polyphenols, glutathione, ascorbic acid, tocopherols). The complex regulation and use of these substances is the therapeutic challenge (232, 273).
- **Regulation of intestinal dysfunction**
  Endogenous and exogenous scavengers act synergistically to maintain the redox homeostasis. Therefore, dietary or natural antioxidants play an important role to stabilize this interaction.
  Treatment of a leaky gut, food intolerance, and food allergy is a prerequisite for maintaining redox homeostasis (274) and also requires special knowledge and experience.
- **Optimizing nutrition**
  Bioactive food is the main source of antioxidant components such as vitamin C, vitamin E, NAC, carotenoids, CoQ10, alpha-lipoic acid, lycopene, selenium, and flavonoids (275, 276). For instance, the regeneration of vitamin E by glutathione or vitamin C is needed to prevent lipid peroxidation. The dietary antioxidants only can have beneficial effects on the redox system if they are present in sufficient concentration

levels (273). Alpha-lipoic acid acts directly and indirectly as a scavenger of free radicals including, singlet oxygen, superoxide, peroxyl radicals, and the breakdown radicals of peroxynitrite (232). It has been shown that the number of free electrons in micronutrients determines how effective they are. In organic food, the number of free electrons is higher than in conventionally produced food (277). Especially in the case of food intolerances, the tailored substitution of micronutrients in the form of supplements is necessary.

- **Control of (silent) inflammation**
  Elevated nitric oxide levels and the reaction with superoxide always leads to elevated peroxynitrate levels, which induce ROS levels as no other substance does ($NO/ONOO^-$ cycle). As a result, the nuclear factor κB (NF-κB) is activated, inducing inflammatory cytokines such as tumor necrosis factor α (TNF-α), interleukin-1β (IL-1β), interleukin-6 (IL-6), interleukin-8 (IL-8), and interferon gamma (IFN-γ) and activating various NO synthases (232). Tocopherols (278, 279), carotenoids at low concentration levels (280), vitamin C (281, 282), NAC (283), curcumin (284), resveratrol (285, 286), flavonoids (287) have shown to interrupt this inflammatory cascade at various points.
- **Normalization of mitochondrial function**
  Mitochondrial function may be disturbed in two ways. First: the high amount of free radicals may block production of adenosine triphosphate (ATP), leading to muscle pain and fatigue. Second: in the case of silent (smoldering) inflammation, the demand for more energy is elevated by 25% (236), causing a high consumption of ATP. In this case, NADH, L-carnitine, and CoQ10 are essential for ATP synthesis.
  Due to the lack of ATP, the stress regulation of catecholamines especially norepinephrine (NE) is reduced because catabolism of NE by S-adenosylmethionine is ATP dependent (288–290). Furthermore, stress regulation has a high demand for folate, vitamin B6, and methylcobalamine. Genetic polymorphisms of COMT and MTHFR influence the individual need for those substances (244, 291).
- **Detoxification**
  In humans, the accumulation of environmental toxins has an individual profile of many different inorganic and organic chemicals, which make up the total body load (292).
  Among the inorganic substances, metals and their salts play the dominant role and might be of importance to patients with EHS. Elemental mercury (Hg^0) and other heavy metals such as lead (Pb) accumulate in the brain (293), especially at chronic low dose exposure. They may have toxic effects and can induce various immune reactions (294, 295). Whereas no specific active substance generally exists for the detoxification of chemicals, there are two groups of substances with more specific effects that can be used for the detoxification of metals.
  1. Substances with nonspecific physiological effects: glutathione, NAC, alpha-lipoic acid, vitamin C, and selenium.
  2. Chelating agents for detoxification of metals (296–298): the most important chelating agents are sodium thiosulfate 10%, DMPS (2,3-dimercapto-1-propanesulfonic acid), DMSA (meso-dimercaptosuccinic acid), and EDTA (2,22,23,232-ethane-1,2-diyldinitrotetraacetic acid).

  It should be noted that these substances should be used only by those designated as experts in this particular field.
- **Adjuvant therapies**

1. Drinking water
For detoxification reasons, a higher intake of high-quality drinking water with low mineral content and no CO_2 is needed. The intake quantity should range from 2.5 to 3.0 L (10–12 8-oz glasses) daily.

2. Light
Most of the people in central and northern Europe are depleted of vitamin D. Sufficient natural daylight exposure during the vitamin D-producing months (spring to fall) is one important factor. At the same time, prevention of actinic damage to the skin is necessary. In addition to natural sunlight, light therapy and low level lasers can promote healing, reduce inflammation, promote circulation, and enhance cellular ATP production.

3. Sauna
Sauna and therapeutic hyperthermia is an adjuvant therapy for the detoxification of almost all xenobiotics. These therapies have to be carefully used. An interaction with detoxifying drugs takes place. Sauna helps to regenerate tetrahydrobiopterin from dihydrobiopterin, which is essential for the metabolism of catecholamines and serotonin (299). However, not all saunas are alike. Traditional saunas or infrared saunas with low electric and low magnetic fields that do not use toxic glues and chemically treated wood are recommended.

4. Oxygen

A part of patients with EHS suffer from mitochondrial dysfunction. Sufficient natural oxygen is helpful. As both hypoxia and hyperbaric oxygen can produce oxidative stress, hyperbaric oxygen therapy should only be performed if the patients are treated with sufficient antioxidants at the same time.

5. Exercise

The optimal amount of exercise is still being debated. A person's physical capacity should be assessed by ergometry in order to prescribe an individual exercise regime. Environmental medicine experience indicates that for sick people only low-impact aerobic exercise should be used. In general, start with a workload of 20–30 watts that often can be finished at 60–70 watts. Exercise on an ergometer allows better control of the consumption of energy compared to walking or running. No fatigue should result from exercising, at least after half an hour.

6. Sleep

Sleep problems are very common in patients with EHS. Sleep disturbance is associated with a reduced melatonin level. In the case of chronic inflammation, the activation of IDO (indolamine-2,3-dioxygenase) reduces the production of serotonin and, in turn, it also reduces melatonin levels. EMF exposure might block the parasympathetic activity while sympathetic activity persists. Concerning sleep disturbances, any therapy has to follow the pathogenic causes. Optimal sleep is necessary to save energy and to regulate the functions of the immune and neuroendocrine systems.

7. Protection from blue light

Wavelengths of visible light below 500 nm are called "blue light". Low doses of blue light can increase feelings of well-being, but larger amounts can be harmful to the eyes. In natural daylight, the harmful effects of "blue light" are balanced out by the regenerative effect of the red and infrared content. The escalating use of electronic light sources – such as fluorescent tubes and compact fluorescent lamps (CFL), computer screens, laptops, tablets, smartphones, and certain LED bulbs – has increased our exposure to "blue light", which at this level is suspected of playing a role in the development of age-related macular degeneration and circadian misalignment via melatonin suppression, which is associated with an increased risk of sleep disturbance, obesity, diabetes mellitus, depression, ischemic heart disease, stroke, and cancer. Extended exposure to artificial "blue light" in the evening should therefore be limited. Antioxidants, especially melatonin (300, 301), and blue light screen filters (302–304) could be helpful.

8. Exposure to the natural electromagnetic fields of the Earth.

Most people in urban centers are disconnected from the Earth's natural grounding/magnetic fields by walking with rubber-soled shoes, wearing synthetic clothing, driving in metal boxes with rubber wheels, and living and working in concrete buildings that are permeated with artificial electromagnetic fields and radiation. Spending time in the woods, walking barefoot along a beach, lying on the grass, sitting on rocks, or strolling outside after a rain shower help ground a person and help balance the often enhanced positively charged ions that are associated with ill health.

Dental medicine

Dental medicine still works with toxic or immunoreactive materials, e.g. mercury, lead oxide, gold, and titanium. Environmental dental medicine demands that these materials not be used (305–308). The removal of toxic dental materials must take place under maximum safety conditions (avoid inhalation!). The elimination of particularly heavy metals from the body might be indicated. In general terms, endoprosthetic materials should be inert with respect to immunoreactivity. Based on our current knowledge, zirconium dioxide seems to be a neutral material. However, mechanical abrasion of the coated surface by the dentist should be avoided.

Immunotoxic metals show a similar pathophysiology with respect to oxidative stress, mitochondriopathy, and inflammation.

Lifestyle coaching

Lifestyle coaching may include balanced exercise, nutrition, reduction of addictive substances, change of sleep habits, etc. and stress reduction measures (reduction of general stress and work stress), as well as methods to increase stress resistance via, e.g. autogenic training, yoga, progressive muscle relaxation, breathing techniques, meditation, tai chi, and qigong.

Treatment of symptoms

A well-balanced treatment of symptoms is justified until the causes have been identified and eliminated. However,

it is of paramount importance to realize that the reduction of symptoms may put the person at risk for an increased environmental EMF load, thus generating possible future, long-term health effects, including neurological damage and cancer. The treating physician faces a very difficult ethical task when doing so, and the associated risks must be pointed out – in an equally well-balanced way – to the patient in question. From an ethical perspective, treating the symptoms is, of course, a very good start to provide immediate relief, but – without a concurrent environmental exposure reduction and lifestyle coaching – it may prove counter-productive in the long run. For a conventionally trained physician, this might seem a very new way of reasoning, but it is the only way to successfully and effectively alleviate symptoms and to achieve complete clinical recovery when dealing with chronic multisystem illnesses (CMI) and EHS. Though even if the causes are not known at the outset, it is already important at this stage to provide advice on how to reduce a person's exposure to electromagnetic fields and other environmental stressors to prevent further damage and promote healing.

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#10-

Princeton Citizens Coalition on EMF

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EMF Studies & Malignancy © 1995

childhood residential & occupational studies

This list of epidemiological studies comes from Medline, the medical data base of the National Library of Medicine, in Bethesda, Maryland. It includes all the residential and occupational studies that have been published in the peer-reviewed medical literature.

An asterisk marks the results that medical scientists consider to be significant.

Odds ratio refers to the ratio of cancer that has been found in the population of children or workers exposed to electromagnetic fields (EMFs) compared to the ratio of cancer one would expect to find in a population of children or workers not exposed to EMFs, or a population exposed to a lower level of EMF.

For example, at the bottom of page 2, in the study conducted by Feychting, the relative risk of leukemia for children living in homes with EMF levels of greater than 3 milligauss means that children living in such homes are 3.8 times more likely to develop leukemia than children living in homes with EMF levels of less than 3 milligauss.

REFERENCES ON ELECTROMAGNETIC FIELDS AND MALIGNANCY

* = statistically significant result
OR = odds ratio
( ) = confidence intervals
NSS = not statistically significant at .05 level

CHILDHOOD RESIDENTIAL LITERATURE

Wertheimer, N., and Leeper, E. (1979), Electrical wiring configuration and childhood cancer. American Journal of Epidemiology 109:273-284.
Case-control.
Wire code (birth addresses).
* Leukemia OR 2.28 (1.97-2.65).
* Nervous system OR 2.48 (1.16-2.36).
* Lymphoma OR 2.36 (1.66-3.35).

Fulton, J. P., et al. (1980), Electrical wiring configurations and childhood leukemia in Rhode Island. American Journal of Epidemiology 111:292-296.
Case-control.
Wire code.
* Leukemia OR 1.08 (1.00-1.16).

Tomenius, L. (1986) 50-Hz electromagnetic environment and the incidence of childhood tumors in Stockholm County. Bioelectromagnetics 7:191-207.
Case-control.
Field measurement.
* All cancers OR 2.12 (1.73-2.59).
* Nervous system OR 3.86 (1.63-8.39).
* Leukemia OR 0.34 (0.17-0.68).

Savitz, D. A., et al. (1988), Case-control study of childhood cancer and exposure to 60-Hz magnetic fields. American Journal of Epidemiology 128:21-38.
Case-control.
Wire code.
* All cancers OR 1.53 (1.04-2.26).
* Nervous system OR 2.04 (1.11-3.76).
Leukemia OR 1.54 (0.90-2.63).

Petridou, E., et al. (1993), Suggestion of concomitant changes of electric power consumption and childhood leukemia in Greece. Scandinavian Journal of Soc. Med. 21(4):281-285.
679 deaths from childhood leukemia in Greece 1976-1989.
Slopes of declining mortality correlated with slopes of increasing electric power use.
Positive association (NSS, p = 0.26).

CHILDHOOD RESIDENTIAL LITERATURE (continued)

Verkasalo, P. K., et al. (1993), Risk of cancer in Finnish children living close to power lines. British Medical Journal 307(6909):895-899.

Studied 68,300 boys and 66,500 girls in Finland 0-19 years of age living within 500 meters of overhead power lines of 110-400 kV in magnetic fields calculated to be greater than or equal to 0.01 microtesla.

Nervous system tumors:

* Statistically significant increase in boys at greater than or equal to 2 milligauss, or with cumulative exposure of more than 4 milligauss-years.

All cancers:

No association.

Leukemias:

No association.

Lymphomas:

No association.

Olsen, J. H., et al. (1993), Residence near high voltage facilities and risk of cancer in children. British Medical Journal 307(6909):891-895.

Case-control, Denmark.

1707 leukemia, lymphoma, and brain cancer cases.

All cancers:

* OR 5.6 (Statistically significant association with exposure to magnetic fields from high voltage installations of greater than or equal to 4 milligauss).
  OR 1.5 (NSS at greater than or equal to 2.5 milligauss.

Hodgkin's disease:

Possible association between cases of HD at greater than or equal to 1 milligauss.

Feychting, M., et al. (1993), Magnetic fields and cancer in children residing near Swedish high-voltage power lines. American Journal of Epidemiology 138(7):467-481.

Case-control, 33 CNS tumors and 39 leukemias.

Calculated EMF from power records and spot measurements.

Leukemia:

* Leukemia RR 2.7 (1.0-6.3) for greater than 2 milligauss.
* Leukemia RR 3.8 (1.4-9.3) for greater than 3 milligauss.
* P for trend = 0.005.

Lymphoma:

No association.

CNS tumors:

No association.

All childhood tumors:

No association.

CHILDHOOD RESIDENTIAL LITERATURE (continued)

Fajardo-Gutierrez, A., et al., Residence close to high-tension electric power lines and its association with leukemia in children. Bol. Med. Hosp. Infant Mex. 50(1):32-38.

Case-control, Mexico City.
81 leukemia cases v. 77 controls.
Residential visits and questionnaires.

* Leukemia OR 2.63 (1.26-5.36) for living near the distribution wires of high voltage.
Leukemia OR 2.5 (0.97-6.67) for living near the transmission wires of high voltage.

Savitz, D. A., et al. (1993), Childhood cancer in relation to a modified residential wire code. Environmental Health Perspectives 101(1):76-80.

Children living in high wire code homes:

* All malignancies OR 1.9 (1.1-3.2).
* Leukemias OR 2.9 (1.5-5.5).
* Brain cancer OR 2.5 (1.1-5.5).

OCCUPATIONAL STUDIES
SMR = standardized mortality rate
PMR = proportional mortality rate
SIR = standardized incidence rate

Wiklund, K., et al. (1981), An application of the Swedish Cancer-Environment Registry. Leukemia among telephone operators at the Telecommunications Administration in Sweden. International Journal of Epidemiology 10:373-376.
Telephone operators.
All leukemia SMR 1.03 (0.53-1.65).

Milham, S. (1982), Mortality from leukemia in workers exposed to electrical and magnetic fields (Letter to the Editor). New England Journal of Medicine 307:249.
Electrical workers.
* All leukemia PMR 1.37 (1.12-1.67).
* Acute leukemia PMR 1.63 (1.14-2.25).

Wright, W. E., et al. (1982) Leukemia in workers exposed to electrical and magnetic fields (Letter to the Editor). Lancet ii:1160-1161.
Electrical workers.
All leukemia PIR 1.29 (0.85-1.88).
Acute leukemia PIR 1.73 (0.93-2.93).
* Acute myeloid leukemia PIR 2.07 (1.02-3.75).

Preston-Martin, S., et al. (1982), Descriptive epidemiology of central nervous system neoplasms in Los Angeles County. Annals of the New York Academy of Sciences 381:202-208.
Electricians.
CNS cancer PIR 1.42 (0.71-2.54).

McDowell, M. E. (1983), Leukemia mortality in electrical workers in England and Wales (Letter to the Editor). Lancet i:246.
Electrical workers.
All leukemia PMR 0.98 (0.78-1.21).
Lympoid leukemia PMR 1.00 (0.66-1.45).
Myeloid leukemia PMR 1.07 (0.81-1.44).
* Acute myeloid OR 2.1 (1.3-3.6).

Coleman, M., et al. (1983), Leukemia incidence in electrica workers (Letter to the Editor). Lancet i:982-983.
Electrical workers.
All leukemia PRR 1.17 (0.96-1.41).
Acute lymphoid leukemia PRR 1.46 (0.75-1.79).
Chronic lymphoid leukemia PRR 1.29 (0.89-1.81).
Chronic myeloid leukemia PRR 0.91 (0.52-1.48).

OCCUPATIONAL STUDIES (continued)

Cammarano, G., et al. (1984), Cancer mortality among workers in a thermoelectric power plant. Swedish Journal of Work and Environmental Health 10:259-261.
Thermoelectric power workers.
Brain cancer SMR 4.76 (0.06-26.5).

Pearce, N. E., et al. (1985) Leukemia in electrical workers in New Zealand. Lancet i:811-812.
Electrical workers.
All leukemia OR 1.70 (0.97-2.97).
Acute myeloid leukemia OR 1.19 (0.42-3.38).

Milham, S. (1985), Silent keys: Leukemia mortality in amateur radio operators (Letter to the Editor). Lancet i:812.
Amateur radio operators.
* All leukemia PMR 1.91 (1.22-2.84).
* Acute myeloid leukemia PMR 2.89 (1.61-4.55).
Chronic myeloid leukemia PMR 2.67 (0.72-6.82).

Calle, E., and Savitz, D. (1985), Leukemia in occupational groups with presumed exposure to electrical and magnetic fields (Letter to the Editor). New England Journal of Medicine 313:1476-1477.
Electrical engineers.
All leukemia PMR 1.98 (0.99-3.18).
* Acute leukemia PMR 2.57 (1.11-5.06).

Milham, S. (1985), Mortality in workers exposed to electromagnetic fields. Environmental Health Perspectives 62:297-300.
Electrical workers.
* All leukemia PMR 1.36 (1.14-1.59).
* Acute leukemia PMR 1.62 (1.26-2.08).
* Brain cancer PMR 1.23 (1.00-1.50).
Electricians.
* Brain cancer PMR 1.55 (1.13-2.05).

Olin, R., et al. (1985), Mortality experience of electrical engineers. British Journal of Industrial Medicine 42:211-212.
Electrical engineers.
All leukemia SMR 0.9 (0.1-3.2).
Brain cancer SMR 1.0 (0.1-3.7).

Lin, R. S., et al. (1985), Occupational exposure to electromagnetic fields and the occurrence of brain tumors. Journal of Occupational Medicine 27:413-419.
Electrical workers.
Glioma (no exposure) OR 1.00
* Glioma (possible exposure) OR 1.44 (1.06-1.95).
Glioma (probable exposure) OR 1.95 (0.94-3.91).
* Glioma (definite exposure) OR 2.15 (1.10-4.00).
* Test for trend, $p < 0.05$.

OCCUPATIONAL STUDIES (continued)

Vagero, D., et al. (1985), Cancer morbidity among workers in the telecommunications industry. British Journal of Industrial Medicine 42:191-195.
Telecommunications workers.
Nervous system cancer SMR 1.03 (0.3-2.3).

Flodin, U., et al. (1986) Background radiation, electrical work, and some other exposures associated with acute myeloid leukemia in a case-referent study. Archives of Environmental Health 41:77-84.
Electrical workers.
* Acute myeloid leukemia OR 3.8 (1.5-9.5).

Stern, F. B., et al. (1986), A case-control study of leukemia at a naval nuclear shipyard. American Journal of Epidemiology 123:980-992.
Electricians.
* All leukemia OR 3.00 (1.29-6.98).
Myeloid leukemia OR 2.33 (0.77-7.06).
* Lympoid leukemia OR 6.00 (1.47-24.45).
Welders.
All leukemia OR 2.25 (0.92-5.53).
* Myeloid leukemia OR 3.83 (1.28-11.46).

Tornqvist, S., et al. (1986) Cancer in the electric power industry. British Journal of Industrial Medicine 43:212-213.
Linesmen.
All leukemia SMR 1.3 (0.7-2.1).
Nervous system cancer SMR 1.5 (0.9-2.4).

Thomas, T. L., et al. (1987), Brain tumor mortality risk among men with electrical and electronics jobs: a case-control study. Journal of the National Cancer Institute 79:233-238.
Electronics workers.
* Glioma OR 4.6 (1.9-12.2).
Electrical tradesmen OR 1.8 (0.8-3.9).

Milham, S. (1988), Increased mortality in amateur radio operators due to lymphatic and hematopoietic malignancies. American Journal of Epidemiology 127:5054.
Amateur radio operators.
All leukemia SMR 1.24 (0.87-1.72).
* Acute myeloid leukemia 1.76 (1.03-2.85).
Brain cancer SMR 1.39 (0.93-2.00).

Speers, M. A., et al. (1988) Occupational exposures and brain cancer mortality: a preliminary study of East Texas residents. American Journal of Industrial Medicine 13:629-638.
Electrical workers.
* Glioma OR 3.94 (1.52-10.20).

OCCUPATIONAL STUDIES (continued)

Pearce, N., et al. (1989), Case-control studies of cancer in New Zealand electrical workers. International Journal of Epidemiology 18:55-59.

Electrical workers.
* All leukemia OR 1.62 (1.04-2.52).
* Chronic leukemia OR 2.12 (1.19-3.76).
Acute leukemia OR 1.25 (0.62-2.54).
Lymphoid leukemia OR 1.73 (0.89-3.37).
Myeloid leukemia OR 1.22 (0.60-2.48).
Acute myeloid leukemia OR 1.16 (0.48-2.84).
Brain cancer OR 1.01 (0.56-1.82).

Electricians.
Brain cancer OR 1.91 (0.84-4.33).

Electrical engineers.
* Brain cancer OR 4.74 (1.65-13.63).

Loomis, D. P., and Savitz, D. (1989), Brain cancer and leukemia mortality among electrical workers (abstract). In: Abstracts of the Society for Epidemiologic Research. 22nd Annual Meeting, 1989. Birmingham, AL. Society for Epidemiologic Research, Baltimore, MD.

Electrical workers
All leukemia OR 0.9 (0.6-1.3).
Acute myeloid leukemia OR 0.9 (0.5-1.8).
* Brain cancer OR 1.5 (1.0-2.1).

Preston-Martin, S., et al. (1989), Risk factors for gliomas and meningiomas in males in Los Angeles County. Cancer Research 49:6137-6143.

Case-control, 272 brain cancer cases v. controls.
Glioma related to duration of prior employment in jogs likely to involve high exposure to electric and magnetic fields (p for trend = 0.05)*.
* Astrocytoma 4.3 (1.2-15.6) for employment > 5 years.

Preston-Martin, S., et al. (1990) Astrocytoma risk related to job exposure to electric and magnetic fields (abstract). In: Abstracts of the Society for Epidemiologic Research, 23rd Annual Meeting, 1990, Snowbird, UT. Society for Epidemiologic Research, Baltimore, MD.

Electrical workers.
* Astrocytoma OR 10.3 (1.3-80.8).
Glioma OR 1.7 (0.7-4.4).

OCCUPATIONAL STUDIES (continued)

Loomis, D. P., et al. (1990), Mortality from brain cancer and leukemia among electrical workers. British Journal of Industrial Medicine 47:633-638.

Case-control.
Brain cancer:
* OR 1.4 (1.1-1.7) for men employed in any electrical occupation.
* OR 2.7 (2.1-3.4) for electrical engineers and technicians.
* OR 1.6 (1.1-2.4) for telephone workers.
* OR 1.7 (1.1-2.7) for electric power workers.
* OR 2.1 (1.3-3.4) for electrical workers in manufacturing industries.

Leukemia OR 1.0 (0.8-1.2).
ORs 1.1-1.5 for same above groups.

Park, R. M., et al. (1990), Brain cancer mortality at a manufacturer of aerospace electromechanical systems. American Journal of Industrial Medicine 17:537-552.

Cohort study.
Missile aircraft guidance systems, gyroscopes.
Brain cancer * PMR 4.2 (P= .00001).
PMR 1.8 (p = .45) for hourly workers < 20 years.
* PMR 8.7 (p = .000003) for hourly workers > 20 years.

Mack, W., et al. (1991), Astrocytoma risk related to job exposure to electric and magnetic fields. Bioelectromagnetics 12:57-66.

Case-control.
272 gliomas and meningiomas v. 272 neighborhood controls.
Gliomas OR 1.7 (0.7-4.4).
Astrocytomas
* OR 10.3 (1.3-80.8).
* Upward trend, p = .01, for tumor incidence with increasing length of employment.
Most were electricians or electrical engineers.
Meningiomas OR 0.3 (0.03-3.2).

Demers, P. A., et al. (1991), Occupationa, socioeconomic status, and brain tumor mortality: A death certificate-based case-control study. Journal of Occupational Medicine 33(9):1001-1006.

Case-control.
904 white male brain tumor deaths.
Plant and system operators:
* OR 4.5 (1.1-18.9) for all brain tumors.
* OR 4.5 (1.1-19.0) for gliomas.
* OR 4.7 (1.1-20.4) for astrocytic tumors.

OCCUPATIONAL STUDIES (continued)

Tornqvist, S., et al. (1991), Incidence of leukemia and brain tumors in some "electrical occupations". British Journal of Industrial Medicine 48:597-603.

Cohort study.
All leukemia:
* SMR 1.3 (1.0-1.7) among electrical/electronic engineers and technicians.
  * SMR 2.1 (1.1-3.6) among telegraph/telephone indust.
  * SMR 2.6 (1.0-5.8) among machine industries.

CLL:
* SMR 1.7 (1.1-2.5) among electrical/electronic engineers and technicians.
  * SMR 4.8 (1.0-14.0) among machine industries.
  * SMR 2.0 (1.0-3.5) for all linesmen.
    * SMR 2.8 (1.1-5.7) for power linesmen.

All brain tumors:
* SMR 2.9 (1.2-5.9) among radio/TV assemblers/repairmen.
* SMR 1.3 (1.0-1.7) for all welders.
  * SMR 3.2 (1.0-7.4) for iron/steel welders.

Gliomblastomas:
* SMR 3.4 (1.1-8.0) for same.
* SMR 1.5 (1.1-2.1) for all welders.

Richardson, S., et al. (1992), Occupational risk factors for acute leukemia: a case-control study. International Journal of Epidemiology 21(6):1063-1073.

Case-control.
185 cases of acute leukemia v. 513 controls.
Acute leukemia OR 1.7 (0.9-3.5) for all EMF exposures.
* Acute leukemia OR 3.9 (1.2-12.5) for EMF exposures excluding arc welding.

Tynes, T., et al. (1992), Incidence of cancer in Norwegian workers potentially exposed to electromagnetic fields. American Journal of Epidemiology 136(1):81-88.

Cohort of 37,945 male Norwegian electrical workers.
Job information from 1960 census data.
Leukemia SIR 1.41 in electrical workers with 10 or more active years.
Brain tumors SIR 1.14 in same group.
Gives support for association between electrical work and risk of leukemia.

Ryan, P., et al. (1992), Risk factors for tumors of the brain and meninges: results from the Adelaide adult brain tumor study. International Journal of Cancer 51:20-27.

110 new glioma cases, 60 new meningioma cases, v. 417 controls.
Glioma:
* RR 4.1 (1.3-13.2) among women working with CRTs.

OCCUPATIONAL EMF LITERATURE

Guenel, P., et al. (1993), Incidence of cancer in persons with occupational exposure to electromagnetic fields in Denmark. British Journal of Industrial Medicine 50(8):758-764.

Cohort of 2.8 million Danes 20-64 years old in 1970.

* Leukemia OR 1.64 (1.20-2.24) for men with continuous exposure to EMF above 3 milligauss, mainly electricians.

Brain cancer no excess risk.

Breast cancer risk suggested increase in men but not women.

Ciccone, G., et al. (1993), Myeloid leukemias and myelodysplastic syndromes: chemical exposure, histologic subtype and cytogenetics in a case-control study. Cancer Genetics and Cytogenetics 68(2):135-139.

Case-control.

50 AML, 17 CML, 19 myelodysplastic syndromes v. 246 controls.

IH assessment of exposure.

Increased risks for welders, electricians.

OR 1.6 (0.6-4.1) increased risk in men for EMF.

OR 0.8 (0.2-2.5) in women for EMF.

OR 2.1 (0.2-19.3) for AML cases and ELF EMF.

MDS cases included a high proportion exposed to EMF.

Matanoski, G. M., et al. (1993), Leukemia in telephone linesmen. American Journal of Epidemiology 137(6):609-619.

Case-control, AT&T workers.

Leukemia OR 2.5 (0.7-8.6) for workers with lifetime exposure scores above the median for the population, compared to those below the median.

Leukemia higher risk associated with jobs with long duration of employments with intermittent peak exposures.

* P for trend = 0.05 for increasing leukemia risk with increasing exposure for cumulative scores based on peak exposure scores.

Peak exposures in cable splicing work and in old telephone switching offices.

Sahl, J. D., et al. (1993), Cohort and nested case-control studies of hematopoietic cancers and brain cancer among electric utility workers. Epidemiology 4(2):104-114.

Cohort of 36,221 electric utility workers with nested case-control studies.

Collected 776 days of magnetic field measurements.

Company job history information.

Electrical workers OR 0.7-1.4, most near 1.0.

Lymphomas OR 0.9-1.4.

Leukemias and brain cancers OR 0.7-1.2.

Limited by imprecision.

OCCUPATIONAL STUDIES (continued)

Floderus, B., et al. (1993), Occupational exposure to electromagnetic fields in relation to leukemia and brain tumors: a case-control study in Sweden. Cancer Causes and Control 4:465-476.

Case-control.
250 leukemia cases, 261 brain cancer cases.
EMF measurements from 1,015 workplaces.
Chronic lymphocytic leukemia:
OR 1.1 (0.5-2.3) for second quartile (compared to 1st).
* OR 2.2 (1.1-4.3) for third quartile (compared to 1st).
* OR 3.0 (1.6-5.8) for fourth quartile (compared to 1st).
Strongest association in those with tasks with frequent or large variations between high and low field-densities.
Acute myeloid leukemia:
OR 1.0 (0.5-1.8)
OR 0.8 (0.4-1.6)
OR 1.0 (0.6-1.9)
Brain tumors:
OR 1.0 (0.7-1.6)
* OR 1.5 (1.0-2.2)
OR 1.4 (0.9-2.1)
Esp. for prolonged high level exposure > 2 milligauss.

London, S. J., et al. (1994), Exposure to magnetic fields among electrical workers in relation to leukemia risk in Los Angeles County. AJIM 26(1):47-60.

Case-control.
* Leukemia OR 1.2 (1.0-1.5) for trend in risk across average occupational magnetic field exposure, per 10 milligaus increase in average magnetic field.
* CML OR 1.6 (1.2-2.0).

Floderus, B., et al. (1994), Incidence of selected cancers in Swedish railway workers, 1961-1979. Cancer Causes and Control 5:189-194.

Railway workers.
Engine drivers and conductors:
RR 1.9 (0.9-4.0) for chronic lymphocytic leukemia.
RR 1.4 (0.4-4.3) for acute myeloid leukemia.
- RR 1.0 (0.5-1.9) for lymphoma.
RR 1.2 (0.8-1.9) for all brain tumors.
* RR 12.2 (2.8-52.5) under age 30.
* RR 4.9 (1.6-11.8) for breast cancer, 3 cases.
* RR 3.2 (1.6-6.2) for pituitary tumors, 9 cases.

Savitz, D. A. and Loomis, D. P. (1995) Magnetic field exposure in relation to leukemia and brain cancer mortality among electric utility workers. *American Journal of Epidemiology* 141 (2): 12-134.

Cohort mortality study:

138,905 men employed at 5 power companies in U.S. 1950-1986.
2,842 workshift magnetic field measurements.
2,656,436 person years of work experience.

* 1) leukemia RR 2.50 (CI 1.08-5.76) in electricians with more than 20 years of work.

* 2) brain cancer RR 1.87 (CI 1.20 -2.92) among all workers with 5-20 years of work.

3) brain cancer RR 1.45 (CI o.83-2.53) among all workers with greater than 20 years of work.