Office of the Public Advocate
Your Trusted Source for Utility Information

Expanding the Grid: How Big and Who Pays?

Summit on Maine’s Economy and Climate Change
May 19,2023
William Harwood
Maine Public Advocate

Regulation

- Merchant transmission Lines – who’s minding the store?
- FERC vs. PUC regulation?
- Northern Maine transmission line – regulated or unregulated?

PUC CPCN Cases

- Traditional standard – Will rates be lower if line is built than if line is not built?
- What about environmental and aesthetic benefits?
- Conditions to PUC Approval
  - How many and how broad?
  - Is paying for these conditions simply a cost of doing business in Maine?
  - How should they be counted toward whether approval is justified?

Non-wire Alternatives (NWAs)

Should utilities be allowed to own and operate NWAs?

Expanding the Grid: What Functions, Flexibility, Costs?

Climate Work Summit on Maine's Economy & Climate Change

David Littell
Chair, Climate Change Practice Group
Energy & Environmental Practice Group
Friday, May 19, 2023

Climate Action and Grid Needs

In Maine, weshould make sure **every ratepayer* dollar is spent efficiently and effectively** to make the best investments for **customers*** to:

- Improve reliability and service,
- Build grid scale solar and wind,
- Support distributed resources,
- Improve efficiency and electrify, and
- Support Maine's future and economic growth.

*ratepayers must pay rates for service; customers receive benefits and choose how to spend their customer dollars

What Maine needs to make climate progress

- Better **planning** < scattershot
  - Long term integrated grid planning will help.
- More **cooperation** > contention
  - Governmental power is a huge diversion from climate progress.
- A plan is **directional**
  - Good plans are flexible.
  - Plans channel effort, spending, and training.

Factoids

Versant is working on 432 active projects to integrate 500+ megawatts of solar, wind.

Solar requests alone would generate more electricity than the Versant system needs.

Advanced Technology is expensive > use to pursue value

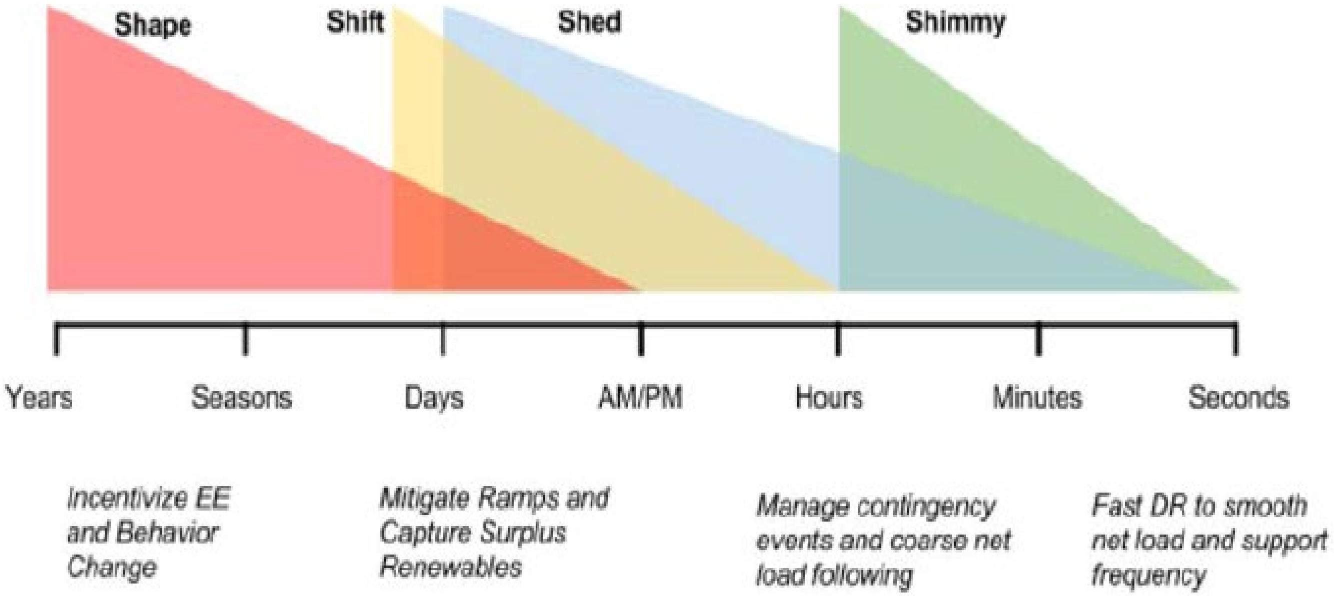
- Grid Value
- Customer Value
- Utility Value

Good policy aligns all three!

With technology and policy evolving, and processes changing – Maine will likely **remain in problem-solving mode**.

Advanced Energy Planning: New Approaches

- Transmission and distribution planning (traditional "supply side") is understood.
- Demand-side management "DSM" is newer.
- Four DSM capabilities to exploit:
  - Shape load
  - Shift load
  - Shed load
  - Shimmy
- Pricing (rate design) is an effective approach to shape, shift, or shed load.
  - Versant **seasonal heating rates**
    - 13% customer adoption
  - Versant offers **time-variant EV charging rates**
  - Versant residential **customers can use both heating and EV rates** with different meters
    - No additional monthly minimum charge



Source: 2015 California Demand Response Potential Study, LBNL, November 2016

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Contact Information

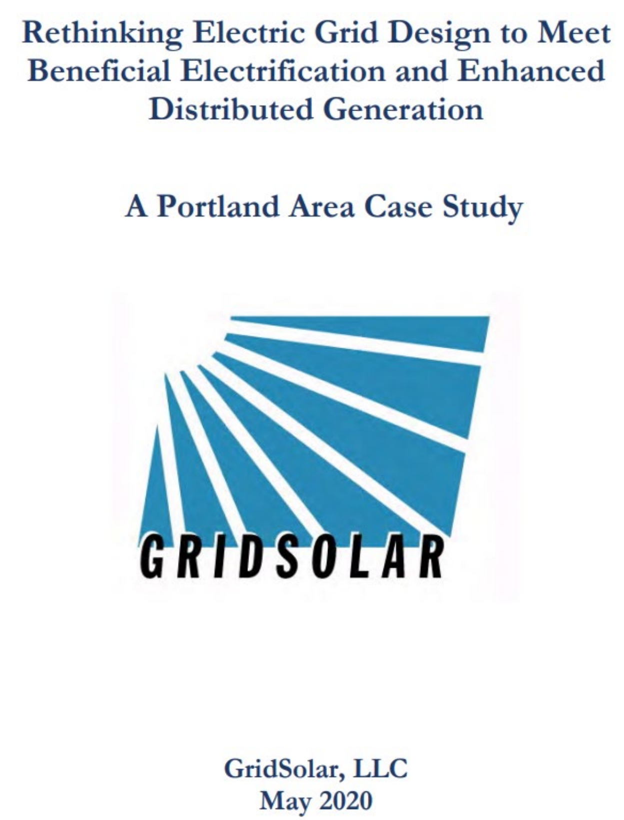
David P. Littell, Esq.
+1207-228-7156
Dlittell@BernsteinShur.com

COMPETITIVE ENERGY SERVICES, LLC

ClimateWork Maine

Richard Silkman, Ph.D.

May 19, 2023



Rethinking Electric Grid Design to Meet Beneficial Electrification and Enhanced Distributed Generation

A Portland Area Case Study

GridSolar, LLC
May 2020

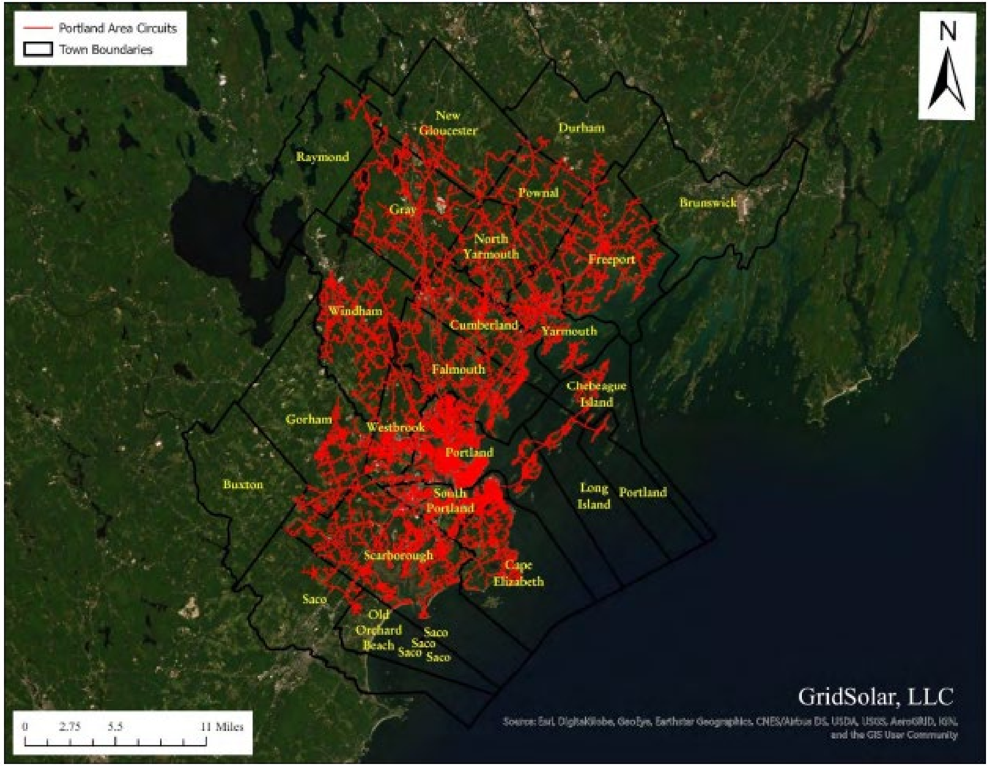
What is required for Maine to achieve a zero-carbon economy through full beneficial electrification and maximum build-out of distributed solar generation

https://www.competitive-energy.com/rethinking-electrical-grid-design

Competitive Energy SERVICES

Portland Region – Electric Grid

Figure 2-4 Electrical Representation of the Distribution Circuits in the Portland Region



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Modeling Energy Use:

- Building-by-Building – every single parcel in the region.
- Data – obtained from tax records in every community and from GIS mapping
- Circuit Data – from CMP

Table 3-1 Summary of Buildings in the Portland Area

	Residential Buildings	Commercial Buildings	Industrial Buildings	Total
Number of Buildings	73,000	6,167	1,003	80,170
Total Square Footage	209,782,673	67,793,059	18,802,851	296,378,583
Average Square Footage per Building	2,874	10,993	18,747	10,871

Current Energy Use – by Fuel and by Sector

Figure 3-1 Model Validation – by Month

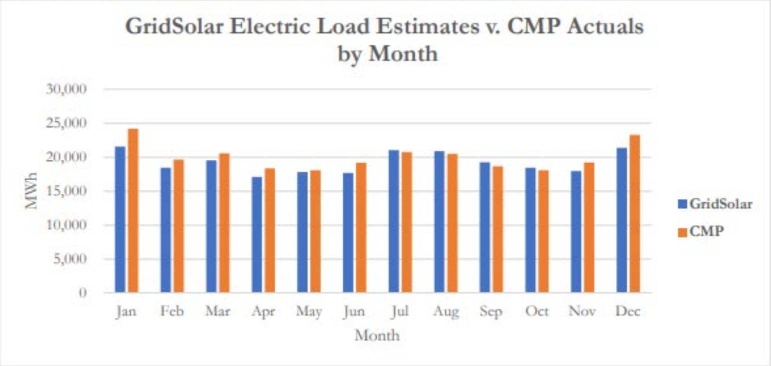


Figure 3-2 Model Validation by Hour of the Day

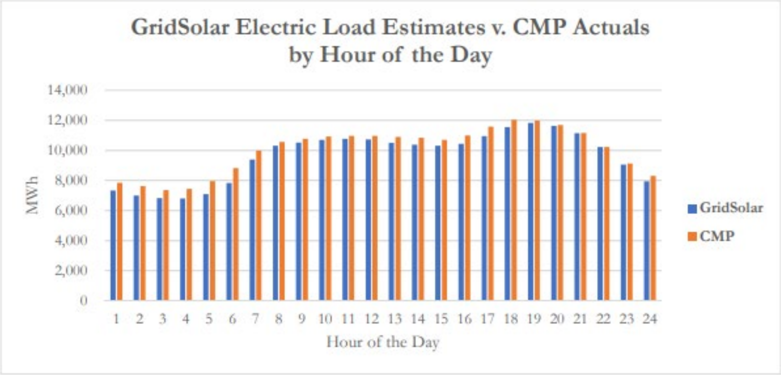
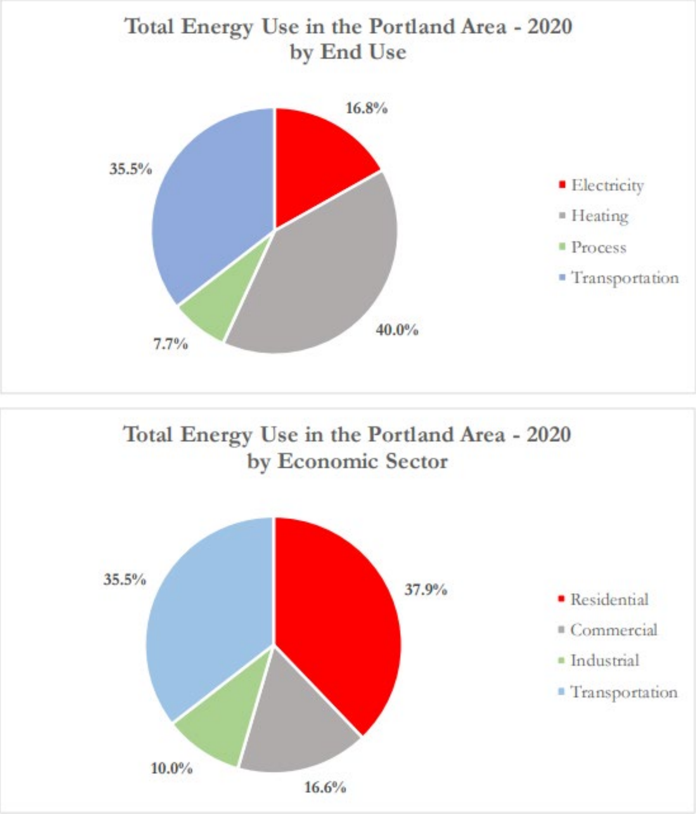


Figure 3-3 Percent Energy Use by End-Use and Economic Sector



Beneficial Electrification

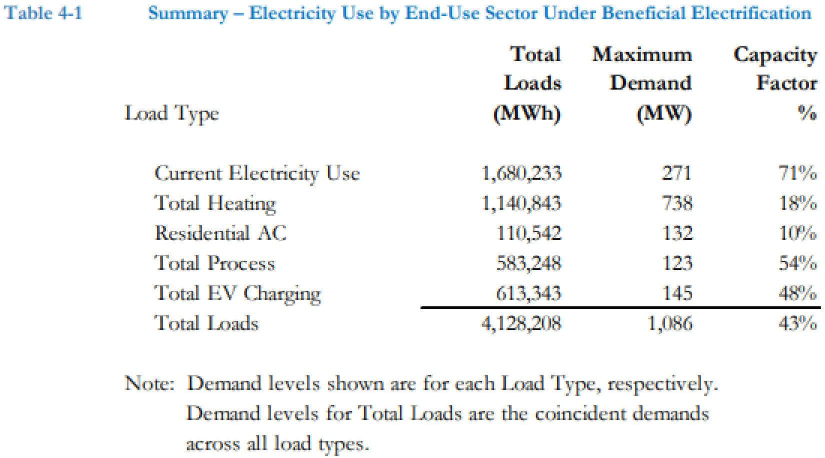


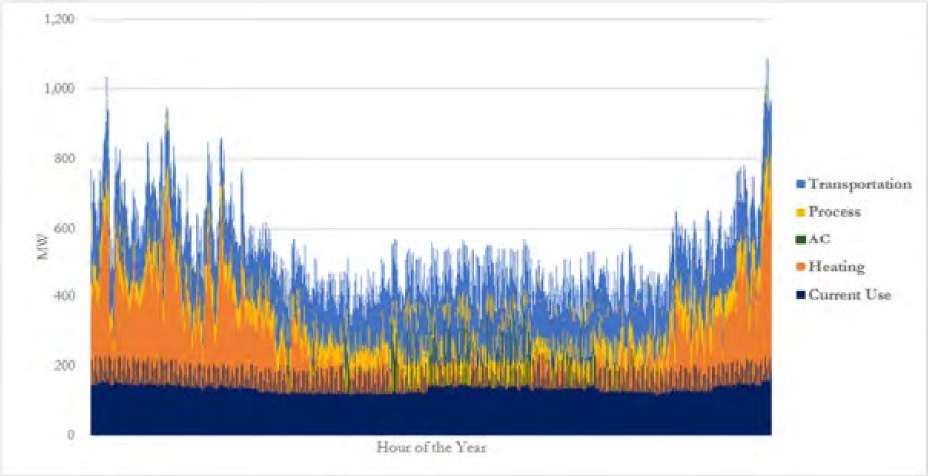
Table 4-1 Summary – Electricity Use by End-Use Sector Under Beneficial Electrification

Load Type	Total Loads (MWh)	Maximum Demand (MW)	Capacity Factor %
Current Electricity Use	1,680,233	271	71%
Total Heating	1,140,843	738	18%
Residential AC	110,542	132	10%
Total Process	583,248	123	54%
Total EV Charging	613,343	145	48%
Total Loads	4,128,208	1,086	43%

Note: Demand levels shown are for each Load Type, respectively. Demand levels for Total Loads are the coincident demands across all load types.

Electricity use - 246% higher
Peak Demand - 400% higher

Figure 4-6 Hourly Electricity Use by End-Use Sector Under Beneficial Electrification



Overall load factor decreases markedly due to conversion of heating systems to electricity

Maximum Build-out of Rooftop Solar in Region

Install Rooftop Solar on Every Building/Structure in the Portland Region – with full build-out achieved in 2050:

Capacity: 1,011 MW

Energy: 1,590,280 MWh

Coverage: 27% of all rooftop surface

39% of Total Electricity Use in the Region by 2050

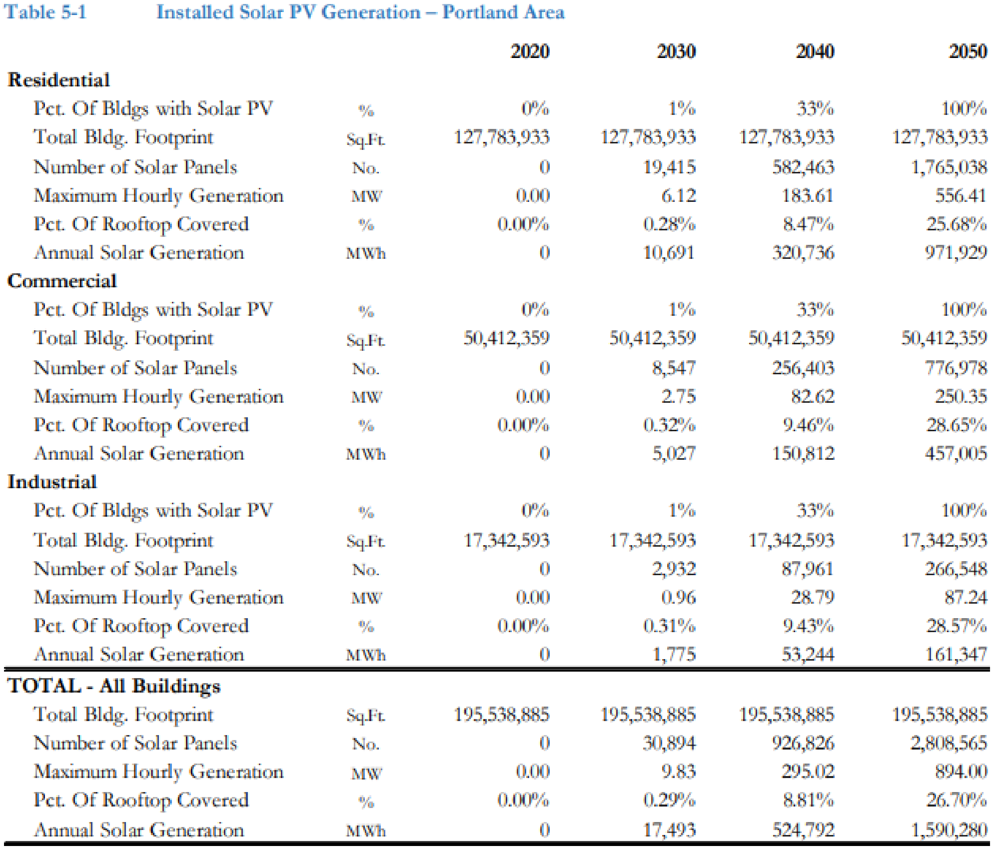


Table 5-1 Installed Solar PV Generation – Portland Area

		2020	2030	2040	2050
Residential					
Pct. Of Bldgs with Solar PV	%	0%	1%	33%	100%
Total Bldg. Footprint	Sq.Ft.	127,783,933	127,783,933	127,783,933	127,783,933
Number of Solar Panels	No.	0	19,415	582,463	1,765,038
Maximum Hourly Generation	MW	0.00	6.12	183.61	556.41
Pct. Of Rooftop Covered	%	0.00%	0.28%	8.47%	25.68%
Annual Solar Generation	MWh	0	10,691	320,736	971,929
Commercial					
Pct. Of Bldgs with Solar PV	%	0%	1%	33%	100%
Total Bldg. Footprint	Sq.Ft.	50,412,359	50,412,359	50,412,359	50,412,359
Number of Solar Panels	No.	0	8,547	256,403	776,978
Maximum Hourly Generation	MW	0.00	2.75	82.62	250.35
Pct. Of Rooftop Covered	%	0.00%	0.32%	9.46%	28.65%
Annual Solar Generation	MWh	0	5,027	150,812	457,005
Industrial					
Pct. Of Bldgs with Solar PV	%	0%	1%	33%	100%
Total Bldg. Footprint	Sq.Ft.	17,342,593	17,342,593	17,342,593	17,342,593
Number of Solar Panels	No.	0	2,932	87,961	266,548
Maximum Hourly Generation	MW	0.00	0.96	28.79	87.24
Pct. Of Rooftop Covered	%	0.00%	0.31%	9.43%	28.57%
Annual Solar Generation	MWh	0	1,775	53,244	161,347
TOTAL - All Buildings					
Total Bldg. Footprint	Sq.Ft.	195,538,885	195,538,885	195,538,885	195,538,885
Number of Solar Panels	No.	0	30,894	926,826	2,808,565
Maximum Hourly Generation	MW	0.00	9.83	295.02	894.00
Pct. Of Rooftop Covered	%	0.00%	0.29%	8.81%	26.70%
Annual Solar Generation	MWh	0	17,493	524,792	1,590,280

Energy Balances/Imbalances by Building

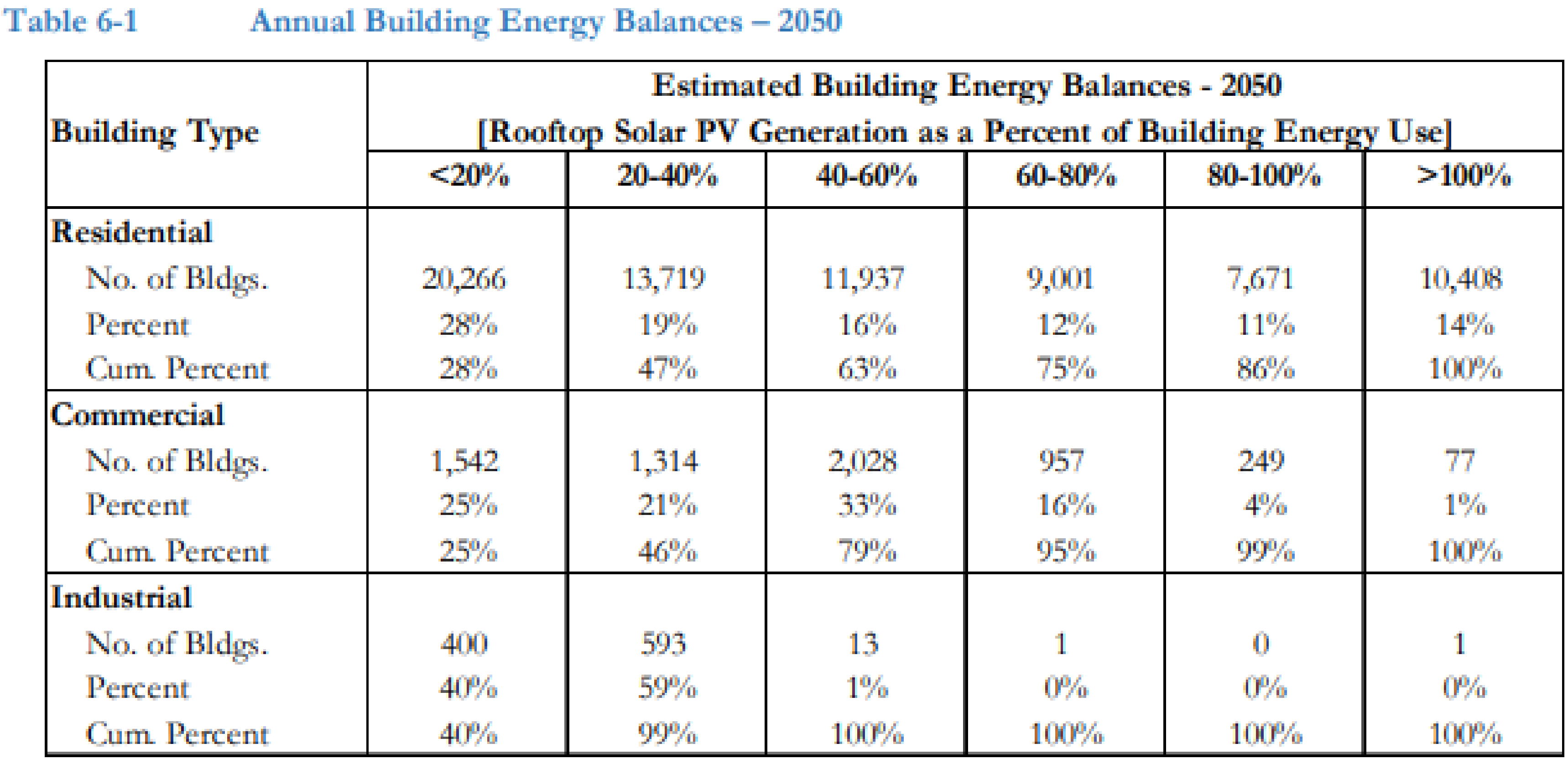


Table 6-1 Annual Building Energy Balances – 2050

Building Type	Estimated Building Energy Balances - 2050 [Rooftop Solar PV Generation as a Percent of Building Energy Use]					
	<20%	20-40%	40-60%	60-80%	80-100%	>100%
Residential						
No. of Bldgs.	20,266	13,719	11,937	9,001	7,671	10,408
Percent	28%	19%	16%	12%	11%	14%
Cum. Percent	28%	47%	63%	75%	86%	100%
Commercial						
No. of Bldgs.	1,542	1,314	2,028	957	249	77
Percent	25%	21%	33%	16%	4%	1%
Cum. Percent	25%	46%	79%	95%	99%	100%
Industrial						
No. of Bldgs.	400	593	13	1	0	1
Percent	40%	59%	1%	0%	0%	0%
Cum. Percent	40%	99%	100%	100%	100%	100%

Distribution Grid – Reliability Issues

Figure 6-1 Distribution Circuit Peak Loads

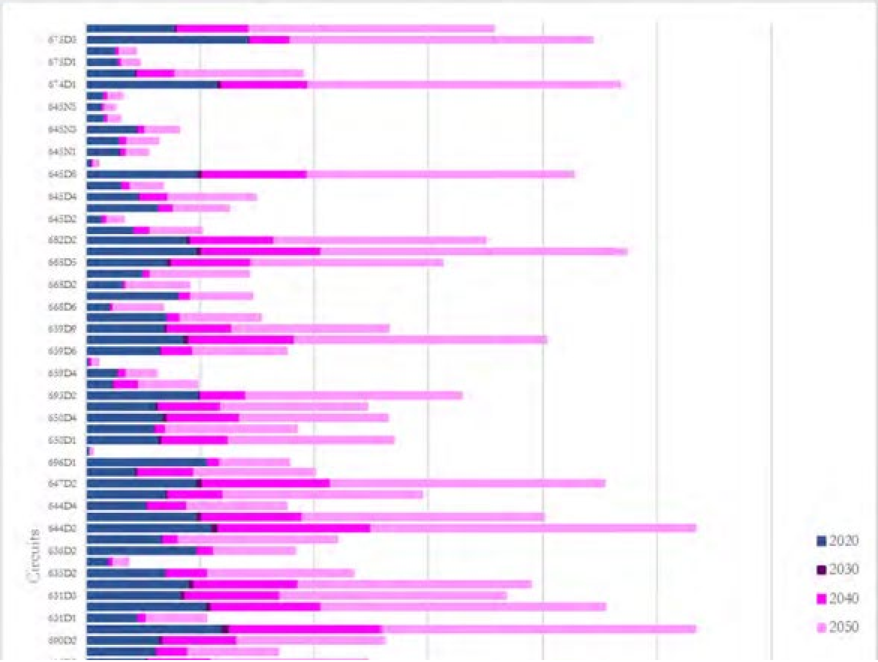
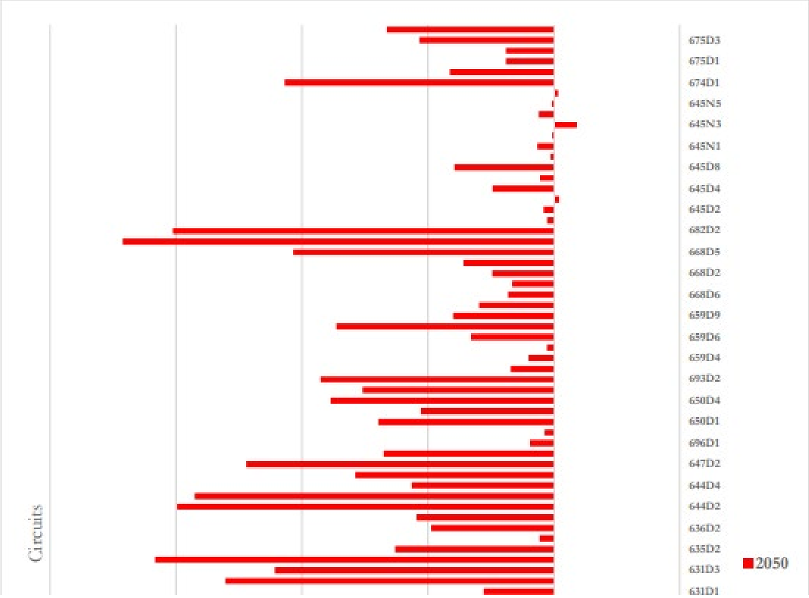


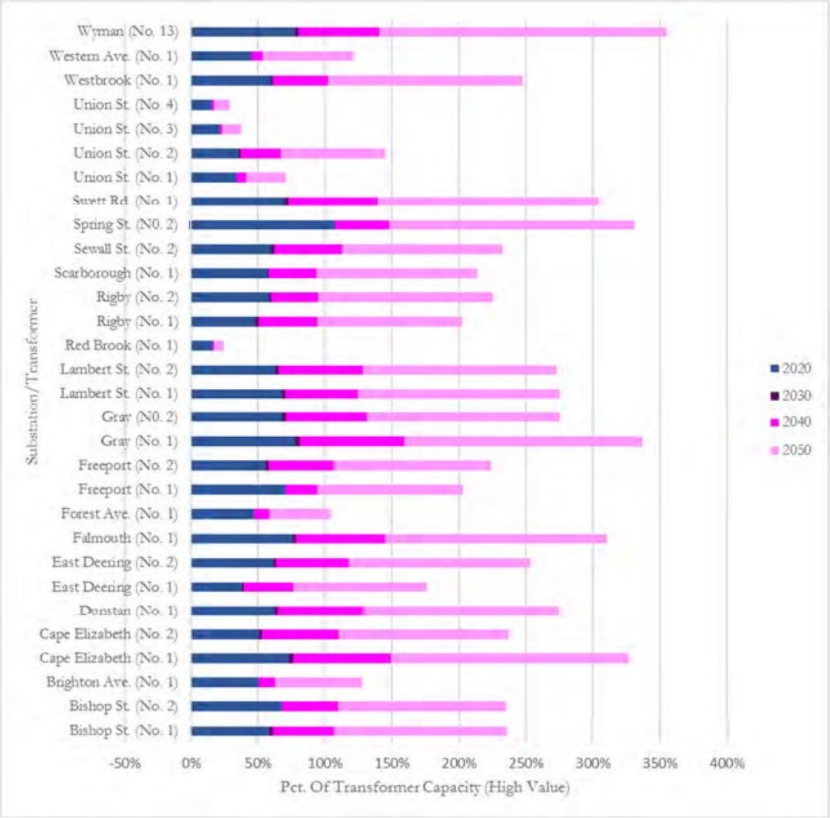
Figure 6-2 Reverse Power Flows on Distribution Circuits



Virtually every circuit in the region is undersized to carry peak loads and will experience significant reverse power flows …

Distribution Grid – Reliability Issues

Figure 6-4 Max. Loads by 34/12.5 kV Transformer – 2020 – 2050 as a Pct. of High Ratings

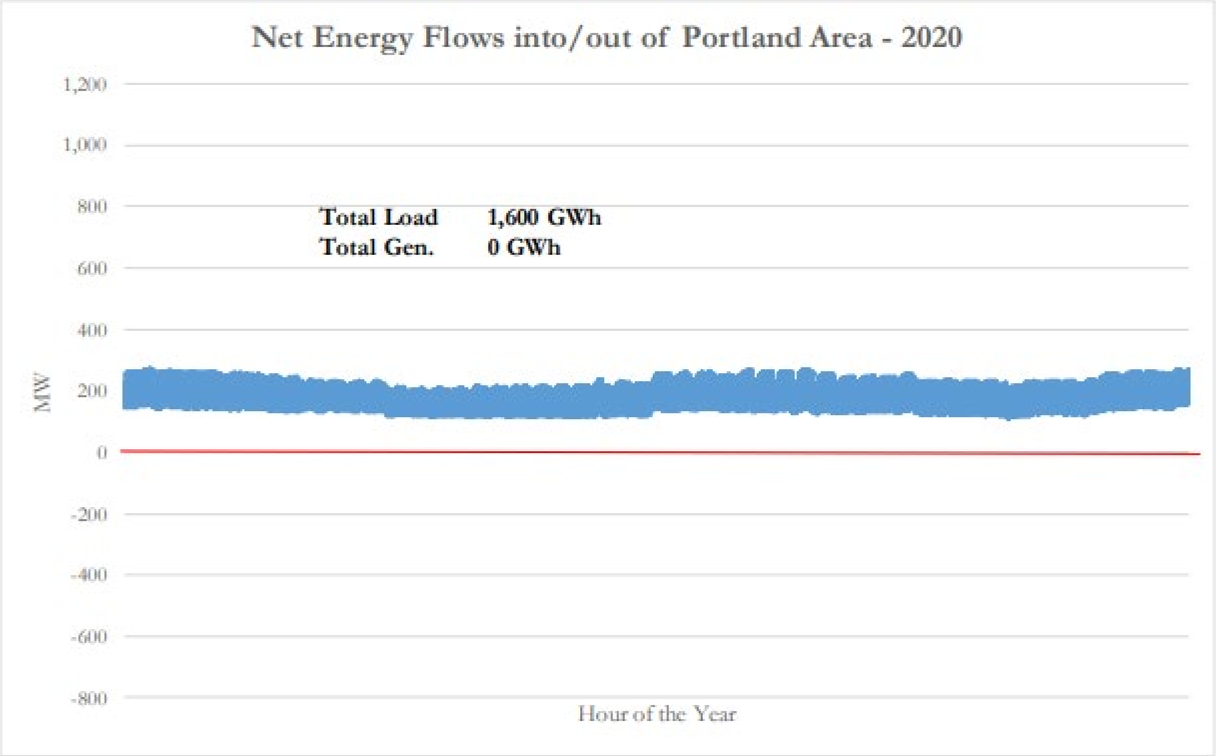


The same problem exists for transformer capacity at the region's substations – by 2040, most will be well-undersized to meet future peak loads.

We will need to see a complete redesign and rebuilding of the region's Distribution Grid.

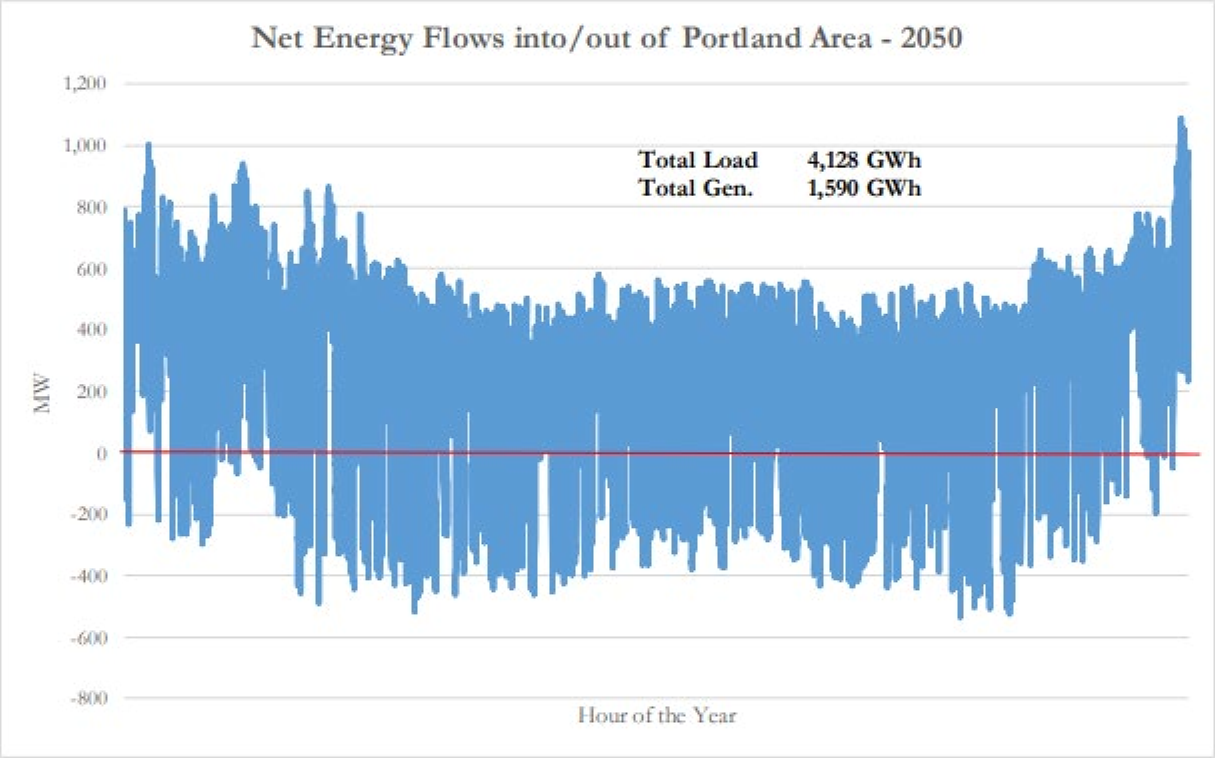
Electricity Flow – Current Imbalances

Figure 6-6 Hourly Energy Balances for the Portland Area



With essentially no Distributed Generation today, all of the region's electricity is imported. Hour-by-hour variation, however, is relatively small due to high annual load factor of current end uses of electricity.

Electricity Flow – Current Imbalances



By 2050, the region's grid must be capable of importing 1,000 MW of power – and this is true regardless of how much distributed solar is installed.

Storage could help – but it must be seasonal storage. Diurnal storage provides very little relief.

Transmission Grid Upgrade Costs

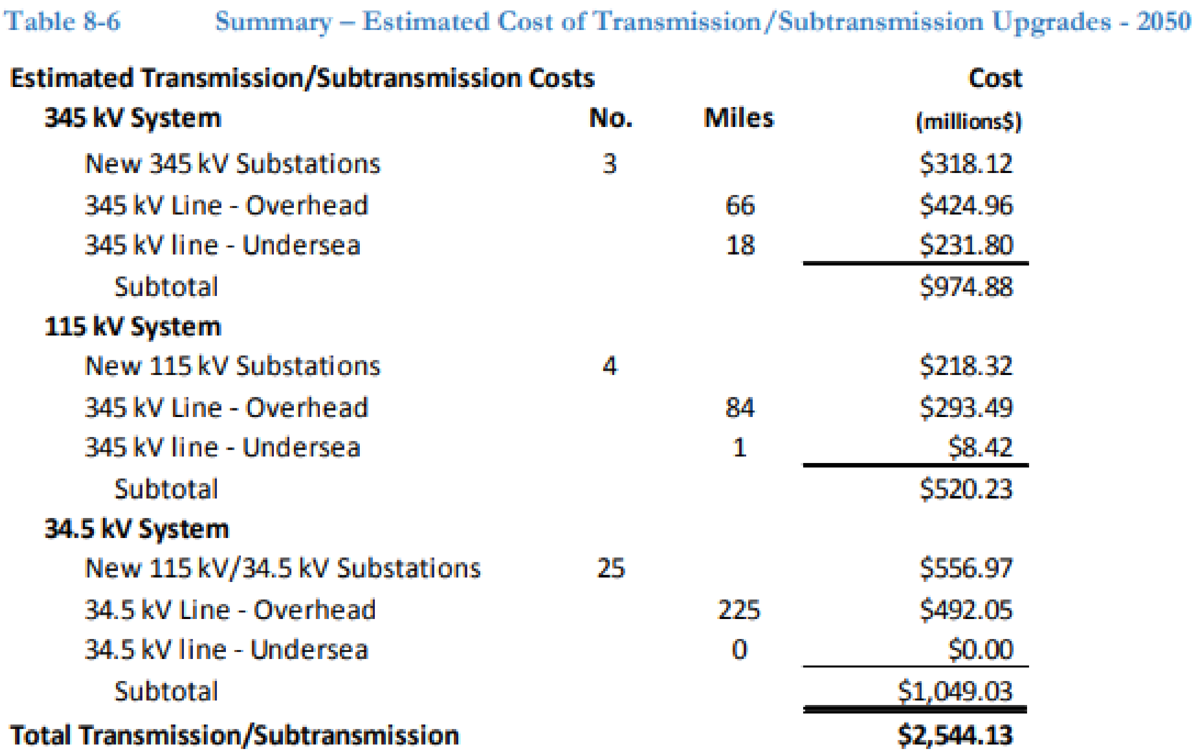


Table 8-6 Summary – Estimated Cost of Transmission/Subtransmission Upgrades - 2050

Estimated Transmission/Subtransmission Costs			**Cost**
345 kV System	**No.**	**Miles**	**(millions$)**
New 345 kV Substations	3		$318.12
345 kV Line - Overhead		66	$424.96
345 kV line - Undersea		18	$231.80
Subtotal			$974.88
115 kV System			
New 115 kV Substations	4		$218.32
345 kV Line - Overhead		84	$293.49
345 kV line - Undersea		1	$8.42
Subtotal			$520.23
34.5 kV System			
New 115 kV/34.5 kV Substations	25		$556.97
34.5 kV Line - Overhead		225	$492.05
34.5 kV line - Undersea		0	$0.00
Subtotal			$1,049.03
Total Transmission/Subtransmission			**$2,544.13**

The total costs for the transmission upgrades required to serve 2050 electrical loads in the Portland Region will be roughly $2.5 billion in 2020$.

The Distribution cost upgrades are on top of this amount.

Grid Upgrade – Land Requirements

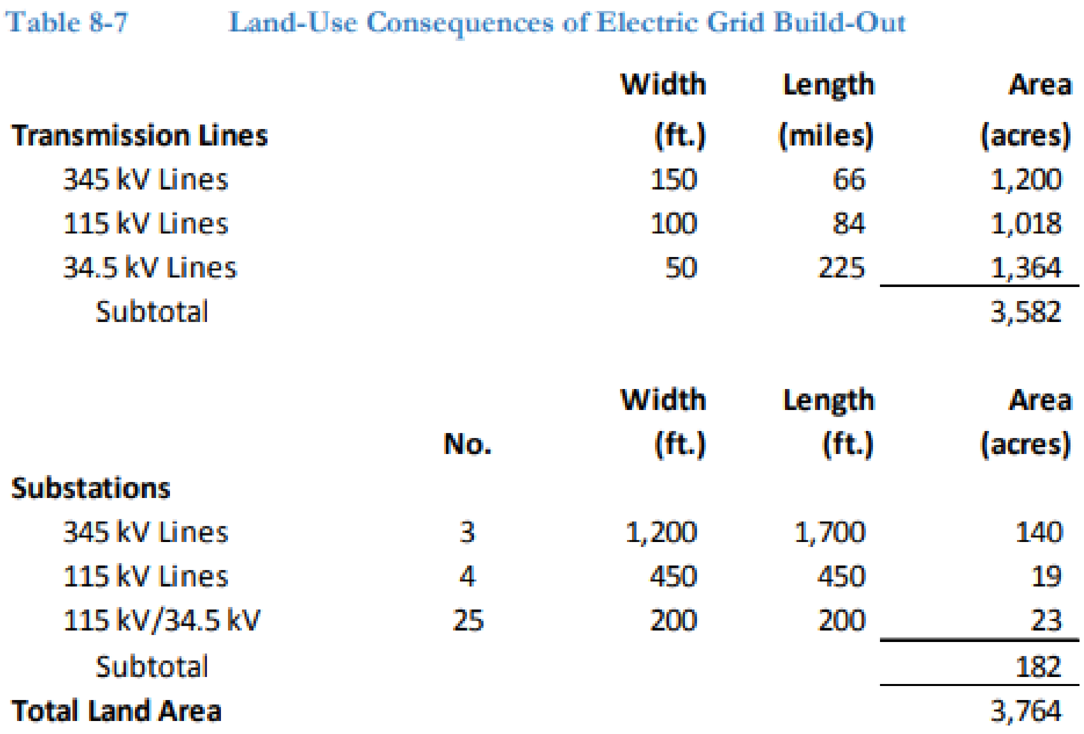


Table 8-7 Land-Use Consequences of Electric Grid Build-Out

Transmission Lines	Width (ft.)	Length (miles)	Area (acres)
345 kV Lines	150	66	1,200
115 kV Lines	100	84	1,018
34.5 kV Lines	50	225	1,364
Subtotal			3,582

Substations	No.	Width (ft.)	Length (ft.)	Area (acres)
345 kV Lines	3	1,200	1,700	140
115 kV Lines	4	450	450	19
115 kV/34.5 kV	25	200	200	23
Subtotal				182
Total Land Area				3,764

Most of the land requirements for the upgrades are for linear corridors.

To put this acreage in perspective, the I-295/I-95 corridor from Freeport to Scarborough takes up a little less than 1,000 acres.

THANK YOU

Competitive Energy SERVICES

DYNAMIC GRID

The $10 Trillion Problem

Estimates from:
*Gupta etal, Spatial analysis of distribution grid capacity and costs to enable massive deployment of PV, electric mobility and electric heating, University of Geneva, and

1898 Company (Burnes and McDonnel), Doug Houseman, Internal research

DYNAMIC GRID

The Challenge

Regulatory solutions are happening too slowly

Why Now?

Rapid growth in DER and Electrification.

Who Cares?

DER and Electrification creates new system dynamics

Why it matters?

need to speed the new solutions, or decarbonization will fail

Slaying the Distribution Dragon

DYNAMIC GRID

Systems Architecture

Apply ’present forward’ + ‘future back’ systems thinking and analysis to evaluate grid expansion proposals so that the grid can function holistically.

DYNAMIC GRID

Grid Architecture

Grid Architecture is critical for making key structural choices to enable a more intelligent, self-optimising power system for the 21st century

VRE & DER energy and systems services rewarded
1

Operational Coordination of desirable system behaviors
1

OPEX and CAPEX efficiencies
2

Affordability, quality and resilience outcomes for all
2

New offerings for customers
1

Enhanced decarbonization
3

Enhanced equity
3

DYNAMIC GRID

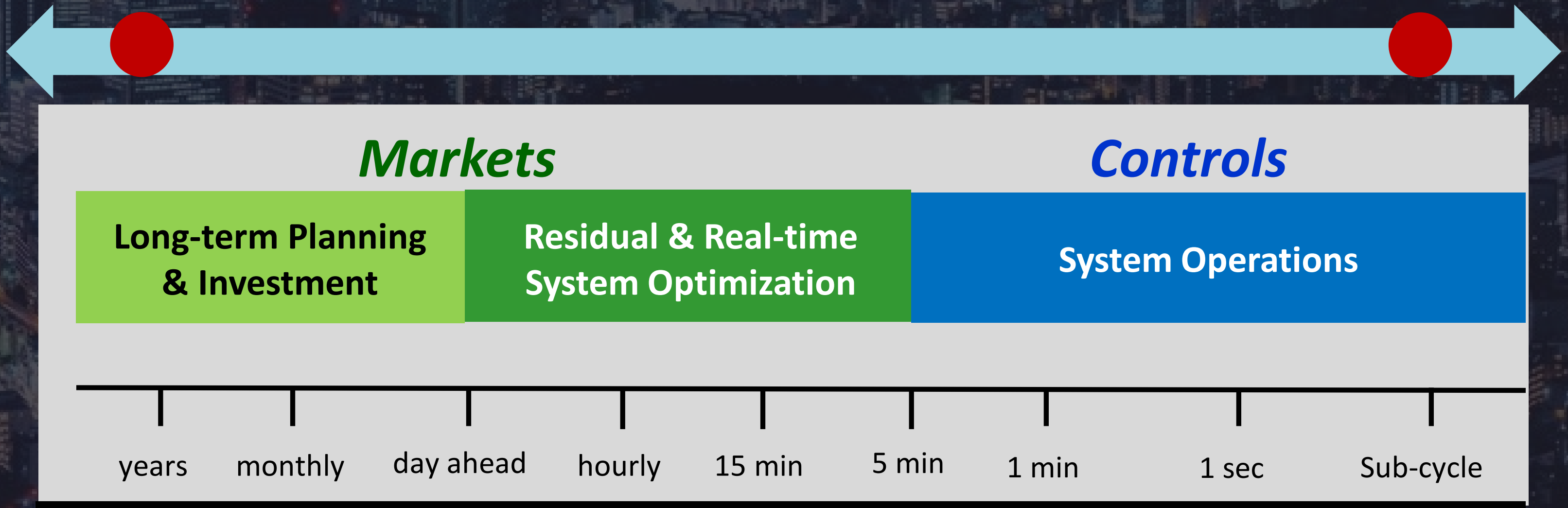
Operational Coordination

Operational Coordination requires interaction between both markets and control structures

Economists
"Get the market rules and prices right and everything will work fine"

✓ Solution:
An ensemble of both market and control features is required

Control Engineers
"Get the algorithms and standards right and everything will work fine"



Markets

Controls

Long-term Planning & Investment	Residual & Real-time System Optimization	System Operations

years | monthly | day ahead | hourly | 15 min | 5 min | 1 min | 1 sec | Sub-cycle

Image / Concept: Newport Consulting and Pacific Northwest National Laboratory (Adapted)