

# Energize Eastside

## Underground transmission lines and EMF webinar

**Leann Kostek**

*Senior Project Manager,  
Puget Sound Energy*

energize**EASTSIDE**

March 11, 2014

# Webinar orientation

- Welcome to the webinar
- Presentation #1:
  - Undergrounding Transmission Lines
  - Questions
- Presentation #2:
  - Electro-Magnetic Fields and Health Effects
  - Questions

# Energize Eastside overview

**Leann Kostek**

**Senior Project Manager**

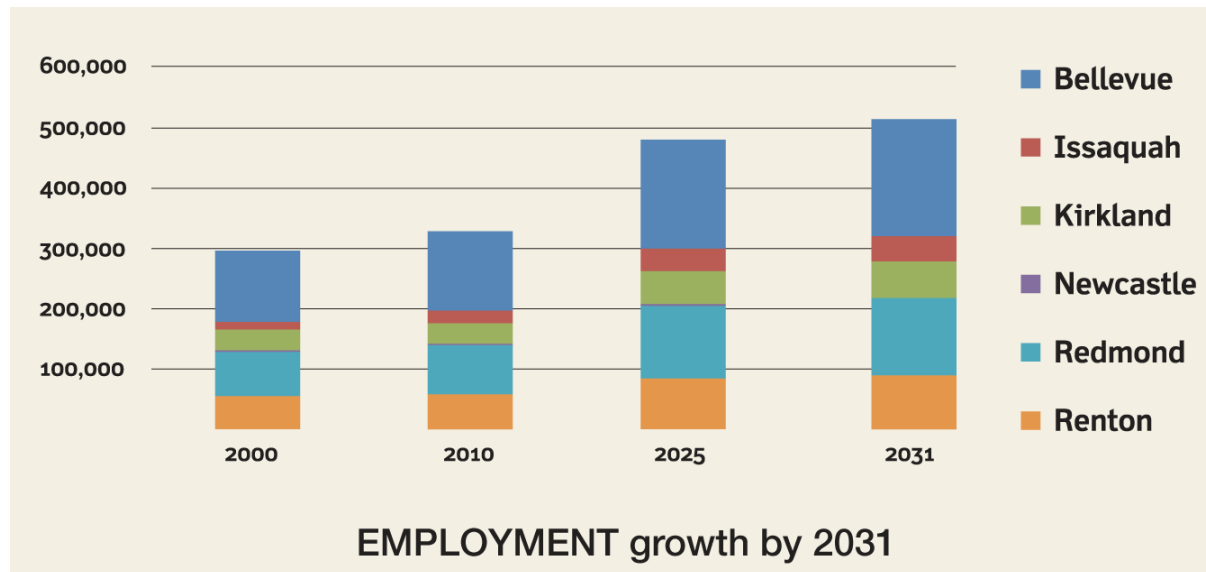
**Puget Sound Energy**

- More than 25 years experience.
- Joined PSE in 1997.

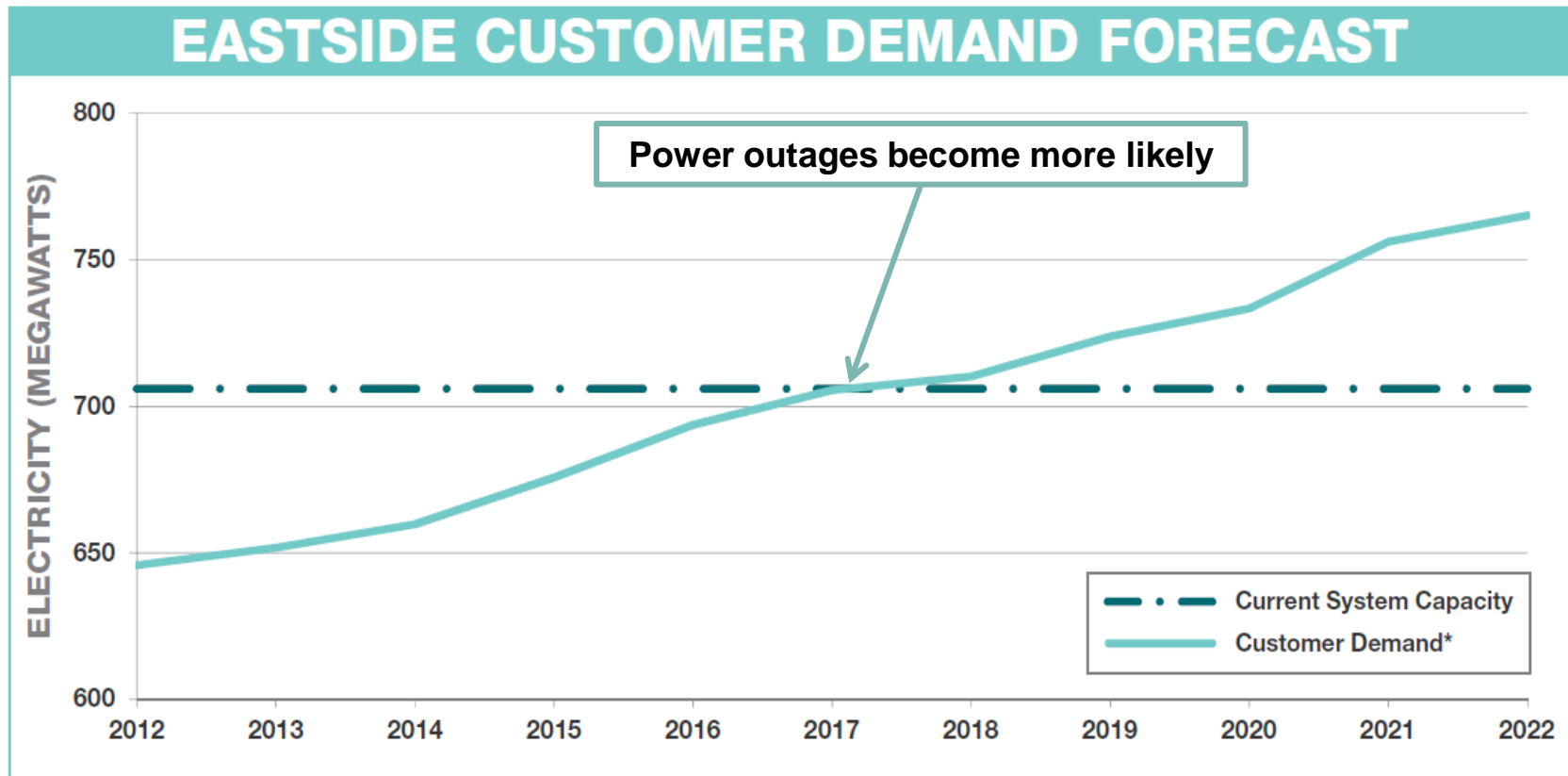


# Growth is straining the system

- The Eastside is growing faster than any other region in Washington
- New businesses moving in, existing businesses expanding



# Customer demand



\*Customer Demand assumes 100% of conservation goals are met.

# Conservation alone is not enough

Energy demand will be met through **both** increased, aggressive **conservation efforts**



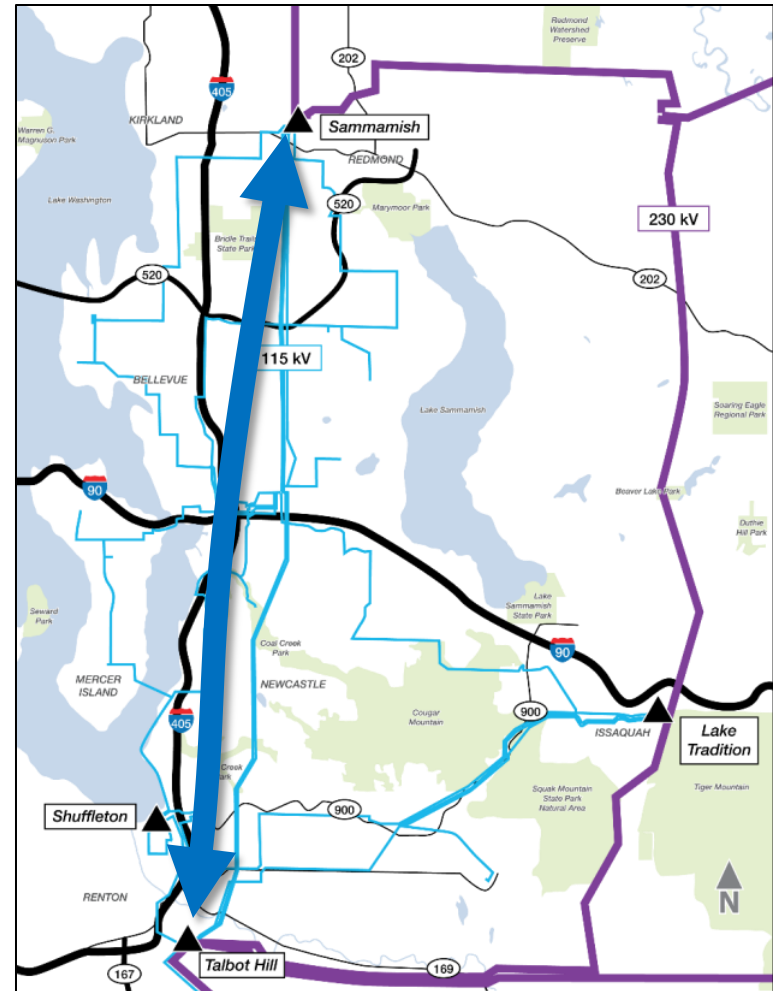
and **infrastructure upgrades** needed to provide reliable power



Single circuit  
230kV T-line

# The Energize Eastside project

- Build a new 230 kV transmission line between Talbot Hill-Sammamish substations and a new substation along the route
- Numerous routing options are being considered and discussed with the public



# Responding to the community

What we've been hearing:

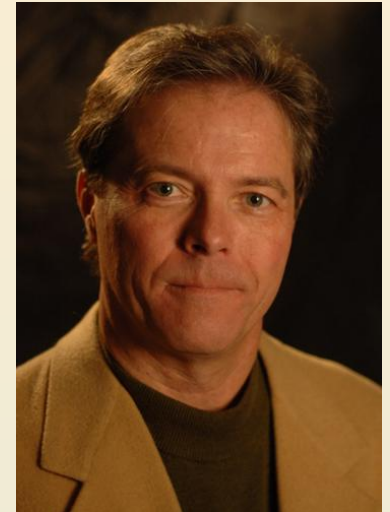
- Request for information about undergrounding transmission lines and health effects of transmission lines
- PSE is providing this webinar with two experts to provide information and address some of the questions we've heard



# Underground Transmission Lines

## Mark Williamson

- Served as executive vice president and chief strategic officer for Madison Gas & Electric Company in Madison, Wis.; responsible for electric transmission engineering and operations, including the operations of underground and overhead transmission lines.
- Served as vice president of major projects for American Transmission Company (ATC) based in Pewaukee, Wis.
- Currently serves as a consultant advising utility companies across North America on transmission project development and construction.



# Key terms

- **Conductor:** The wire that carries power from one place to another.
- **Phase:** One of the three wires that make up a circuit. Modern transmission circuits have three phases. Each carries part of the power needed for a complete transmission line.
- **Circuit:** A complete three-phase transmission line. All three phases are needed to make a circuit and carry the full power of a given line.
- **Lines:** The needed conductors in an overhead or underground transmission system.
- **Transmission:** Network of extra high-voltage lines that carry power from generation sources or major substations to local substations. Energize Eastside is building transmission lines.
- **Distribution:** Lines that carry lower-voltage power from substations to homes and businesses

## Underground systems - two major components

- Cable System
- Installation Methodology

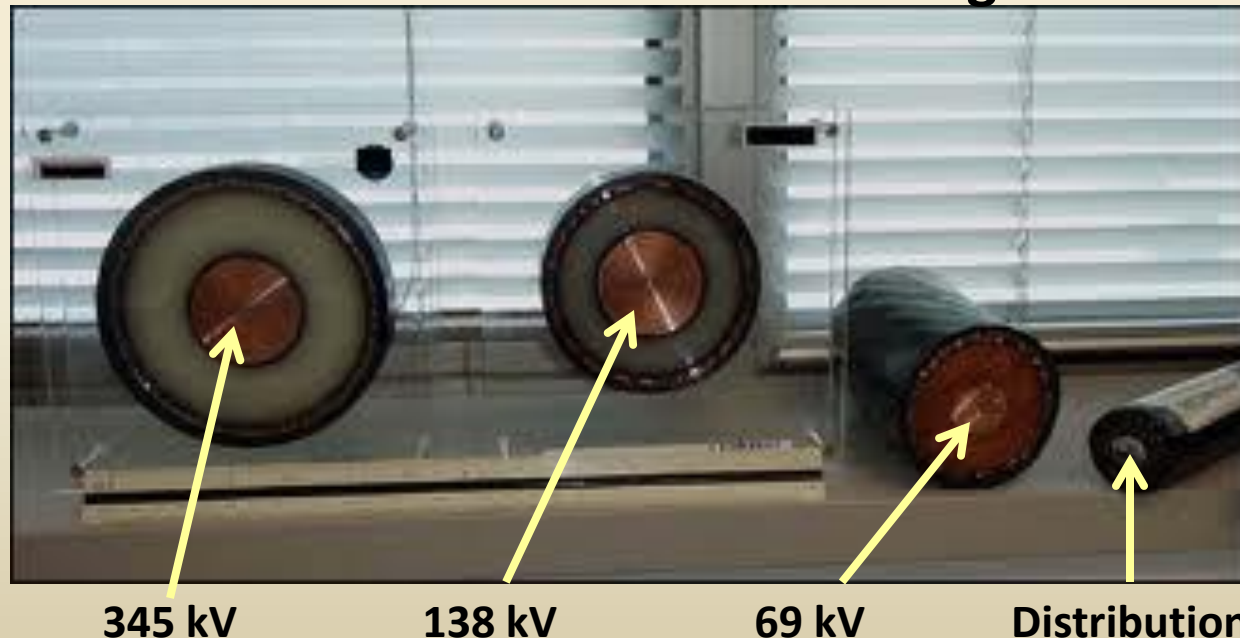
# Parts of the Underground System

- Cable(s)
- Conduit system
- Vaults
- Transition structures

# Cables

- Cables carry power
- Number of cables depends on size of line

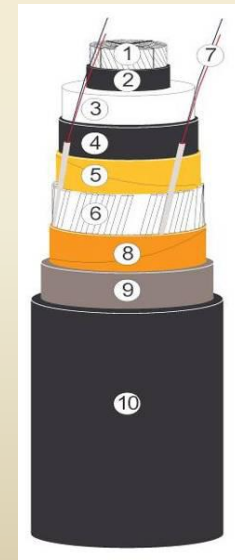
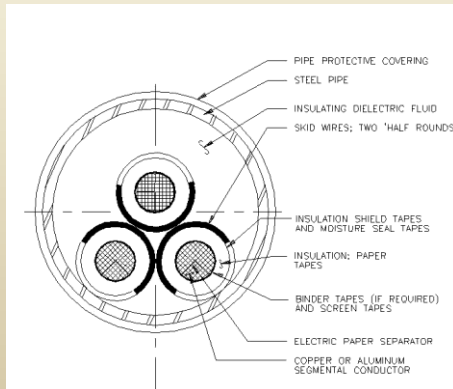
**XPLE cables for various voltages**



# Cable Systems

## Types of Cables

- High Pressure Fluid Filled Pipe (HPFF)
- Self Contained Fluid Filled (SCFF)
- High Pressure Gas Filled Pipe (HPGF)
- Extruded (Solid Dielectric) Cable System (XLPE)



# Conduit System

**Conduit in an urban setting**



**Conduit with thermal backfill installed**



**Conduit along a retired railroad corridor**



# Vaults

- Length of cable requires splicing
- Vaults house the splice locations
- Typical size of vaults (10' x 30' x 10' high)
- Different types of cables require different spacing between vaults
- More circuits requires more vaults



**230 kV splices**

# Transition Structures

- Needed to transition from underground cables to some form of overhead wires



**Single-circuit three-cable  
system**



**Double-circuit six-cable  
system**



# Constructing underground systems

## 1. “Open Cut” trenching

- Excavation to remove the concrete or asphalt (for roadways), topsoil and sub-grade material to the desired depth.



**Urban trench**

## 2. Conduit

- PVC conduit is assembled and lowered into the trench.



**Suburban trench**

# Constructing underground systems

## Trenchless Installation (when needed)

- **Pipe Jacking / Jack and Bore**
  - Commonly used for short crossings, typically under 400 feet
  - Where no bends are required
- **Horizontal Directional Drilling**
  - Commonly used for longer crossings
  - Where bends may be needed



**Jack and Bore setup**

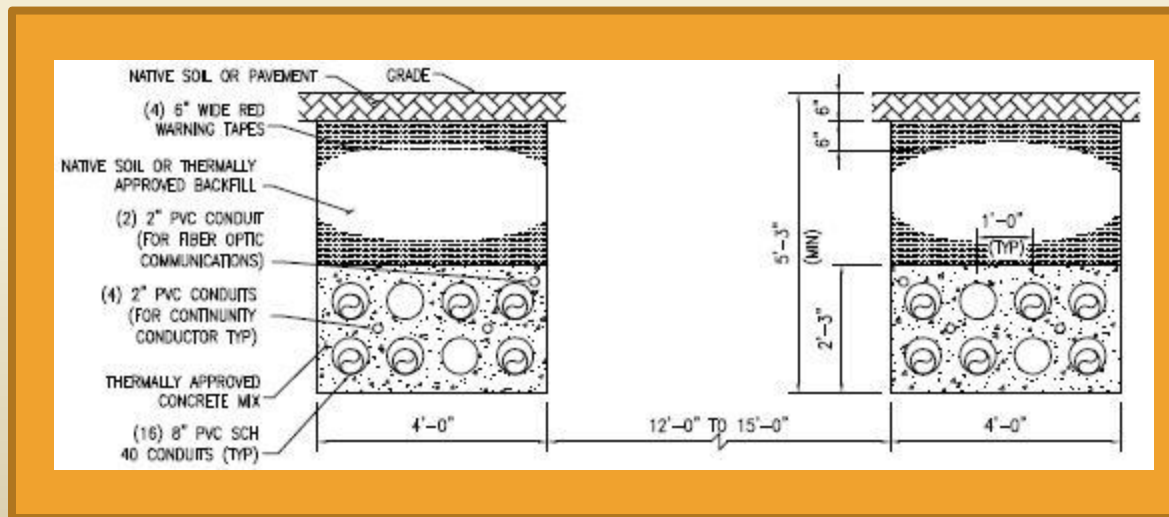


**Horizontal Direction Drilling set up**

# Constructing underground systems

## 3. Backfill

- Area around conduit filled with high-strength thermal concrete
- Surrounding the conduit with backfill creates the duct bank



**Double-circuit two-cable per phase  
trench configuration**

# Constructing underground systems

## 4. Vault installation

- Vaults installed periodically along underground route to facilitate cable installation, for maintenance requirements, and access for future repairs.
- Vaults are typically spaced every 1,500 to 2,500 feet along the route.





# Constructing underground systems

## 5. Cable installation and testing

- Cable installed after installation of the conduit, duct bank and vaults
- Prior to installation of the cable, conduit is tested and cleaned

## 6. Connect to transition structures and energize



**Cable being fed into the conduit system**

# Differences between Overhead and Underground Transmission Lines

	Overhead	Underground
<b>Vegetation</b>	<ul style="list-style-type: none"> <li>• No trees taller than 15' under line</li> <li>• Trimmed back 20' from conductor</li> </ul>	<ul style="list-style-type: none"> <li>• No deep rooted trees or shrubs for width of trench</li> </ul>
<b>Reliability</b>	<ul style="list-style-type: none"> <li>• Susceptible to wind and ice storms</li> <li>• Susceptible to 3<sup>rd</sup> party damage (i.e. car/pole accidents)</li> <li>• Outages infrequent</li> </ul>	<ul style="list-style-type: none"> <li>• Susceptible to 3<sup>rd</sup> party damage (digging)</li> <li>• Susceptible to root intrusion</li> <li>• Outages very infrequent</li> </ul>
<b>Repair</b>	<ul style="list-style-type: none"> <li>• Easier to find problem and repair</li> <li>• Repairs typically within hours to days</li> </ul>	<ul style="list-style-type: none"> <li>• Additional skills needed for repair work underground</li> <li>• Repairs typically within days to months</li> </ul>

# Differences between Overhead and Underground Transmission Lines

	Overhead	Underground
<b>Capacity Requirements</b>	<ul style="list-style-type: none"> <li>Can carry more power per circuit due to air cooling</li> </ul>	<ul style="list-style-type: none"> <li>Heat limits power per cable</li> </ul>
<b>Visual Effects</b>	<ul style="list-style-type: none"> <li>Poles and wires visible</li> </ul>	<ul style="list-style-type: none"> <li>Transition structures visible</li> </ul>
<b>Construction Cost</b>	<ul style="list-style-type: none"> <li>Range per mile: \$3-4 million</li> </ul>	<ul style="list-style-type: none"> <li>Range per mile: \$20-28 million</li> </ul>
* Preliminary costs for construction only. Final costs may vary with final design.		
<b>Construction timeline</b>	<ul style="list-style-type: none"> <li>Approx. through 2018</li> </ul>	<ul style="list-style-type: none"> <li>Approx. through 2020</li> </ul>

## **Washington Utilities and Transportation Commission**

- PSE is a regulated utility.
- PSE's rates and operations are controlled by the UTC.

## **Paying for Underground Transmission**

- PSE's standard approach is overhead lines
- All of PSE's 1.1 million customers absorb the cost of overhead lines
- Substantial cost difference between overhead and underground lines
- Undergrounding not necessary ensure reliable service
- Therefore, difference between overhead and undergrounding is responsibility of requesting party

## **Washington State tariff requirements**

- Schedule 80, Section 34: "Where an overhead solution is available, the incremental cost of undergrounding must be paid by the people requesting it."



The following documents are posted on the project website:

- Wisconsin Public Service Commission Underground Electric Transmission Lines Overview
- Evaluation of Underground Electric Transmission Lines in Virginia
- Puget Sound Energy Electric Tariff G, Schedule 80

PSE is also commissioning an underground feasibility study for the project, which will be final this spring. When it is complete, it will be posted in the project library.

# QUESTIONS?

# Magnetic Fields and Public Health

## Drew Thatcher

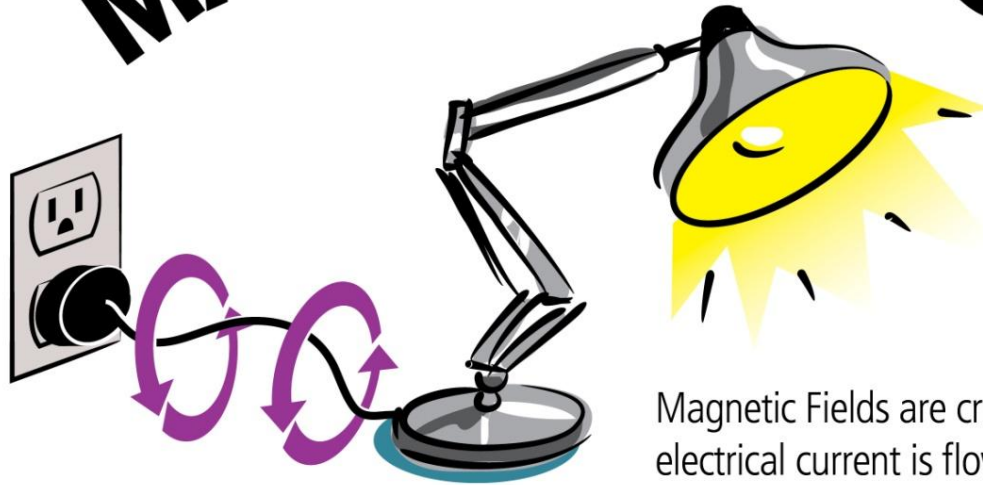
- Certified Health Physicist
- Clinical Associate Professor at Vanderbilt University
- Consultant at American Conference of Industrial Hygienists



# Overview

- What are magnetic fields?
- Magnetic fields comparison between power lines and other electronic devices
- Sample magnetic field levels from transmission lines
- Review of the science to-date
  - Human studies (epidemiology), animal studies (in vivo) and cellular studies (in vivo)
- Latest studies and what they tell us
- Exposure concerns related to health, quality of life
- Wrap up
- Questions

# What Are MAGNETIC FIELDS?



Magnetic Fields are created when electrical current is flowing.

## What are they NOT?



Ultraviolet

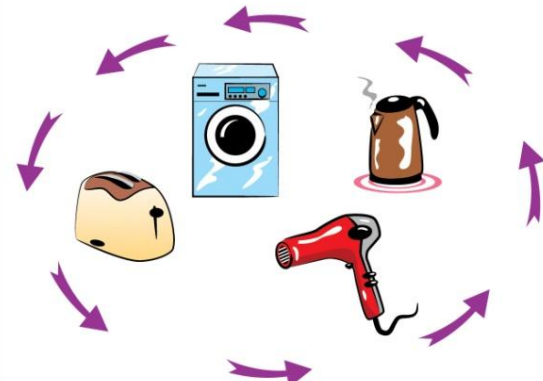


X-Rays



Gamma Rays

## WHERE are they?

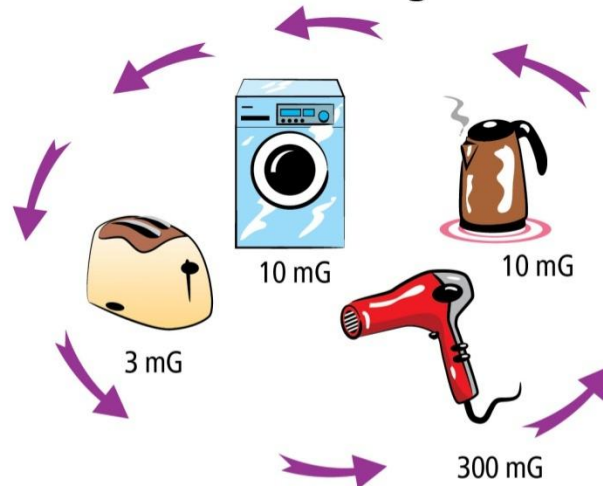


Anywhere electricity is used.

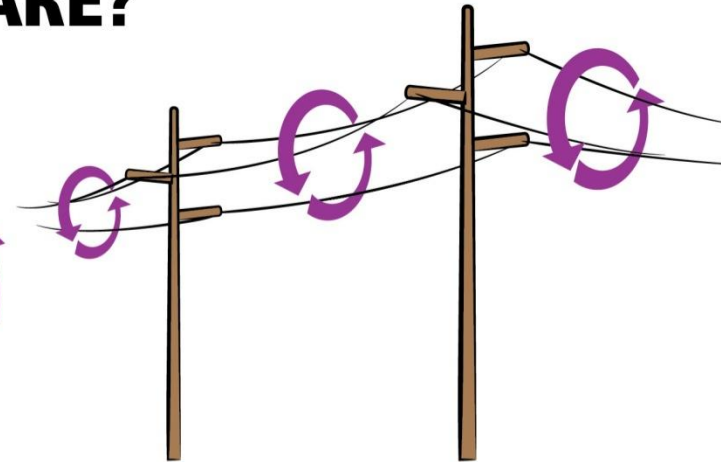
## How do they COMPARE?



550 mG, static field



Exposure at 1 ft distance

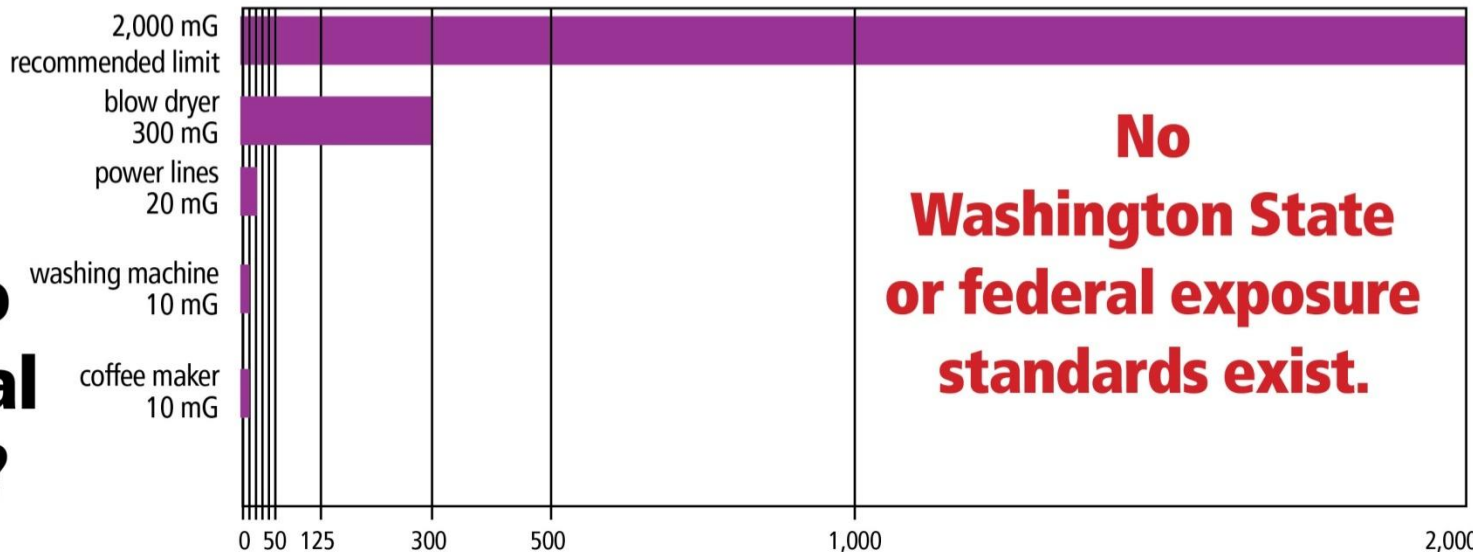


230 kV Power Line:

at 50 feet the magnetic field is ~20 mG  
at 100 feet the magnetic field is ~7 mG

mG = milliGauss

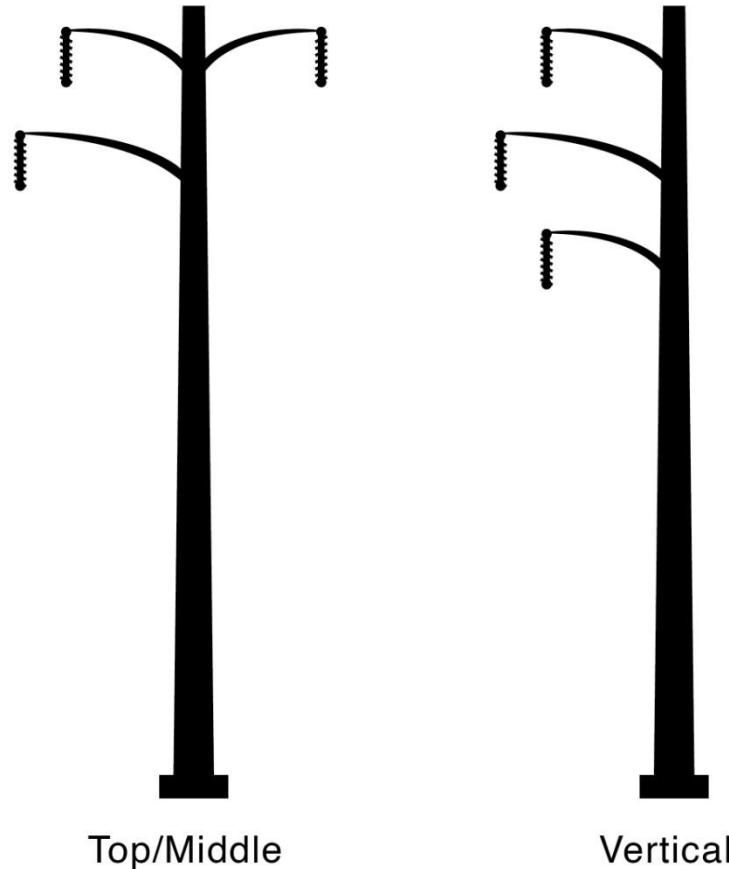
**How do  
exposures  
compare to  
international  
guidelines?**



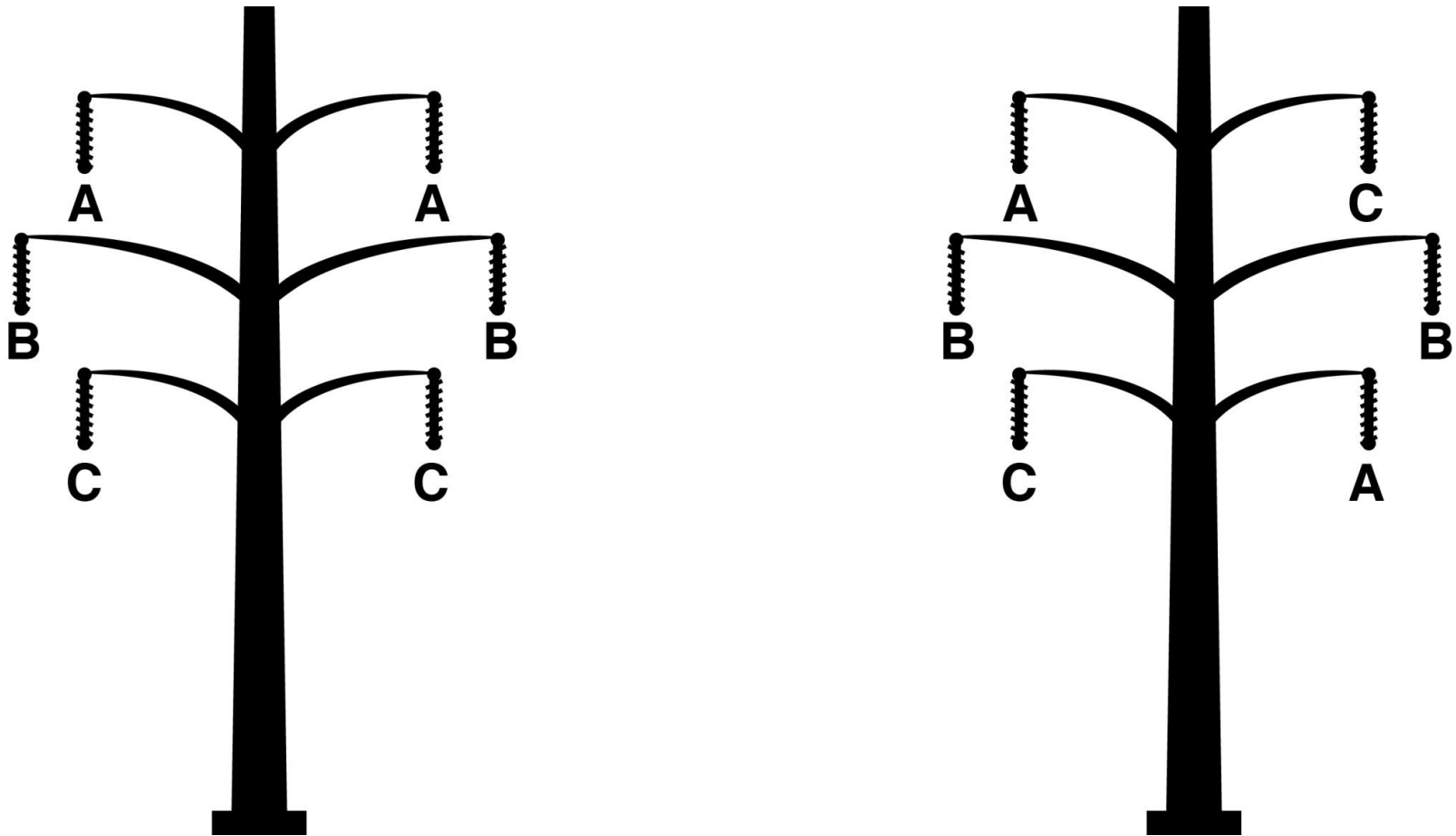
**No  
Washington State  
or federal exposure  
standards exist.**

# Ways to Minimize Magnetic Fields with a Single Circuit

A top/middle configuration results in a ~30% reduction as compared to a vertical design



# What Does Reverse Phasing Actually Mean?



Reverse phasing of the conductors on a double circuit can result in a  
~70% reduction in the magnetic field



# Sample Magnetic Fields from Overhead and Underground Transmission Lines (mG)

Transmission Lines	Maximum in ROW	50' from Structure / Duct CL	100' from Structure / Duct CL	150' from Structure / Duct CL
Line Type				
Overhead Line, double circuit, normal phase	77.4	42.6	16.0	7.8
Overhead Line, double circuit, reverse phase	54.7	25.0	8.0	3.6
Overhead Line, single circuit	62.7	33.4	12.0	5.7
Overhead Line, single circuit, spacing optimized	32.2	19.8	8.4	4.3
Underground Line, double circuit, 230/115 kV, 600/300 A, concrete encased duct bank	29.32	2.20	<1	<1
Underground Line, single circuit, 230 kV, 600 A, concrete encased duct bank	30.78	<1	<1	<1

EMF measured at 3.28 ft (1 m) above grade

EMF measured at 3.28 ft (1 m) above grade

**Note: These values are ballpark estimates**

# Background on EMF studies

- Epidemiology – real world observations of humans based upon collected data
- Animal and laboratory studies
  - Multiple types of studies with multiple endpoints
  - Allows for the ability to control study conditions
- Is there a plausible biological explanation?

# Epidemiological studies

- Overall results: Link between magnetic field exposure and childhood leukemia have been mixed with some studies finding an association and some not
- Epidemiological studies are weakened by methodological problems associated with selection and reporting biases
- Epidemiological studies are insufficient to prove a cause and effect because results are statistical associations and not direct evidence

# Laboratory tests



# Animal Studies

- Why conduct animal studies?
- The reason why all almost major scientific review organizations have failed to conclude that the possible risk from exposures and childhood leukemia is real is because animal and cellular studies have consistently failed to demonstrate any reproducible effects that show that magnetic field exposures cause or promote cancer.
- Animal and cellular studies had consistently been negative in regard to magnetic field exposures and possible genetic effects with a small caveat.
  - We now have rat strains that mimic the leukemia found in humans. The initial study results using these strains have also failed to find an association.

# Some Recent Studies

- Pedersen et al (2014): Relatively large Danish epidemiology study
  - No evidence of higher risk of leukemia in children
- Elliott et al (2013): UK study on adult cancers near high voltage power lines
  - Study does not show any association between adult cancers and residential magnetic fields close to power lines
- Feychting (2013): Commentary following a study by Li et al (2013) on breast cancer and ELF magnetic fields
  - A consistently negative association and greater confidence that ELF magnetic fields do not cause breast cancer

# How the Evidence Stacks up for Adverse Health Effects

- Epidemiological studies: Inconclusive
- Little evidence for an association with adult leukemia, brain tumors or breast cancer
- Lab and cellular studies have failed to find replicated evidence for leukemia, brain cancer and breast cancer
- No dose response relationship
- No plausible biological mechanism for effects less than 500 mG

# Electromagnetic Hypersensitivity

- What is it, what are the symptoms?
- Does exposure to magnetic or electric fields cause this?
  - Not according to the WHO – double blind studies showed that symptoms were not correlated with EMF exposures
- This does not mean that EHS is not real, it is, but electric or magnetic field exposures are not the cause.



# Conclusions

- 45 years of research on EMF
- \$500 million spent on research in the United States alone
- About 2,900 studies conducted to date related to cancer
  - Very large amount of scientific knowledge
- World Health Organization in 2012 concluded that:
  - “The current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields”
- The international public exposure limits:
  - 2,000 mG - International Commission on Non-Ionizing Radiation Protection
  - 9,040 mG - Institute of Electrical and Electronic Engineers

<http://www.who.int/peh-emf/about/WhatisEMF/en/index.html>

# QUESTIONS?

# For more information

## PSE Contacts:

Leann Kostek, Senior Project Manager

Cody Olson, Community Projects Manager

## Stay in touch:

[pse.com/energizeeastside](https://pse.com/energizeeastside)

[energizeeastside@pse.com](mailto:energizeeastside@pse.com)

800-548-2614

# Thank you!

Thank you for attending the March 11, 2014 ***Energize Eastside: Underground Transmission Lines and EMF*** webinar. The purpose of this event is to present information and gather input from people and organizations as Puget Sound Energy evaluates route options for the Energize Eastside 230 kV route.

PSE is conducting this event and others like it to present information about the factors involved in developing route segments and the combination of those segments into potential route options. Nothing contained in these materials is intended for nor should it be construed, relied upon, used as, or constitute evidence in any proceedings, either in whole or in part, of a final or determinative factor in the ultimate route to be selected for the Energize Eastside 230 kV project.

The final route selected will balance the needs of customers, the local communities and PSE, and upon selection, will be subject to appropriate environmental and permit review processes by jurisdictions with authority to approve the project.