Integrated Resource Planning

Roundtable 17-2

May 10, 2017

Meeting Logistics

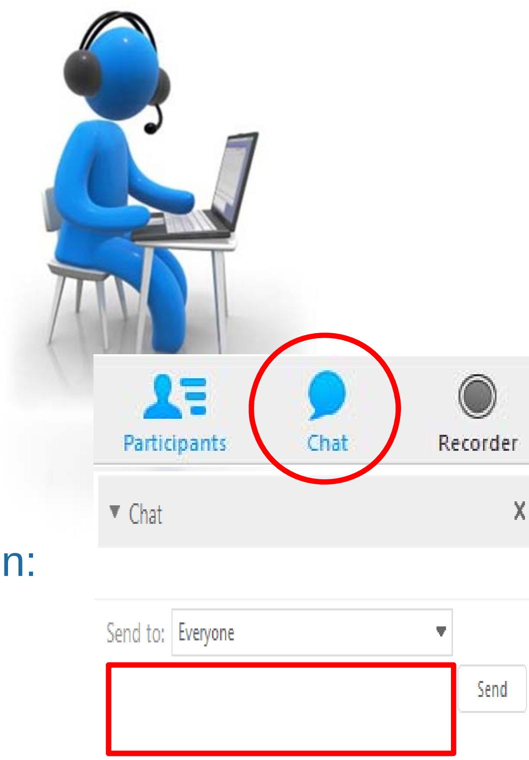
Local Participants:

- World Trade Center facility
- Wireless internet access
  - Network: 2WTC_Event
  - Password: 2WTC_Event$
- Sign-in sheets

Virtual Participants:

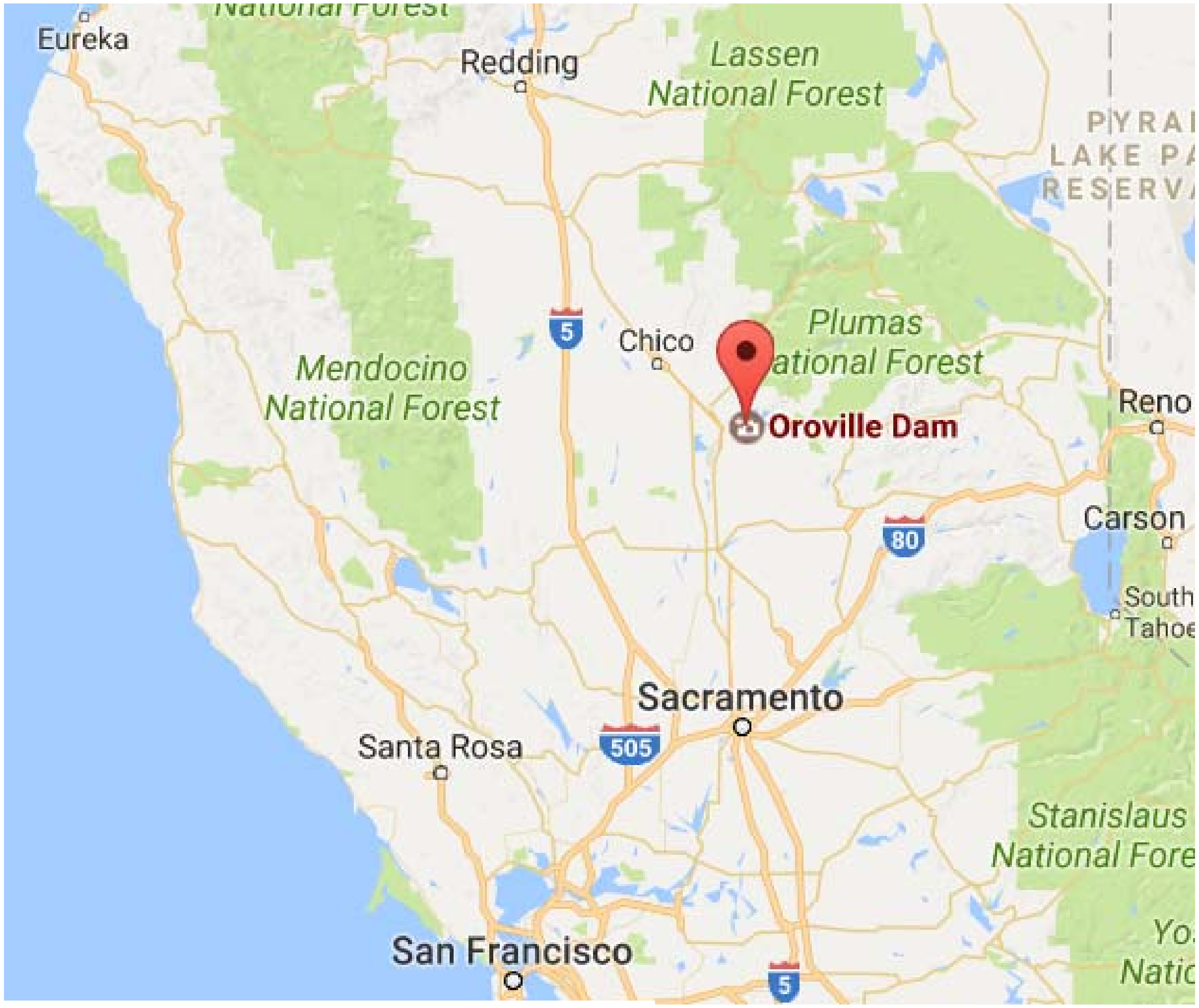
- Ask questions via 'chat' feature
- Meeting will stay open during breaks, but will be muted
- Electronic version of presentation: *portlandgeneral.com/irp*

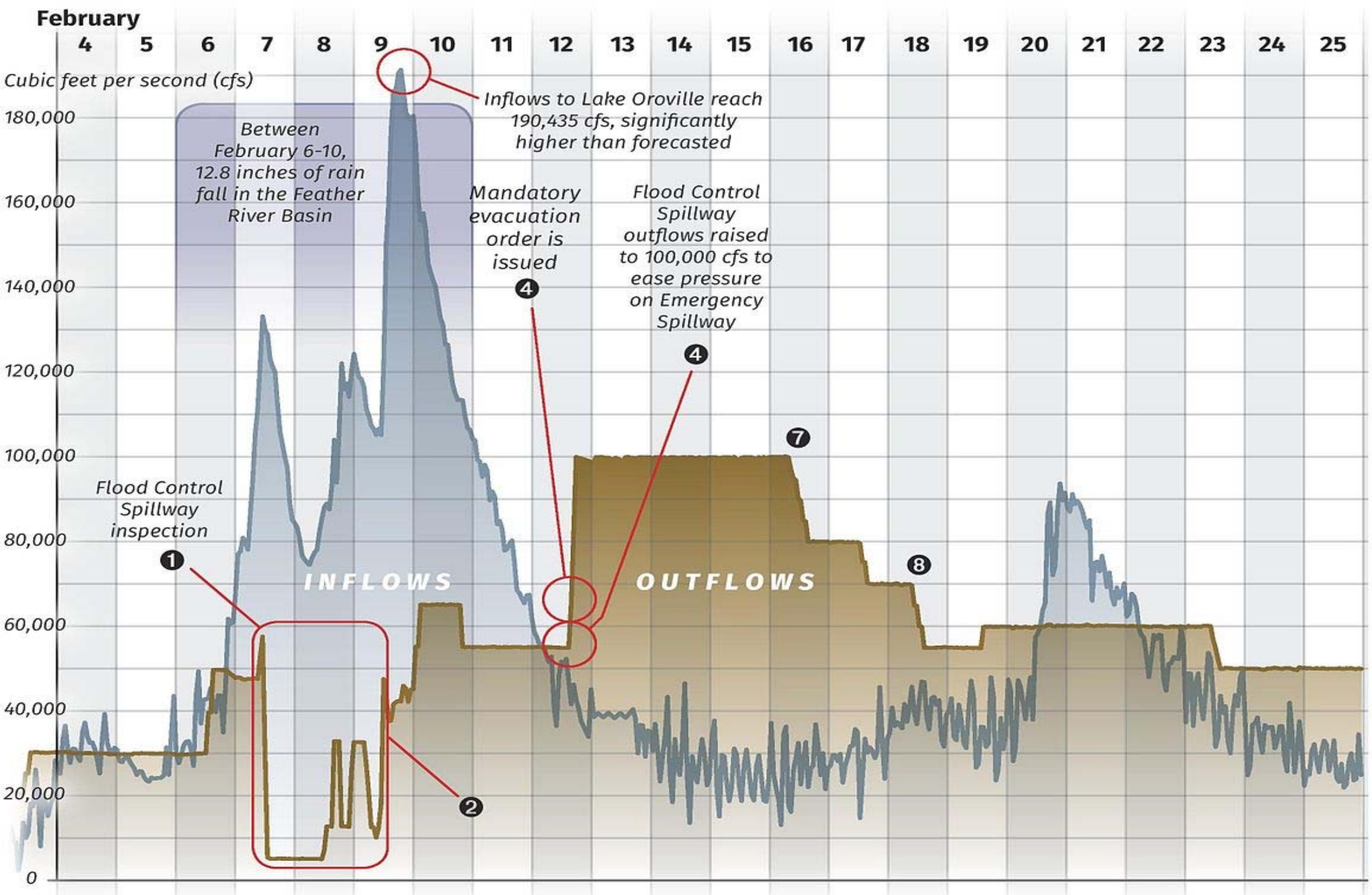
>> Integrated Resource Planning



Safety Moment

Oroville Dam





By California Department of Water Resources - Lake Oroville Spillway Incident: Timeline of Major Events February 4-20, Public Domain, https://commons.wikimedia.org/w/index.php?curid=56768391

Safety Moment

Oroville Dam

More information:

https://twitter.com/CANGJ3OPS

http://www.cnn.com/2017/02/13/us/california-oroville-dam-spillway-failure/

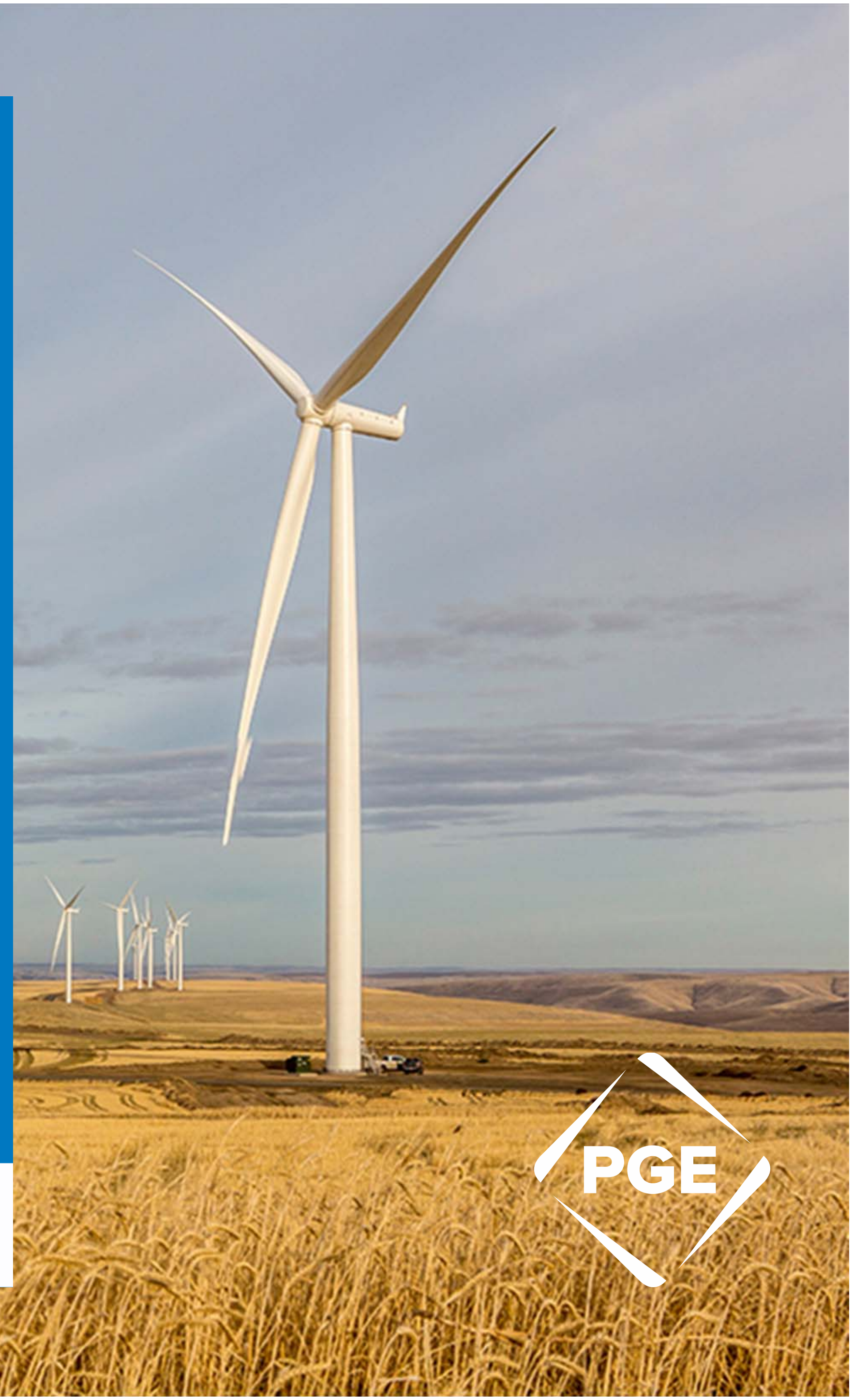
http://www.npr.org/2015/10/11/447181629/aging-and-underfunded-americas-dam-safety-problem-in-4-charts

Today's Roundtable Topics

9:00a	**Start**
9:00a	Welcome / Safety Moment
9:15a	2016 IRP Update
9:45a	IRP Process Deep Dive
10:45a	**Break (15 minutes)**
11:00a	IRP Development Schedule
11:30a	Resource Options & Resource Cost Studies
12:15p	**Lunch (30 minutes)**
12:45p	PGE's Inputs EE
1:15p	Energy Efficiency Cost-Effectiveness Methodology
2:00p	Next Steps/Wrap-Up
2:15p	**Adjourn**

2016 IRP Update

Franco Albi



2016 IRP Progress

Demand Reduction

- **Energy Efficiency: 176 MW**
- **Demand Response: 77 MW**

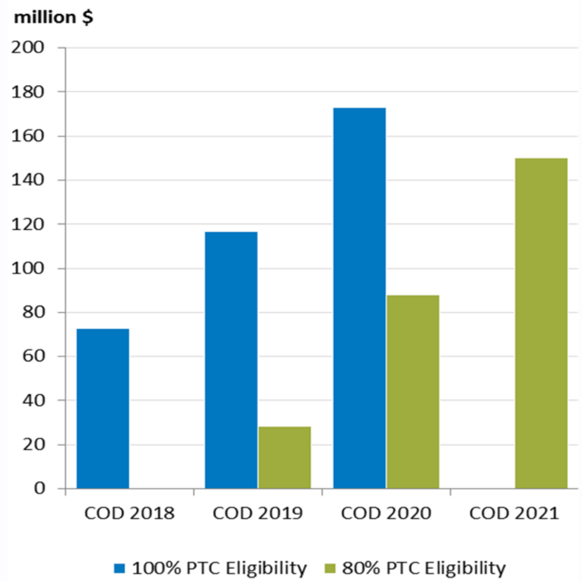
RPS Renewables

- **RFP for up to ~175 MWa of RPS resources**
- **Maximize PTC value**
- **Potential NPVRR savings of ~ $170M**

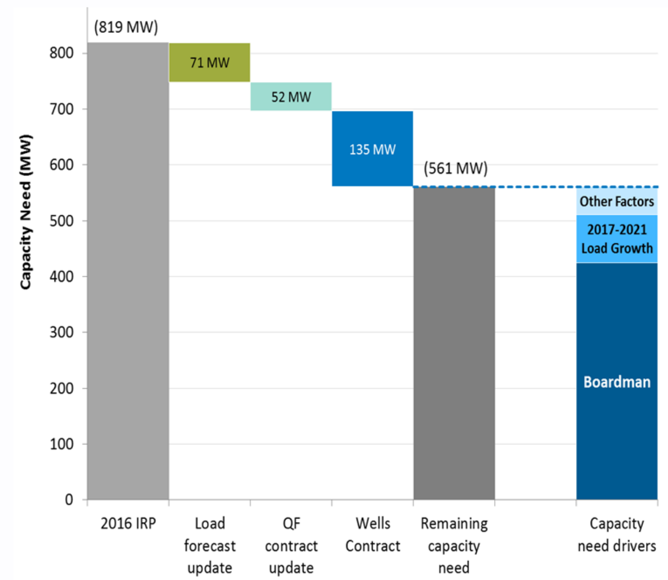
Capacity

- **561 MW capacity**
- **Pursuing bilateral negotiations**
- **Plan to issue RFP for remaining need**

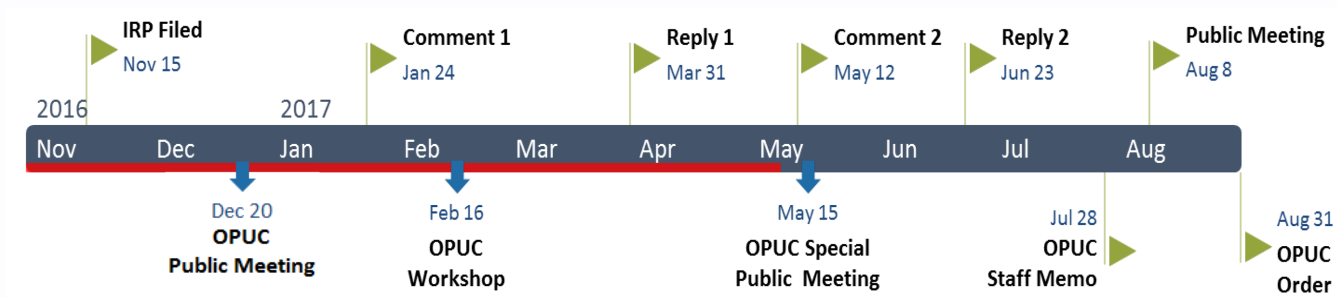
RPS Renewable Value



Capacity Need



Schedule



Acquisition with 2020 COD maximizes production tax credit (PTC) value before phase-out erodes opportunity

Renewable Value

Economics support renewable acquisition now to capture value of federal Production Tax Credits for customers

PTC value vs Delay

2016$, millions	Commercial Operation Date (COD) 2018	2019	2020	2021
100% PTC	$72.7	$116.8	**$172.8**	
80% PTC		$28.4	$88.1	**$150.2**
60% PTC			$3.4	$68.7
40% PTC				–$12.7

SB1547 RPS obligations

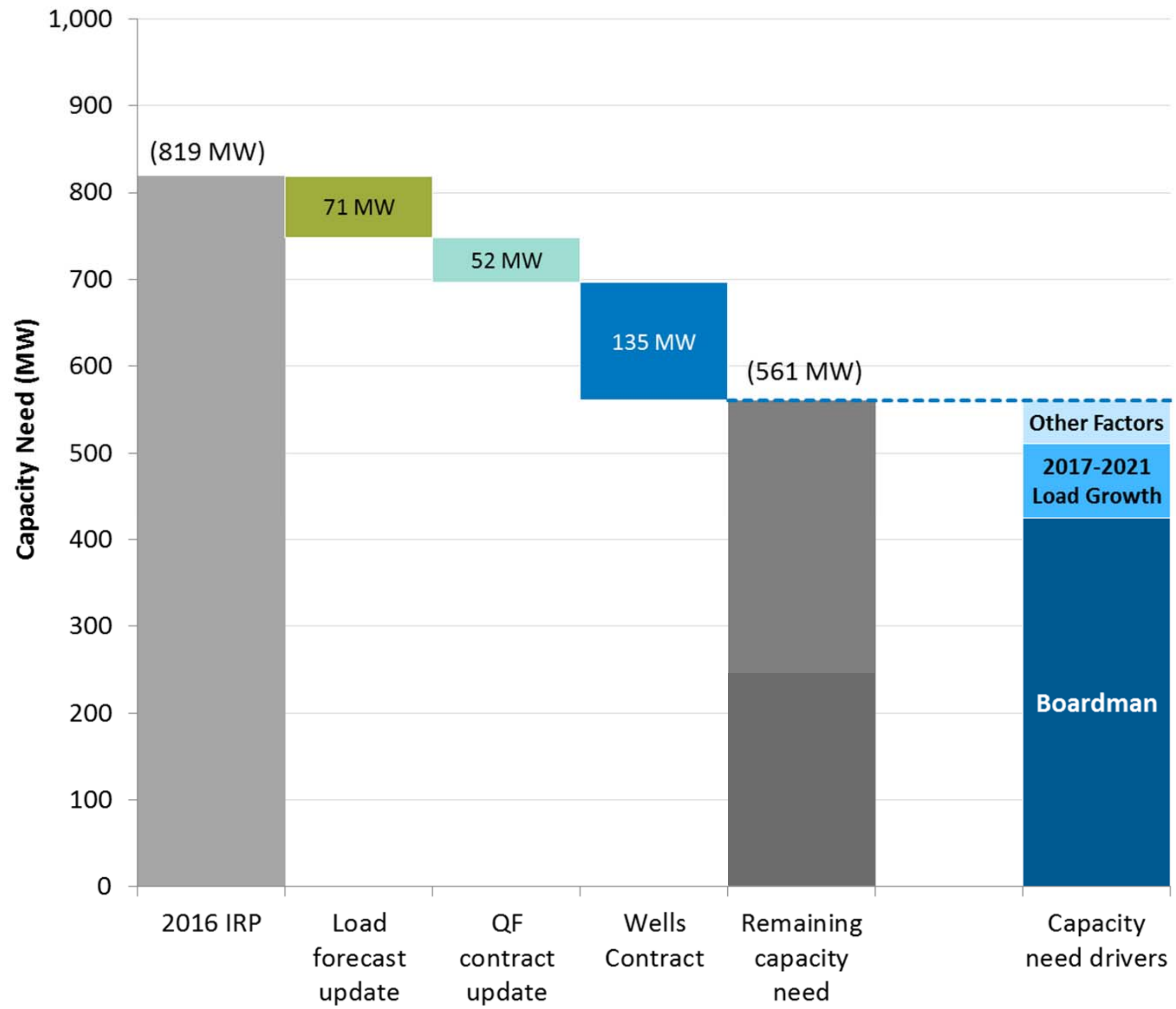
Year	% of Retail Load
2015	15%
2020	20%
2025	27%
2030	35%
2035	45%
2040	50%

Values in the table represent the delta in net present value of revenue requirements (NPVRR) between the PTC/COD shown and a delayed acquisition in which incremental physical renewables are deferred using Renewable Energy Certificates (REC)

Capacity Need

Action Plan working as intended; allows for load forecast updates and new executed contracts to reduce need ahead of RFP

At a minimum, 240MW of the remaining capacity need must be annual dispatchable



PGE is always exploring opportunities to acquire reliable and cost-effective energy and capacity for our customers

Bilateral Discussions

"[I]t makes sense to explore any compelling and time-limited opportunity to acquire existing capacity, particularly while market prices are historically low"

– PGE Reply Comments

- PGE continues to pursue bilateral discussions to determine the feasibility for developing executable contracts
- Any such bilateral transactions would occur outside the traditional RFP process
- If the market produces a desirable solution, PGE intends to submit contracts to the Commission for review along with a request for waiver of the Commission's Competitive Bidding Guidelines
- PGE will provide the Commission with a report on the status of its bilateral negotiations and an update on the amount of capacity that it needs to procure (based on newly executed contracts and approved waivers) before issuing an RFP for capacity

PGE continues to explore the possibility of submitting a benchmark bid in a future renewable resource RFP

Benchmark Resources

PGE has identified a potential benchmark wind resource and is exploring the development of an energy storage site

Wind Benchmark

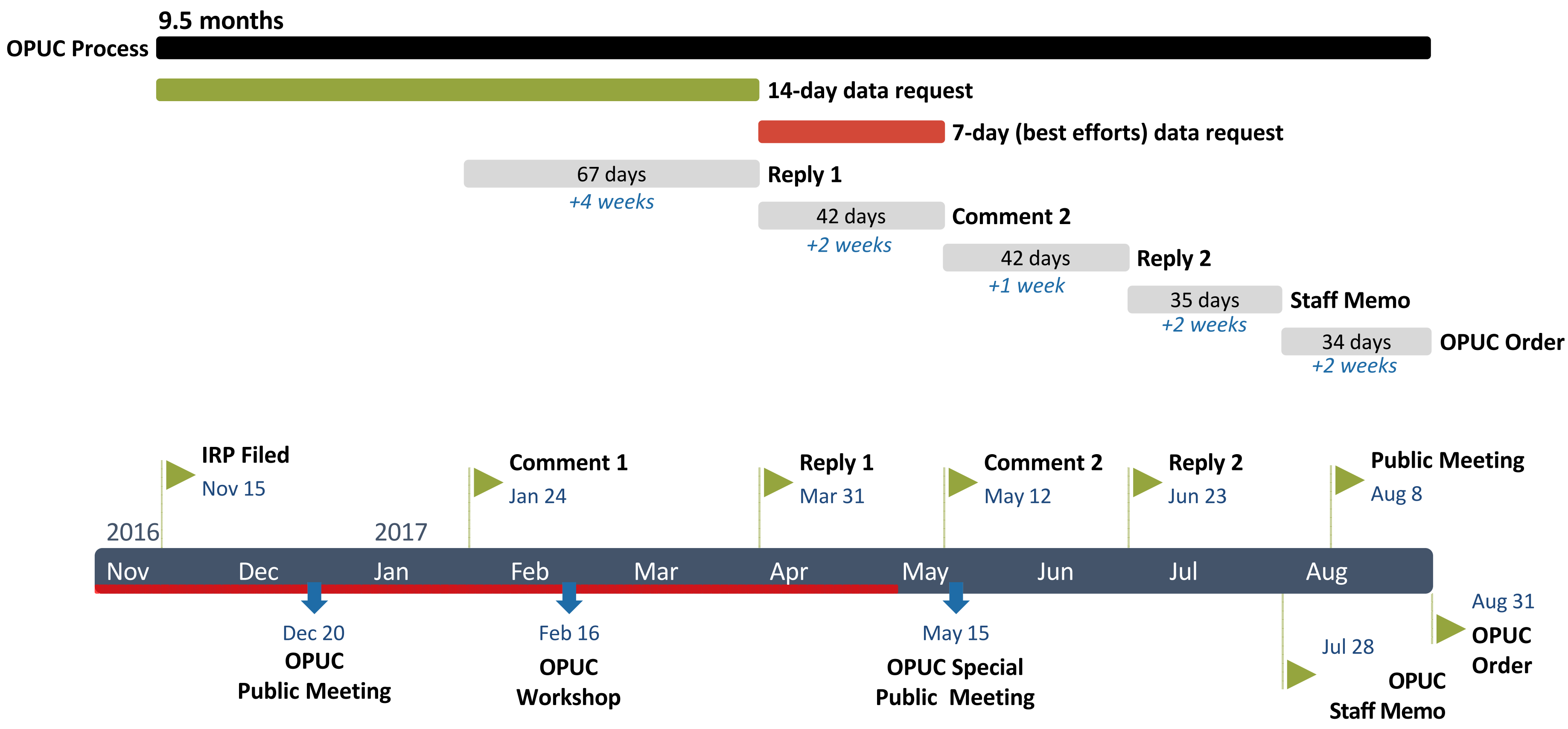
- PGE has identified a wind project with a nameplate capacity of up to approximately 500 MW and located in eastern Oregon
- PGE will inform the Commission and parties if, and when, it signs definitive agreements enabling it to submit the project as a benchmark bid

Storage Benchmark

- PGE continues to explore the possibility of developing a site with technical specifications that the Company could offer to potential bidders in an RFP

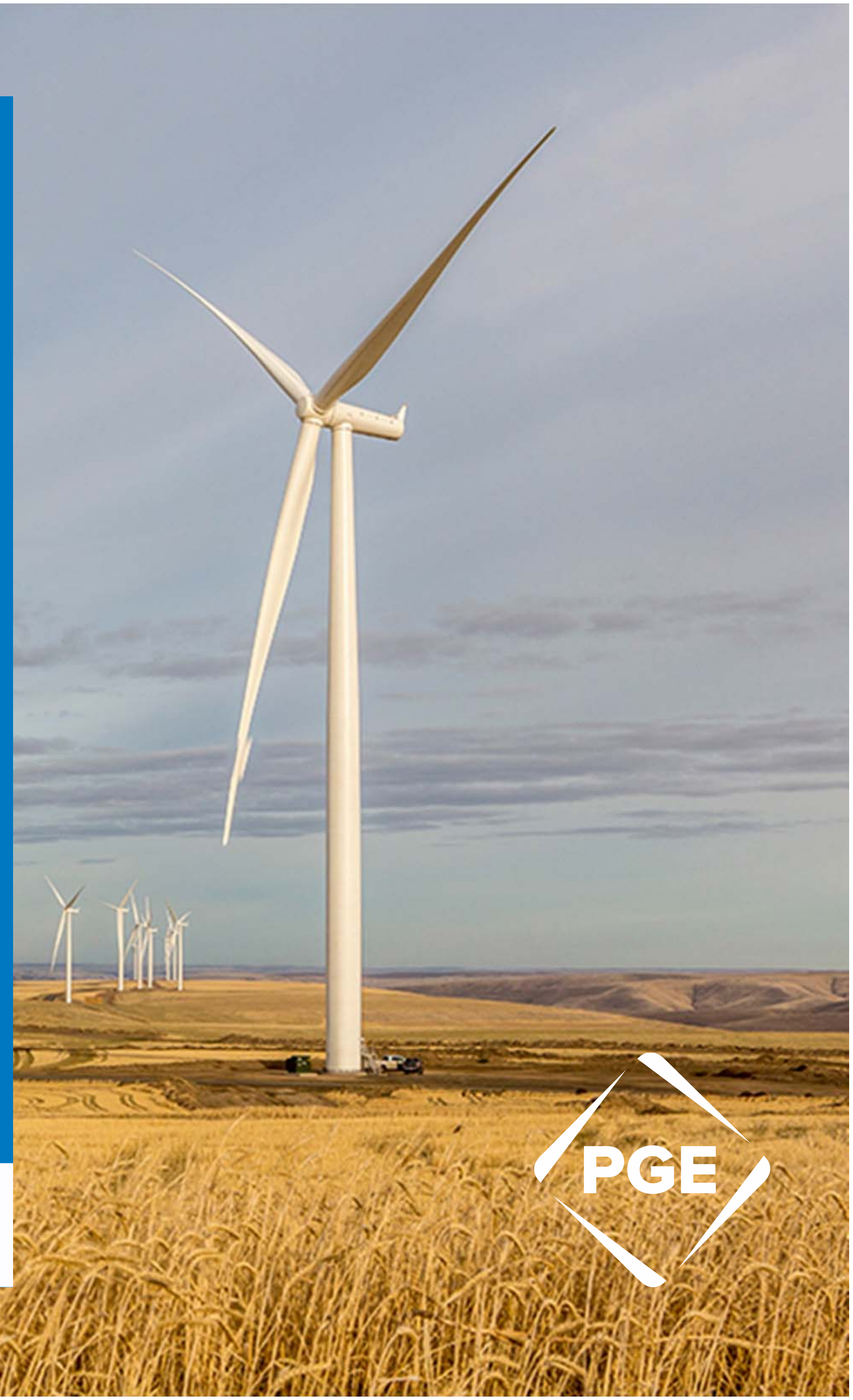
IRP Acknowledgement Schedule

OPUC Order expected on or before August 31, 2017



IRP Process Deep Dive

Elaine Hart
Kate von Reis Baron



IRP Modeling Process

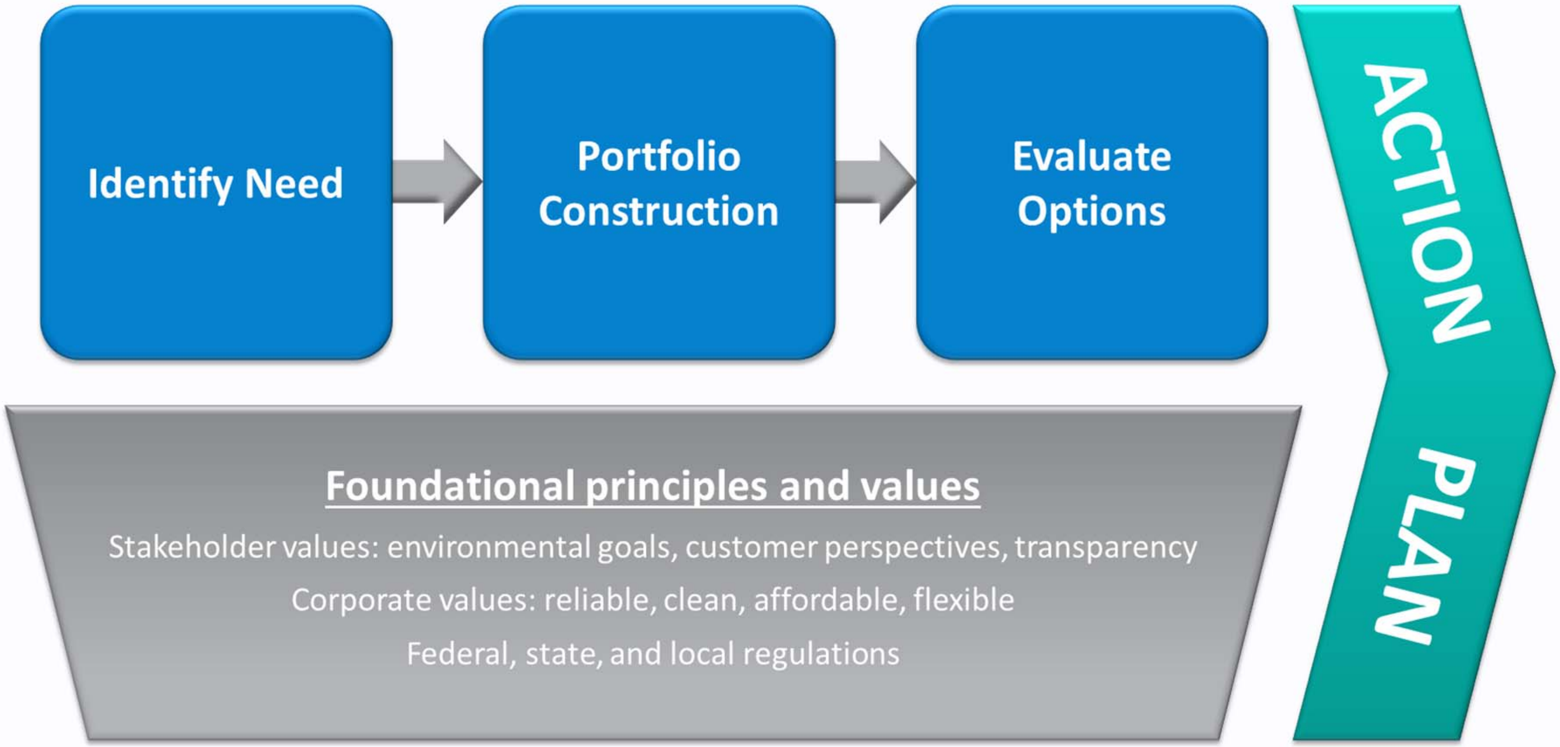
Feedback from Stakeholders at Roundtable #16-2 suggested that a more detailed discussion of the IRP modeling process would provide Stakeholders with important context.

Goals for today:

- Describe the IRP modeling process at a high level
- Establish a recurring map to help place future IRP discussions into context
- Identify key areas of interest for future technical meetings, learning more about methodology, or providing feedback

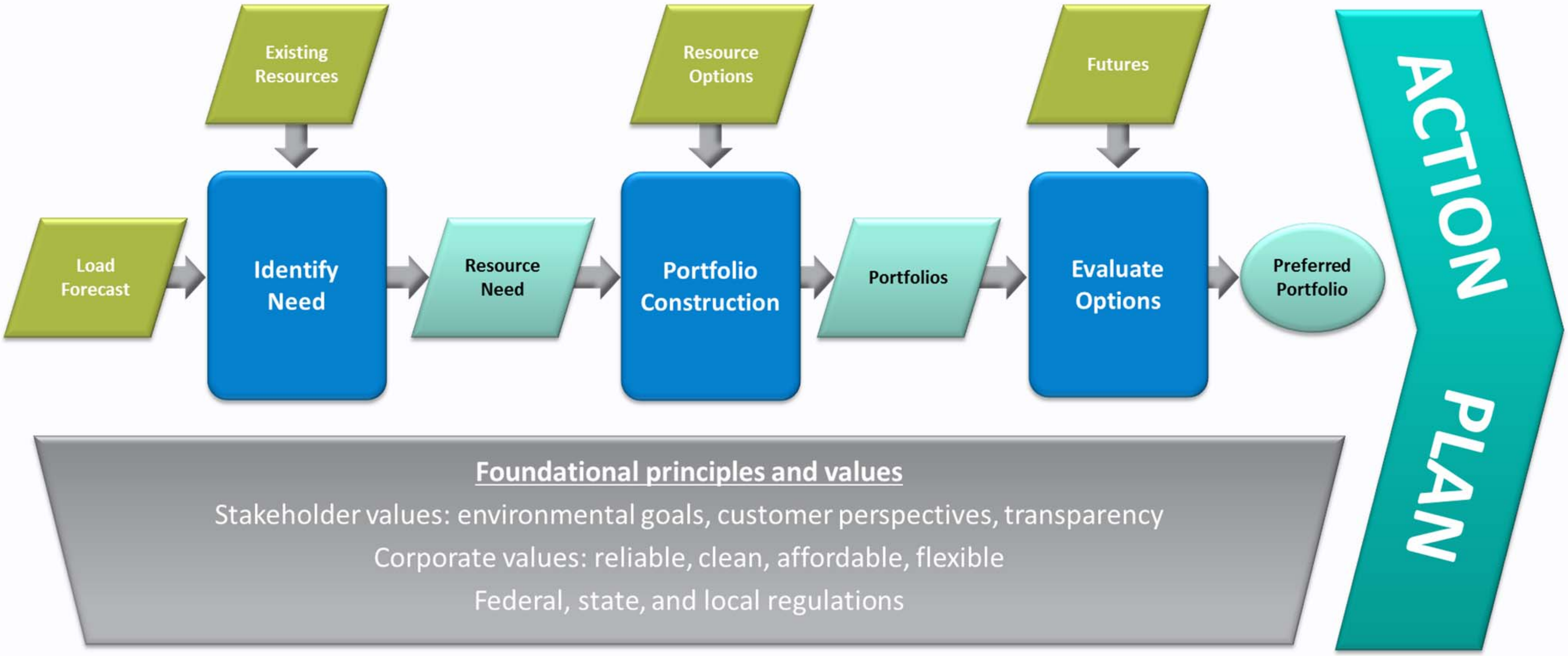
IRP Modeling Process

- The IRP modeling process has three primary steps, which inform the IRP Action Plan
- Both the modeling process and the development of the Action Plan rely on a common set of foundational principles and values



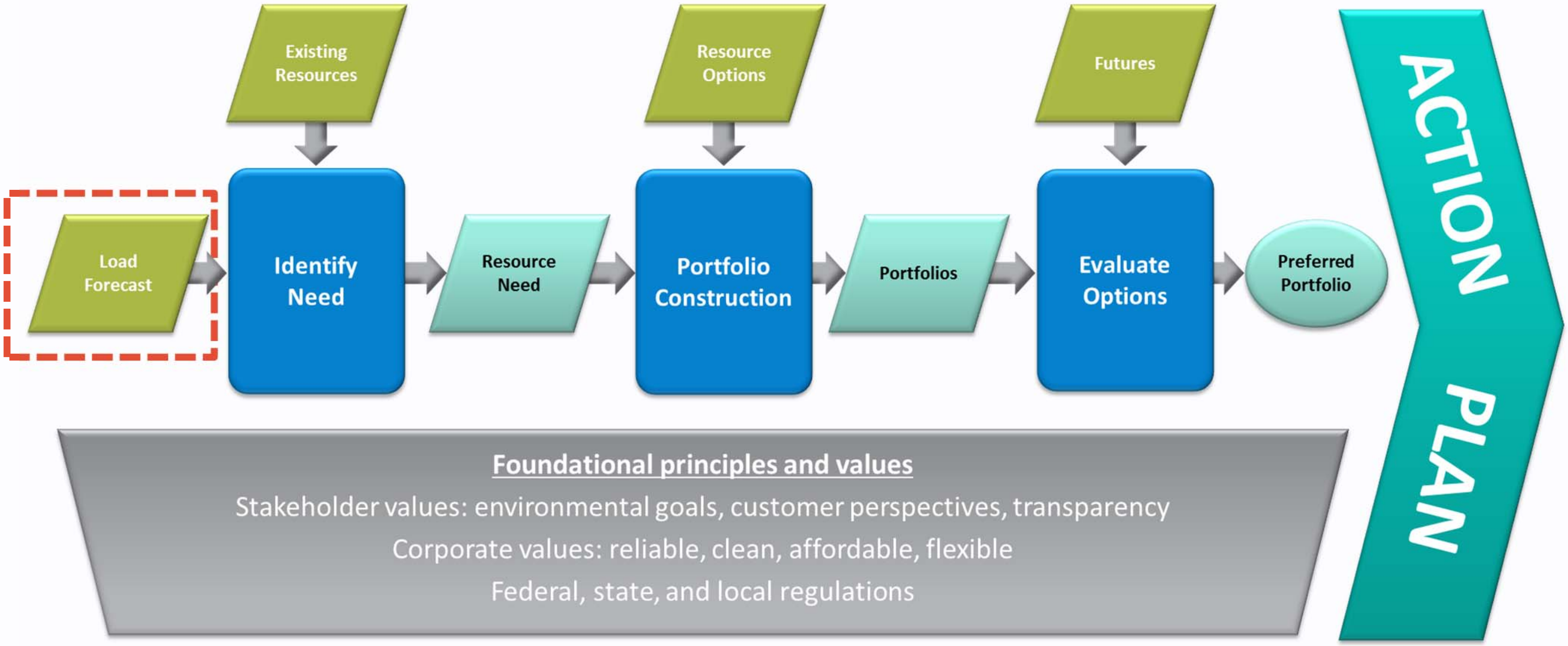
IRP Modeling Process

- The primary steps utilize input data developed in a number of sub-processes, summarized by four areas below



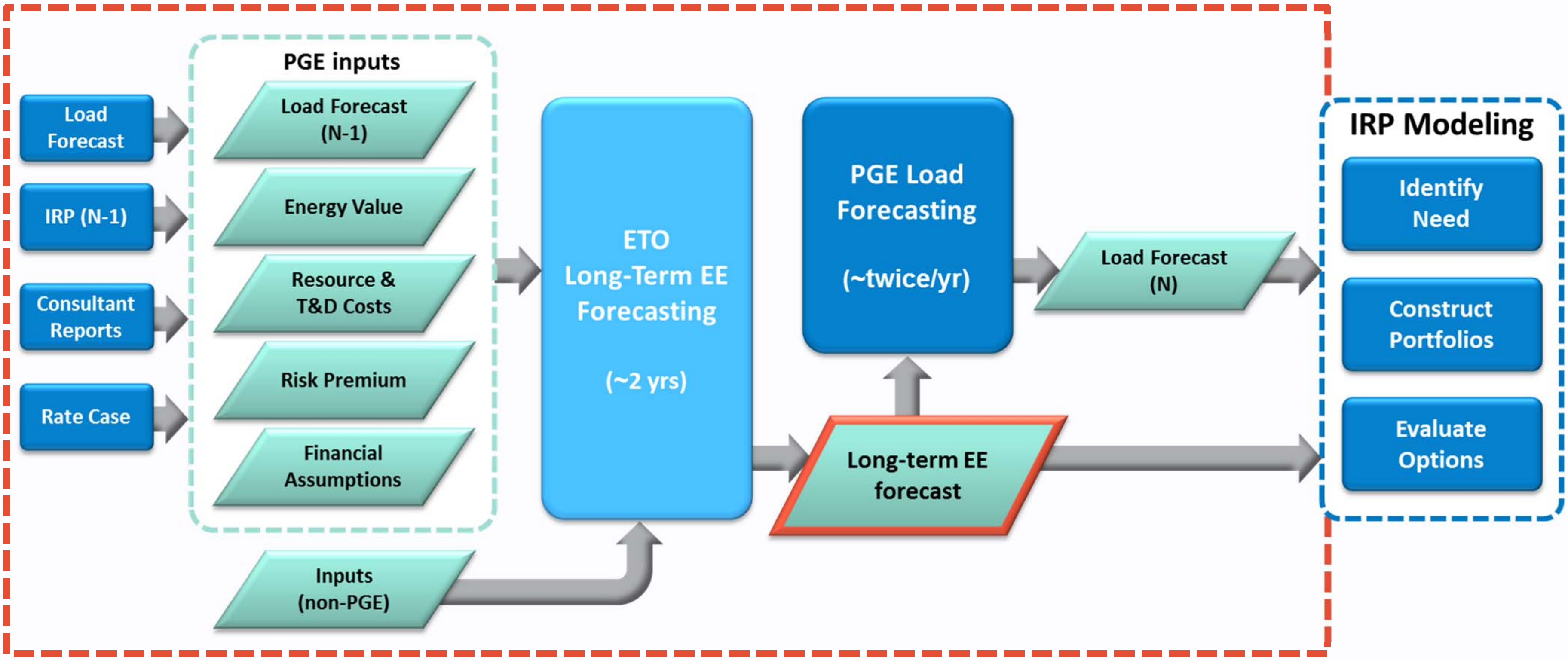
IRP Modeling Process

- Zoom in on “Load Forecast” to focus on the energy efficiency forecasting process



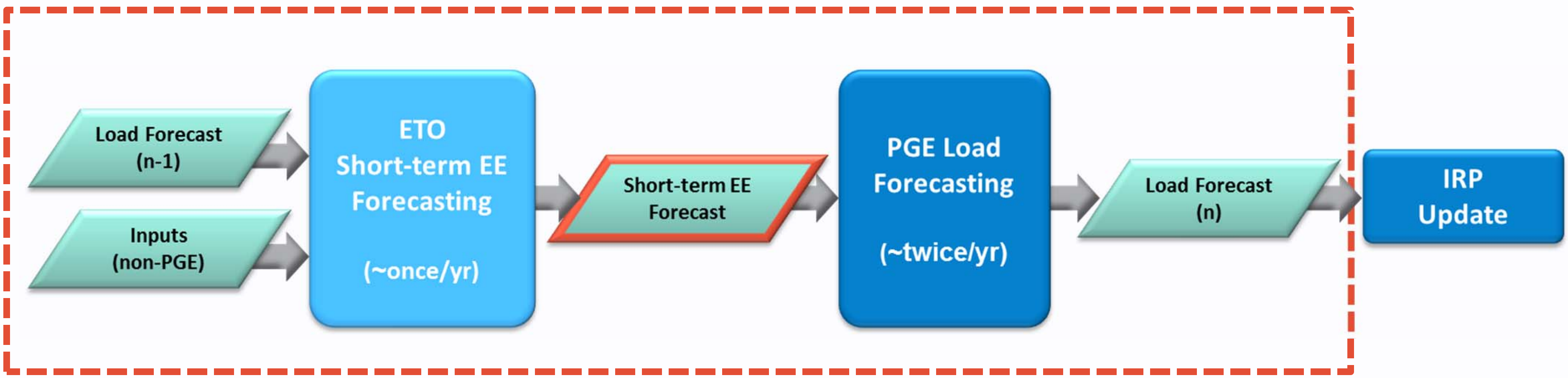
Energy Efficiency

- Long-term energy efficiency forecast process



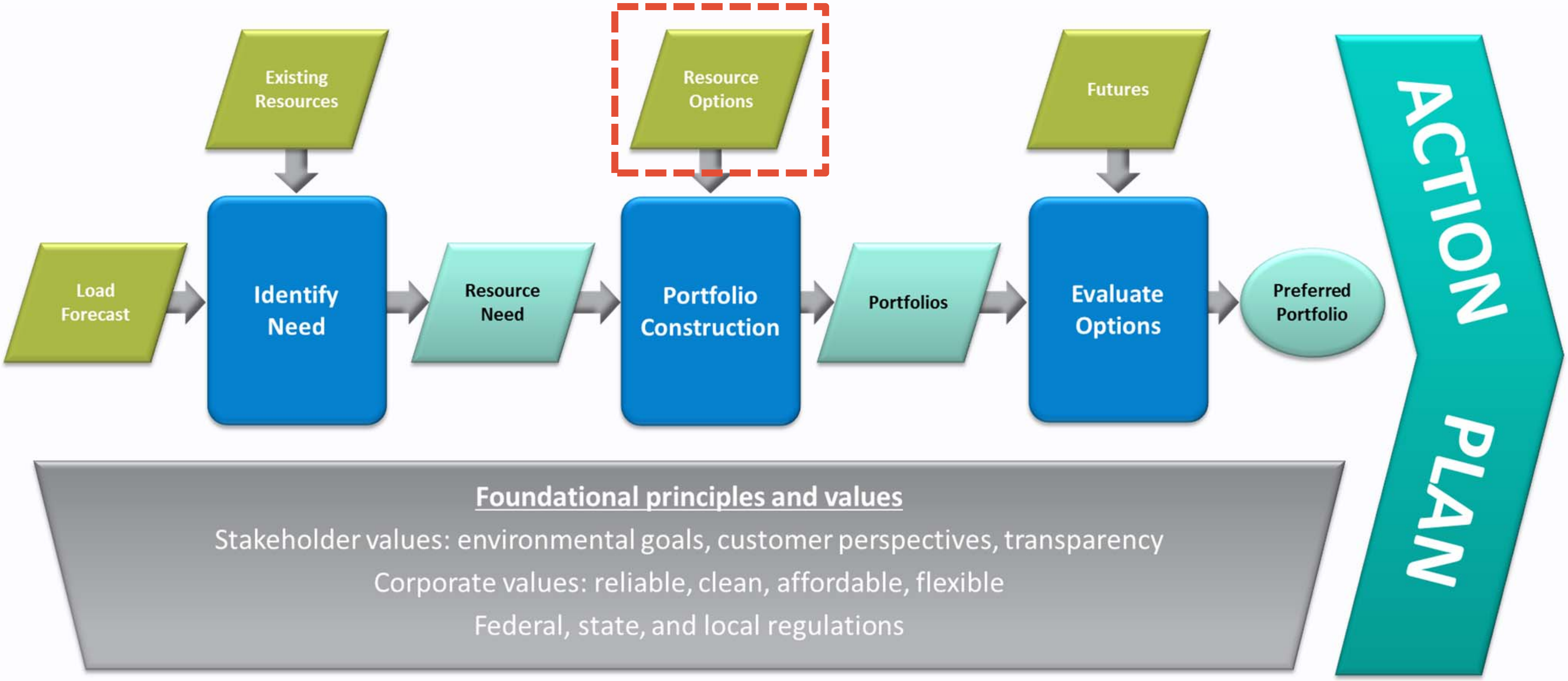
Energy Efficiency

- Short-term energy efficiency forecast process



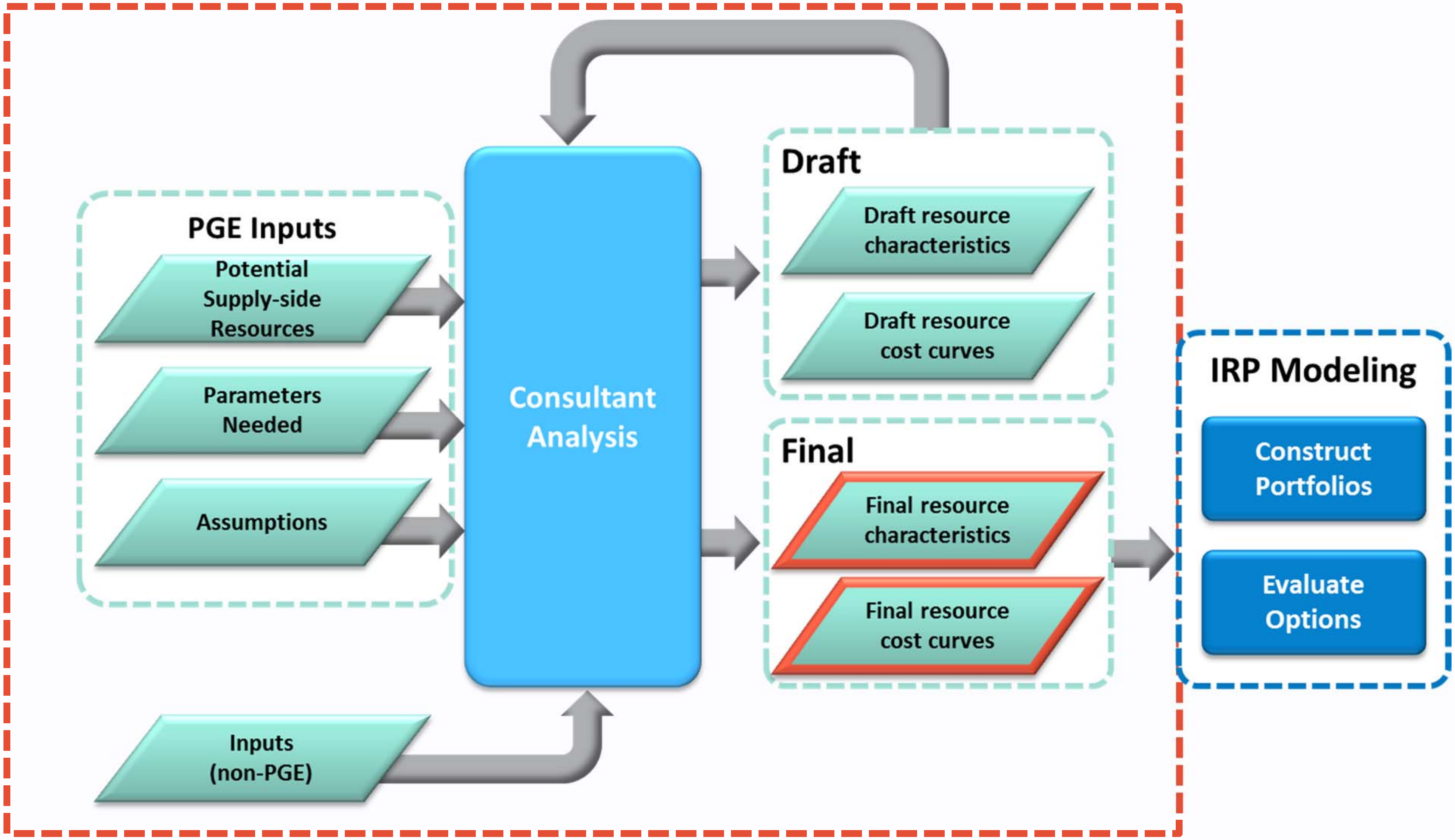
IRP Modeling Process

- Zoom in on “Resource Options” to focus on Supply-side Resource Options



Supply-side Resources

- Performance and cost parameters for supply-side resources



The IRP process will include technical meetings to focus on the details of key topics

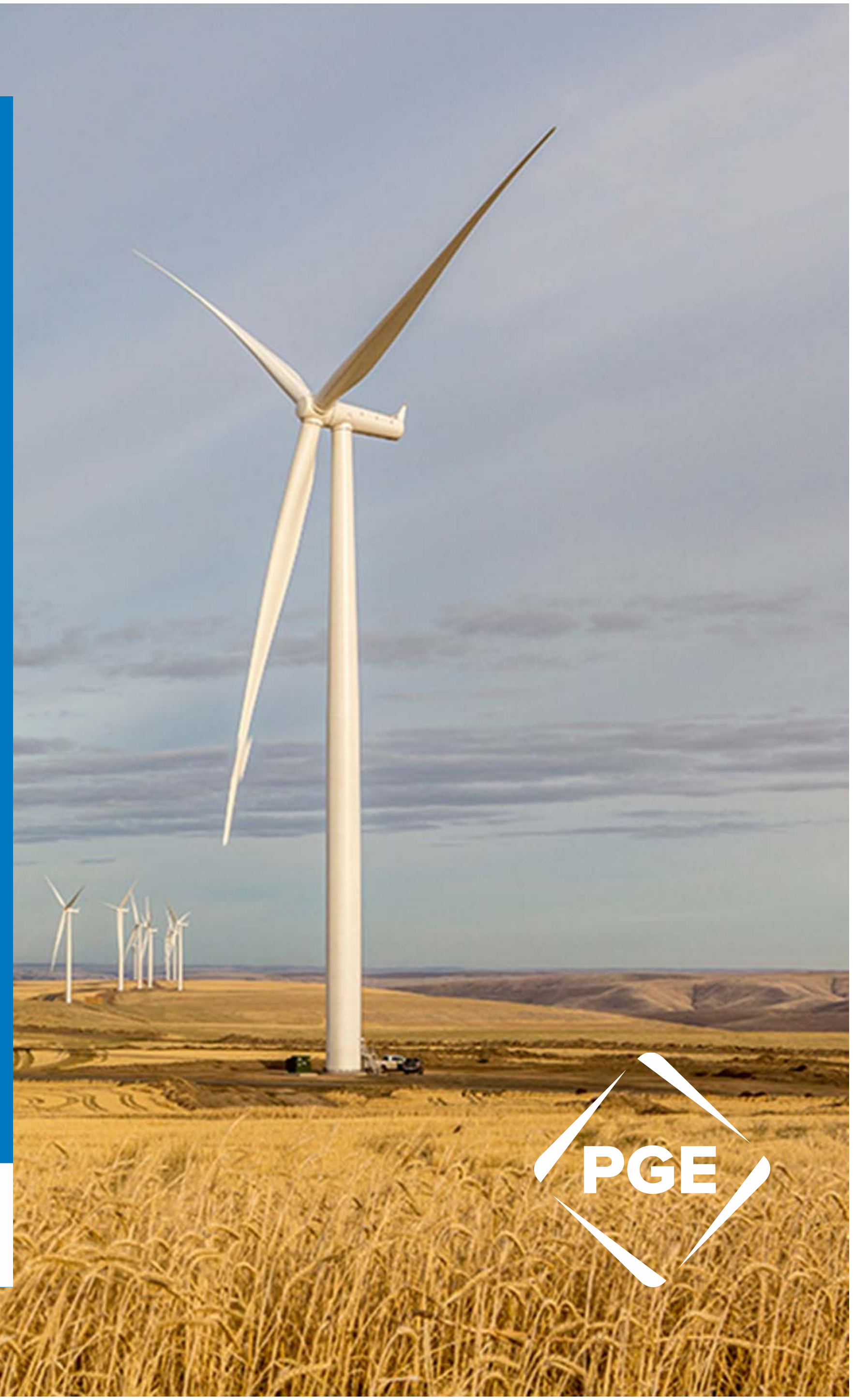
Technical Meetings

- **Topics of interest for focused discussions**

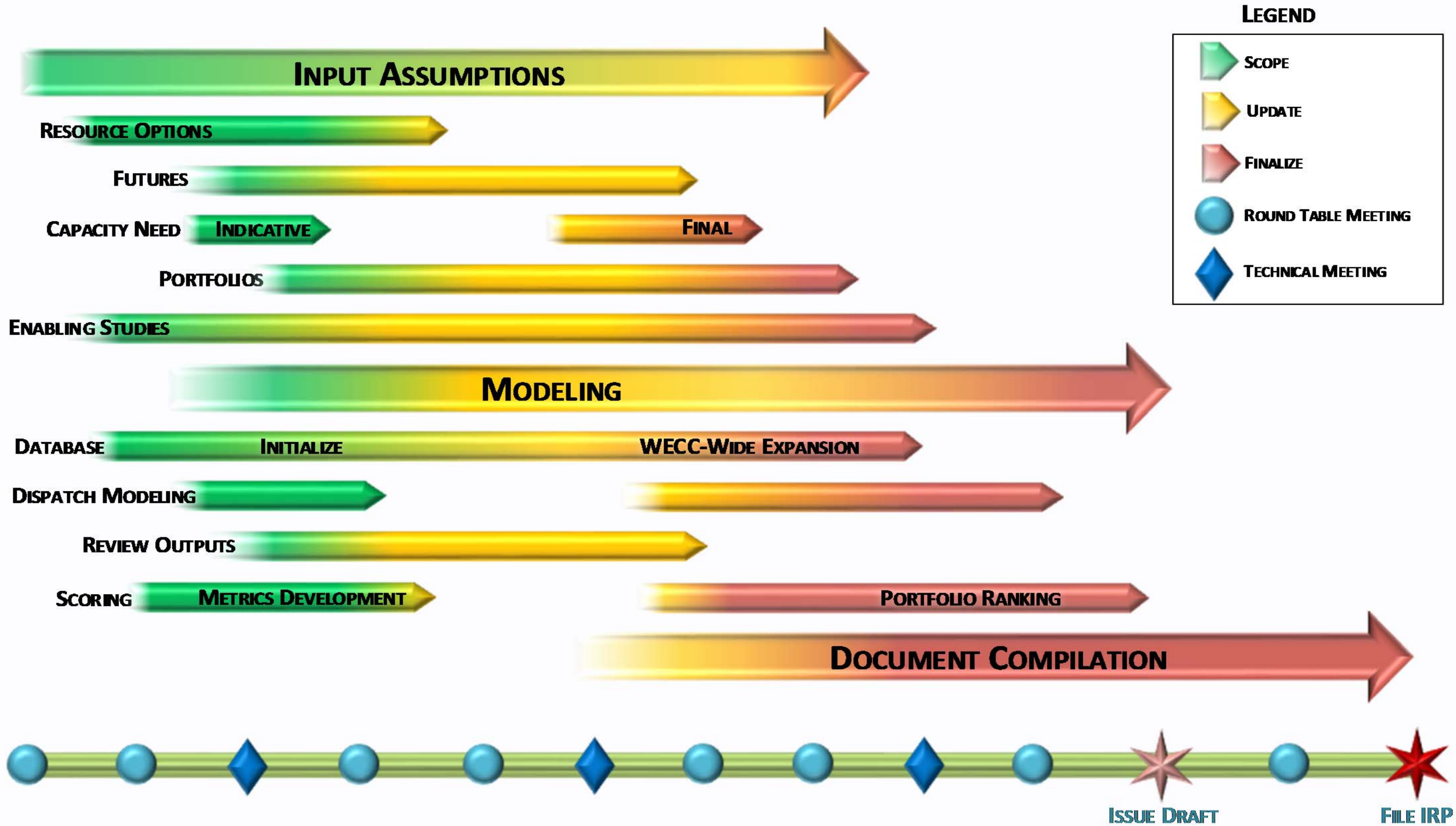
- ❑ Load forecast
- ❑ Portfolio construction
- ❑ Portfolio scoring
- ❑ AURORA modeling
- ❑ RPS strategy
- ❑ Additional topics?

IRP Development Schedule

Shauna Jensen

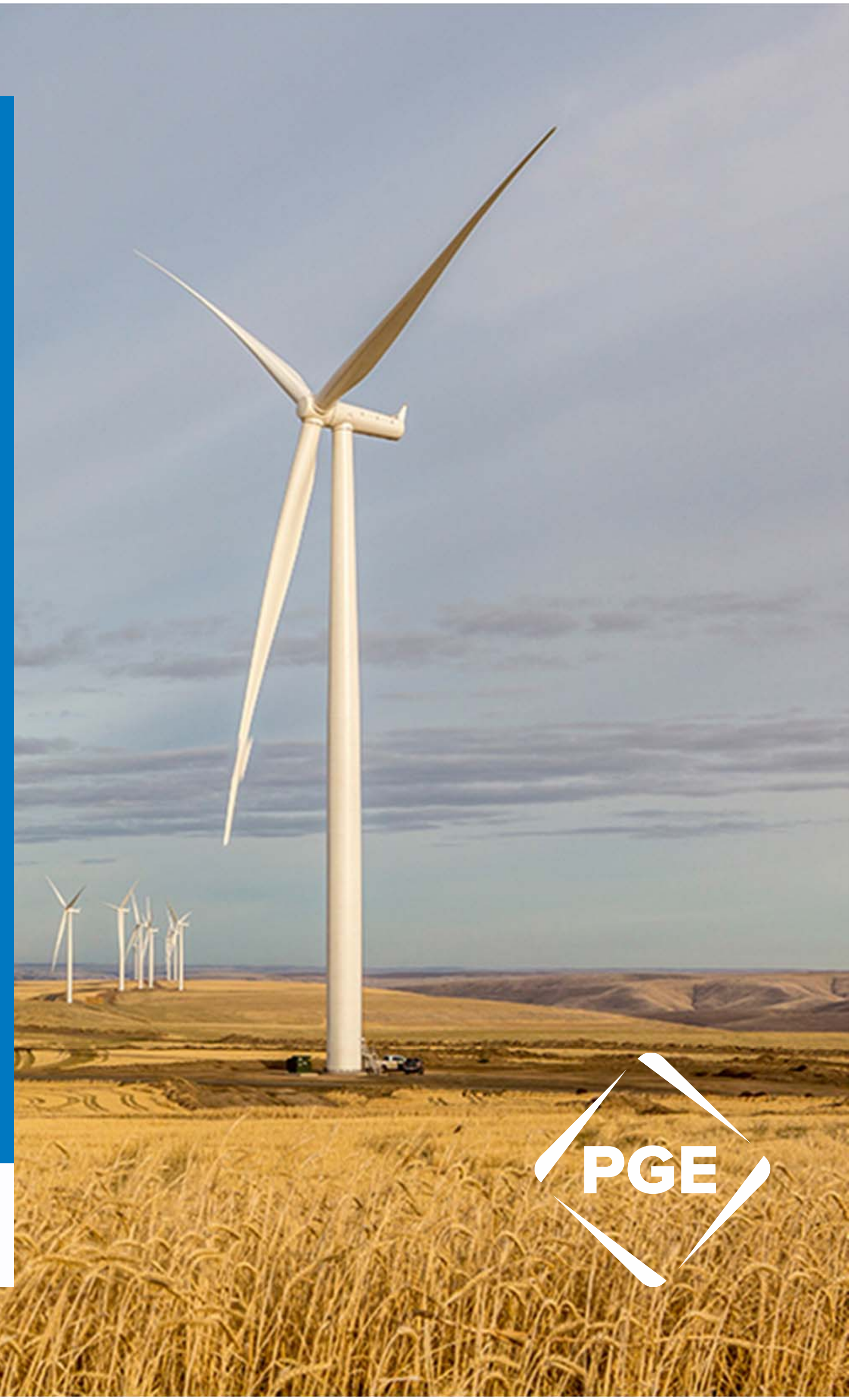


IRP Development Schedule



Resource Options & Resource Cost Studies

Sima Beitinjaneh



Consultants developed cost and technical assumptions for generic resources

Supply side options in the 2016 IRP

- In March 2015, PGE commissioned Black & Veatch and DNV-GL to develop technical and financial assumptions
- Final reports were obtained at the end of 2015.
- Results of the studies are described in detail in Chapter 7
- Full reports are attached in Appendices J, K and M
- 16 generic resource options were considered in the 2016 IRP

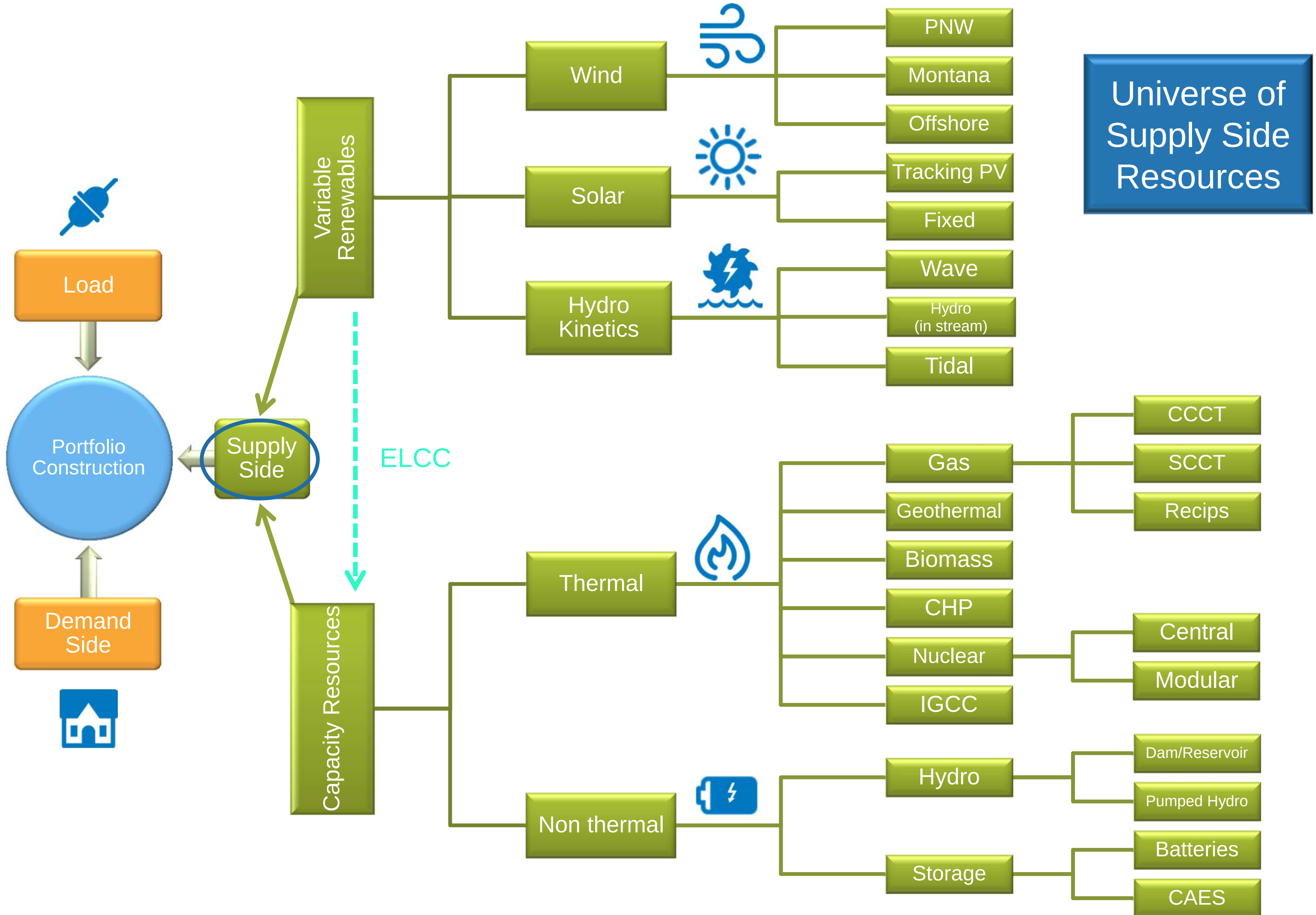
BLACK & VEATCH

DNV·GL

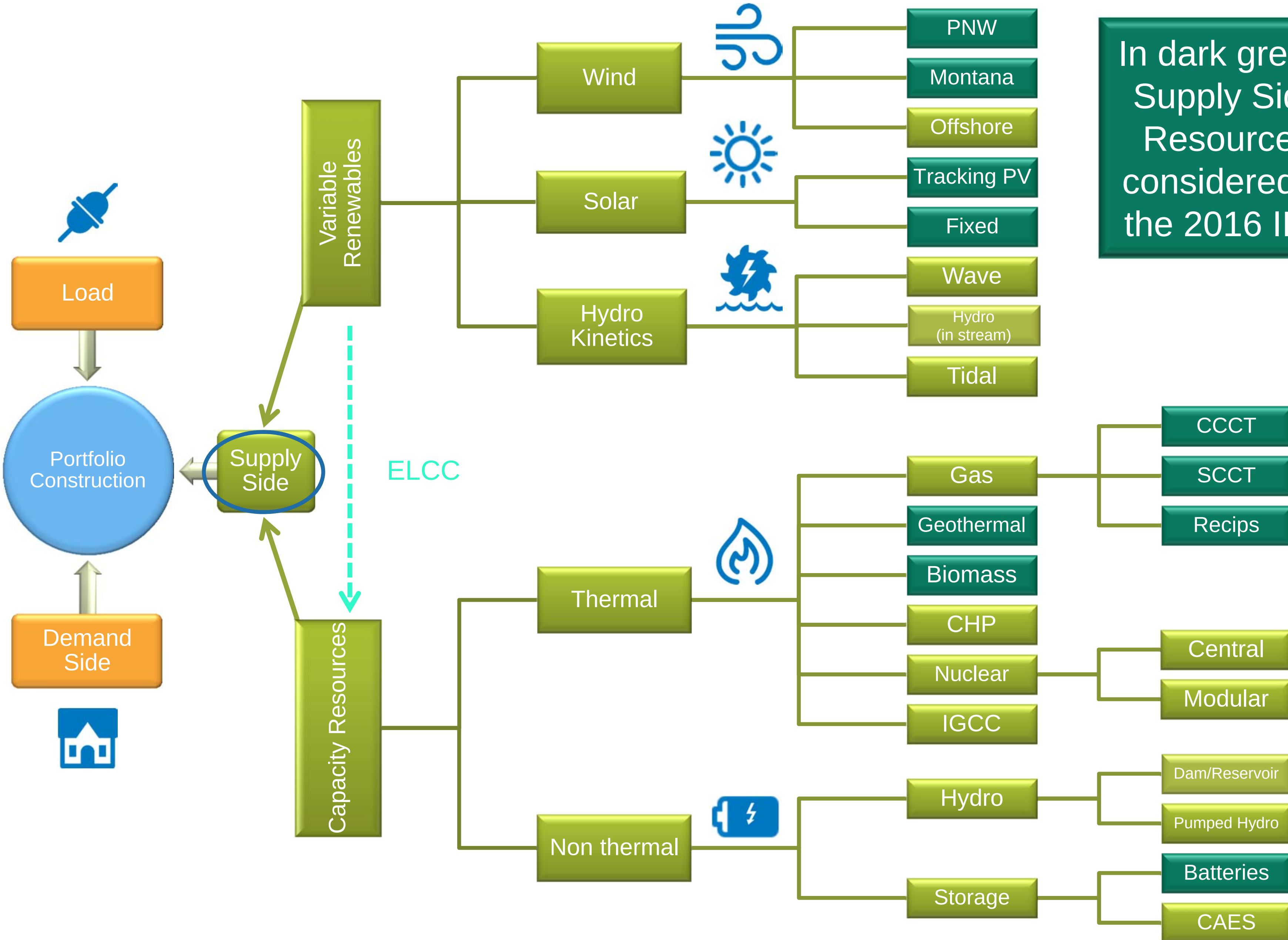
In the next IRP, PGE will work with consultants to develop resource characteristics for additional technologies

Supply side options in the next IRP

- For the 2016 IRP update, PGE is planning to engage Black & Veatch and DNV-GL to refresh the cost estimates
- For the next IRP, PGE will work with consultants to develop new studies with the goal of identifying and including an expanded list of resource options
- Additional, and more detailed, financial and operational characteristics will be included to better fit our constantly changing modeling capabilities
- PGE will evaluate more technologies that will be available and commercially viable during the time horizon of the next IRP



Universe of Supply Side Resources
Load
Portfolio Construction
Demand Side
Supply Side
ELCC
Variable Renewables
Capacity Resources
Wind
Solar
Hydro Kinetics
Thermal
Non thermal
PNW
Montana
Offshore
Tracking PV
Fixed
Wave
Hydro (in stream)
Tidal
Gas
Geothermal
Biomass
CHP
Nuclear
IGCC
Hydro
Storage
CCCT
SCCT
Recips
Central
Modular
Dam/Reservoir
Pumped Hydro
Batteries
CAES



In dark green, Supply Side Resources considered in the 2016 IRP

2016 IRP Supply options cost and technical parameters

Thermodynamic Resources	Renewable Resources	Energy Storage Resources

- Ten Cost Parameters
  - What are the fixed and variable costs of the resource?
- Thirteen Technical Parameters
  - What are capabilities of the resource?
- Technical Maturity Outlook
  - How will the resource costs change over time?

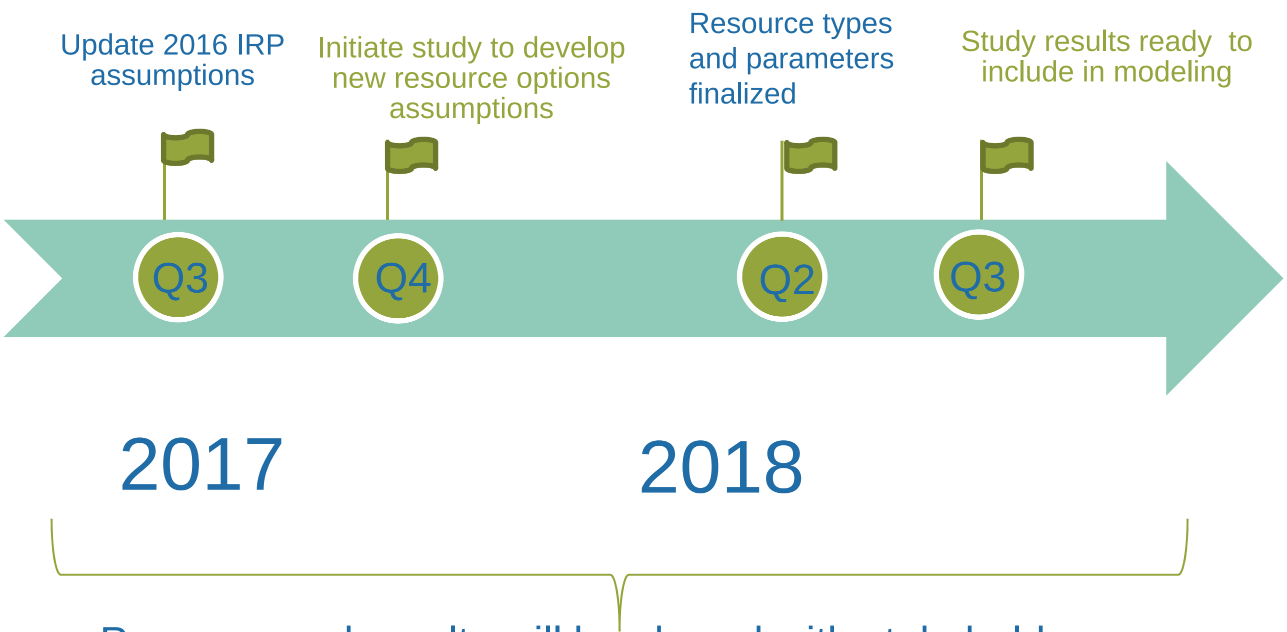
Cost and Technical Parameters of Thermodynamic and Storage Resources

Cost Parameters	Technical Parameters
Overnight EPC and total capital cost	Net plant heat rate
Capital cost standard deviation	Average design life net heat rate, including degradation
Fixed O&M	Fuel consumption vs output
Nonfuel variable O&M	Minimum turndown capacity
Nonfuel variable wear and tear	Ramp rate
Capital additions/maintenance	Min Run/Down time
Nonfuel startup variable O&M	Start time to full load
Fuel startup variable O&M	Water consumption
Decommissioning cost	Scheduled maintenance
	Equivalent FOR
	Storage assumptions for : Energy capacity and round trip efficiency

Cost and Technical Parameters of Renewable Resources

Cost Assumptions	Technical Assumptions
Total overnight capital cost	Capacity/ capacity factor
Standard deviation from average overnight capital cost	Power curve
Escalation rate for capital cost over next 20 years	Expected FOR
Fixed O&M with breakdown	Panel and inverter efficiency (solar)
Nonfuel variable O&M	Maintenance cycle
Capital drawdown schedule	Approximate footprint
Ongoing expected capital additions	Construction period
Decommissioning accrual	

Timeline of Development of New Resource Options and Assumptions for the Next IRP



Progress and results will be shared with stakeholders as and when they are available throughout the public process for the next IRP

Energy Efficiency

Cost Effectiveness Methodology

Portland General Electric

Energy Trust of Oregon

Background

- Energy Efficiency

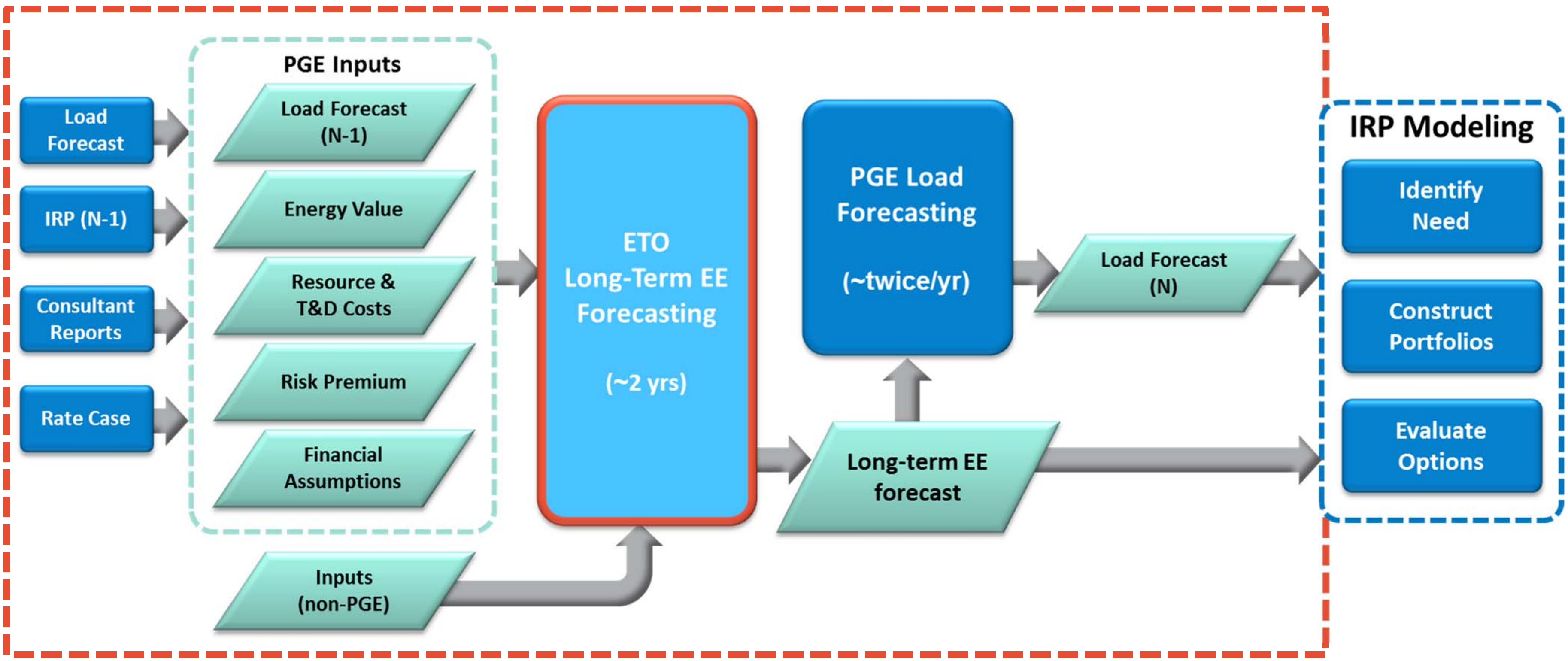
- Legislative Acts
  - SB 1149
  - SB 838

- Energy Trust of Oregon

- Process
  - PGE collects funds
  - ETO develops and administers the program

Energy Efficiency

- Energy Trust of Oregon Long-term EE Forecasting



Energy Trust of Oregon
Energy Efficiency Resource Assessment Study
May 10th, 2017

EnergyTrust of Oregon

Agenda

- About Energy Trust
- Purpose & background
- Process
- Results
- Questions

About

- Independent nonprofit
- Serving 1.5 million customers of Portland General Electric, Pacific Power, NW Natural and Cascade Natural Gas
- Providing access to affordable energy
- Generating homegrown, renewable power
- Building a stronger Oregon and SW Washington

Resource Assessment Overview

What is a resource assessment?

- Estimate of cost-effective energy efficiency resource potential that is achievable over a 20-year period (2017-2036)

Energy Trust uses a model in *Analytica* that was developed by Navigant

Background – How is RA used?

- Informs utility IRP work & strategic planning / program planning
- Does not dictate what annual savings are acquired by programs
- Does not set incentive levels

Inputs:

- Utility Service Territory Data (from PGE)
  - Customer counts, 20-year load forecasts
  - Line losses, avoided costs, discount rate
- Building characteristics
  - Heating & hot water fuel, measure saturations
- Measure assumptions
  - Savings, costs, O&M, NEBs, measure life, load profile, end use, baseline, technical applicability, achievability rates

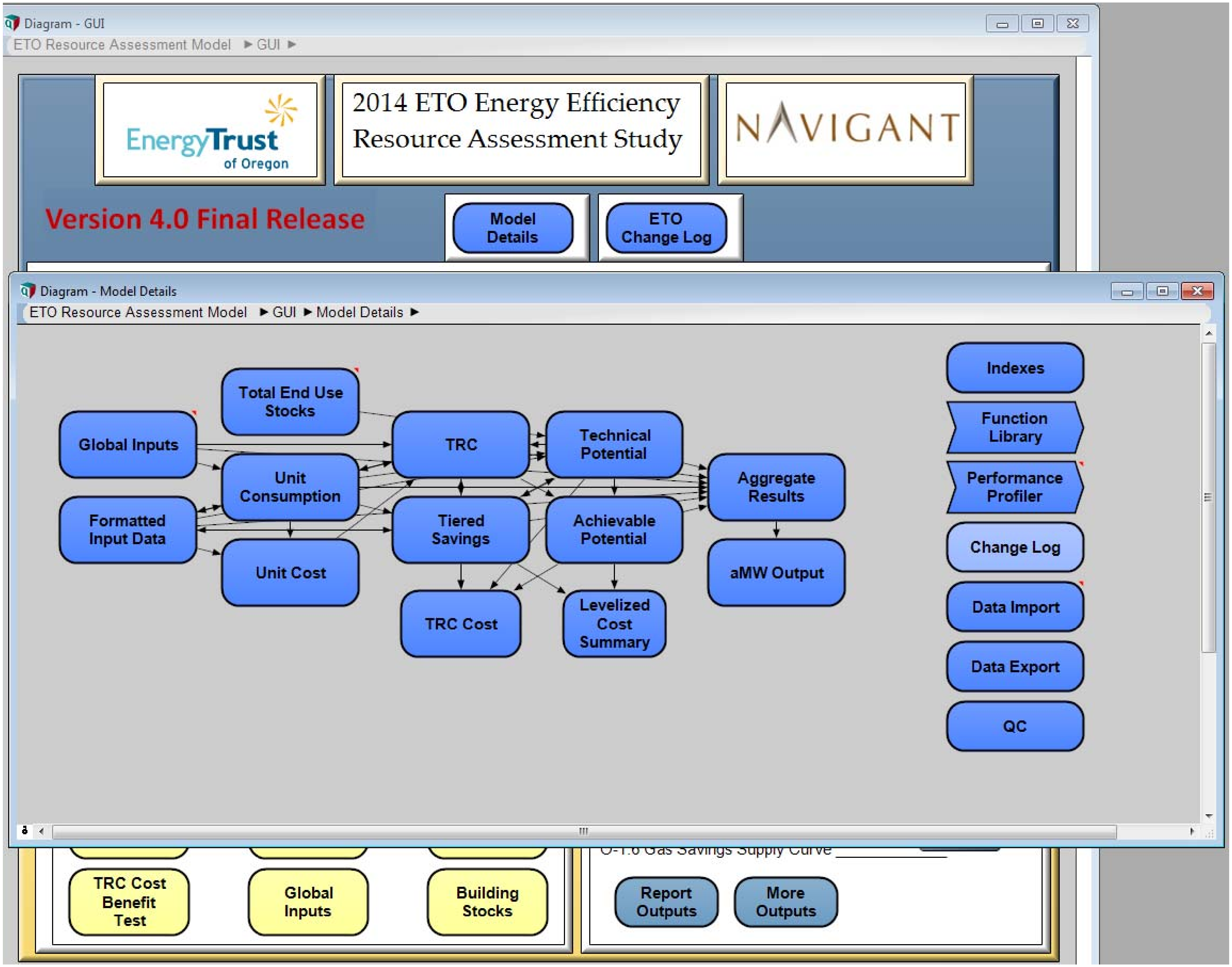


Diagram - GUI
ETO Resource Assessment Model ► GUI ►
EnergyTrust of Oregon
2014 ETO Energy Efficiency Resource Assessment Study
NAVIGANT
Version 4.0 Final Release
Model Details
ETO Change Log
Diagram - Model Details
ETO Resource Assessment Model ► GUI ► Model Details ►
Total End Use Stocks
Global Inputs
TRC
Technical Potential
Unit Consumption
Aggregate Results
Formatted Input Data
Tiered Savings
Achievable Potential
Unit Cost
aMW Output
TRC Cost
Levelized Cost Summary
Indexes
Function Library
Performance Profiler
Change Log
Data Import
Data Export
QC
TRC Cost Benefit Test
Global Inputs
Building Stocks
Report Outputs
More Outputs

Outputs:

<table>
<tr><td>Not technically feasible</td><td colspan="3">Technical Potential</td></tr>
<tr><td>Not technically feasible</td><td>Market barriers</td><td colspan="2">Achievable Potential</td></tr>
<tr><td>Not technically feasible</td><td>Market barriers</td><td>Not cost effective</td><td>Cost-Effective Potential</td></tr>
</table>

mid

Mid Value of Cumulative Potential by Customer Segment (MWh, MW, MM Therms)

Selected Utilities: PGE

Savings Type: MWh

Potential Type: Cost-effective achievable

Selected Customer Segment ☑ Totals

Simulation Year (year) ☐ Totals

	2017	2018	2019	2020	2021	2022	2023	2024	2025
C_College	10,919	11,100	11,534	11,814	11,971	12,167	12,366	12,608	12,771
C_Data Center	18	26	26	29	29	36	36	36	36
C_Grocery	29,317	32,499	35,166	41,511	43,841	46,268	48,367	50,445	52,128
C_Hospital	84,811	85,950	87,052	96,913	98,173	99,277	101,046	102,382	103,243
C_Lodging	18,797	19,698	20,767	21,669	23,477	25,947	27,051	27,867	28,504
C_Office	207,359	211,916	213,199	216,688	234,274	236,326	267,537	274,401	276,674
C_Other	222,961	226,179	227,925	230,259	231,950	231,662	233,920	236,744	248,466
C_Other Health	10,698	11,666	12,766	13,679	14,509	15,277	15,850	16,461	17,860
C_Restaurant	47,733	51,522	54,876	58,008	61,899	65,192	66,992	68,881	70,288
C_Retail	138,810	141,306	145,541	148,014	148,283	151,197	164,998	170,133	172,453
C_School	15,747	16,509	17,247	18,959	19,763	20,419	21,086	21,864	22,429
C_Street Lights	2,467	4,770	6,919	8,925	10,797	12,544	14,175	15,697	17,118
C_Warehouse	46,933	51,476	52,105	53,231	59,889	56,687	57,416	67,146	67,737
I_Agriculture	15,760	17,521	19,159	20,757	22,239	23,546	24,783	26,039	27,062
I_Chemicals	46,698	47,320	47,978	48,428	48,938	49,267	49,575	49,886	50,137
I_Cold Storage	17,402	17,402	17,402	17,402	17,402	17,402	17,402	17,402	17,402
I_Food Products	61,323	61,614	61,885	62,152	62,396	62,624	62,839	63,057	63,235
I_Hi Tech	365,063	369,052	372,586	375,696	378,837	381,162	383,362	385,609	387,424
I_Metal Fab	17,717	17,837	17,949	18,061	18,161	18,268	18,369	18,471	18,555
I_Metal Foundries	61,759	62,110	62,440	62,766	63,061	63,374	63,670	63,970	64,216
I_Other	135,714	137,694	139,791	141,331	143,107	144,359	145,543	146,752	147,730
I_Pulp & Paper	89,014	89,885	90,699	91,492	92,212	92,993	93,731	94,477	95,089
I_Transportation and Equipment	65,844	66,368	66,908	67,317	67,773	68,140	68,487	68,841	69,128
I_Wood Products	17,859	17,914	17,914	18,016	18,048	18,151	18,247	18,345	18,425
R_Manuf	59,928	61,696	62,393	64,101	65,619	66,987	68,915	70,006	70,978
R_Multi Fam	161,045	172,809	184,575	196,187	209,696	223,269	239,766	252,323	264,443
R_Single Fam	623,571	632,079	640,617	648,528	655,786	666,283	693,869	702,846	711,218
Totals	2,575,267	2,635,918	2,687,421	2,751,933	2,822,128	2,868,822	2,979,399	3,042,689	3,094,748

Determining Cost-effectiveness

Total Resource Cost (TRC) BCR =

$$\frac{(Lifetime\ Savings\ *\ Avoided\ Costs) + NEBs}{Total\ Cost\ of\ Measure}$$

NEBs = quantifiable non-energy benefits

Avoided Costs

=(1+RegionalCredit)*P15*(1+Combined_TD_Loss_Factor)+Q15+R15

		Avoided Cost Calculation						
Measure Life	Year	Weighted avoided Cost ($/kWh)	Capacity Adders ($/kWh)	Premium Adder ($/kWh)	Avoided Costs (NPV/kWh)	Levelized Cost ($/kWh)	Year	Annual Real Value for RA Model
0		$ -	$ -	$ -	$ -	$ -	0	$ -
1	2017	$ 0.0392	$ 0.02	$ 0.007	$ 0.071	$0.0745	1	$ 0.0745
2	2018	$ 0.0411	$ 0.02	$ 0.007	$ 0.142	$0.0756	2	$ 0.0769
3	2019	$ 0.0427	$ 0.02	$ 0.007	$ 0.211	$0.0766	3	$ 0.0788
4	2020	$ 0.0439	$ 0.02	$ 0.013	$ 0.283	$0.0789	4	=(1+RegionalCredit)*P15*(1+Combined_TD_Loss_Factor)+Q15+R15
5	2021	$ 0.0441	$ 0.02	$ 0.019	$ 0.358	$0.0815	5	$ 0.0931
6	2022	$ 0.0456	$ 0.02	$ 0.019	$ 0.431	$0.0835	6	$ 0.0949
7	2023	$ 0.0475	$ 0.02	$ 0.019	$ 0.502	$0.0852	7	$ 0.0972
8	2024	$ 0.0496	$ 0.02	$ 0.019	$ 0.572	$0.0868	8	$ 0.0997
9	2025	$ 0.0494	$ 0.02	$ 0.019	$ 0.639	$0.0879	9	$ 0.0995
10	2026	$ 0.0500	$ 0.02	$ 0.019	$ 0.704	$0.0889	10	$ 0.1003
11	2027	$ 0.0497	$ 0.02	$ 0.019	$ 0.765	$0.0897	11	$ 0.0998
12	2028	$ 0.0493	$ 0.02	$ 0.019	$ 0.824	$0.0904	12	$ 0.0994
13	2029	$ 0.0514	$ 0.02	$ 0.019	$ 0.881	$0.0910	13	$ 0.1020
14	2030	$ 0.0517	$ 0.02	$ 0.019	$ 0.936	$0.0916	14	$ 0.1023
15	2031	$ 0.0519	$ 0.02	$ 0.019	$ 0.989	$0.0922	15	$ 0.1025

Avoided Costs continued

Real Annual Avoided Cost (2017$)

Update

Lifetimes (years)

Code	Friendly Name	0	1	2	3	4	5	6	7	8	9	10	11
R-All-Ref-Refrig-All-All-C	Res Refrigerator	0.0000	0.0572	0.0595	0.0614	0.0690	0.0779	0.0798	0.0820	0.0842	0.0841	0.0849	0.0841
R-All-Ref-Freezer-All-All-R	Res Freezer	0.0000	0.0570	0.0592	0.0611	0.0687	0.0779	0.0798	0.0819	0.0841	0.0841	0.0849	0.0841
R-All-Plug-Dryer-All-All-R	Res Dryer	0.0000	0.0809	0.0833	0.0852	0.0927	0.1009	0.1026	0.1046	0.1074	0.1072	0.1080	0.1074
R-All-WH-Cwash-All-All-R	Res Clotheswasher	0.0000	0.0659	0.0683	0.0702	0.0778	0.0884	0.0902	0.0924	0.0946	0.0945	0.0954	0.0946
R-All-HVAC-CAC-All-All-E	Res Cental AC	0.0000	0.1173	0.1199	0.1219	0.1293	0.1391	0.1413	0.1434	0.1456	0.1466	0.1475	0.1462
R-All-HVAC-RAC-All-All-E	Res Window AC	0.0000	0.1281	0.1307	0.1327	0.1401	0.1502	0.1523	0.1545	0.1567	0.1577	0.1586	0.1573
Residential-res-Water Heating	Res Water Heat	0.0000	0.0647	0.0671	0.0690	0.0765	0.0869	0.0887	0.0908	0.0931	0.0930	0.0939	0.0931
R-All-WH-HPWH-All-All-R	Res HP Water Heat	0.0000	0.0673	0.0698	0.0717	0.0792	0.0891	0.0908	0.0930	0.0953	0.0951	0.0960	0.0953
R-All-WH-SWH-All-All-C	Res Solar Water Heat	0.0000	0.0625	0.0649	0.0668	0.0744	0.0841	0.0858	0.0880	0.0903	0.0901	0.0910	0.0903
R-All-HVAC-ASHP-All-All-E	Res Air Source HP	0.0000	0.0745	0.0769	0.0788	0.0863	0.0931	0.0949	0.0972	0.0997	0.0995	0.1003	0.0998
R-All-HVAC-DHP-HZ1-All-N	Res Ductless HP	0.0000	0.0679	0.0703	0.0722	0.0798	0.0871	0.0888	0.0910	0.0936	0.0933	0.0940	0.0937
R-All-HVAC-Zonal-All-All-E	Res Zonal Ele Heat	0.0000	0.0707	0.0731	0.0751	0.0826	0.0897	0.0914	0.0937	0.0962	0.0959	0.0967	0.0963
R-All-HVAC-ER-All-All-E	Res Ele Resistance Heat	0.0000	0.0769	0.0793	0.0813	0.0888	0.0966	0.0983	0.1006	0.1031	0.1028	0.1036	0.1032
R-All-Lgt-Lighting-All-All-R	Res Lighting	0.0000	0.0648	0.0672	0.0692	0.0767	0.0862	0.0881	0.0902	0.0925	0.0924	0.0932	0.0926
Residential-res-Other	Res Other	0.0000	0.0594	0.0618	0.0637	0.0712	0.0807	0.0825	0.0846	0.0869	0.0868	0.0876	0.0869
R-All-Bld-Bldg-All-All-R	Res Whole Home	0.0000	0.0628	0.0652	0.0671	0.0747	0.0835	0.0853	0.0875	0.0899	0.0898	0.0906	0.0899
Residential-Spa Heater	Res Spa Cover	0.0000	0.0736	0.0760	0.0779	0.0855	0.0967	0.0987	0.1009	0.1028	0.1029	0.1037	0.1030
Residential-Res-TV	Res Power Strip	0.0000	0.0624	0.0648	0.0667	0.0742	0.0836	0.0853	0.0875	0.0898	0.0897	0.0905	0.0898
A-Irr-Irr-Irrigation-All-All-E	Ag-Irrigation	0.0000	0.0583	0.0604	0.0621	0.0698	0.0814	0.0835	0.0855	0.0873	0.0876	0.0884	0.0873
DSI-0	Flat	0.0000	0.0542	0.0564	0.0582	0.0658	0.0744	0.0762	0.0783	0.0805	0.0804	0.0812	0.0804
IndShift1	1-Shift Industrial	0.0000	0.0598	0.0622	0.0641	0.0716	0.0827	0.0844	0.0865	0.0886	0.0886	0.0894	0.0887
IndShift2	2-Shift Industrial	0.0000	0.0593	0.0617	0.0636	0.0710	0.0819	0.0835	0.0857	0.0878	0.0878	0.0886	0.0879
IndShift3	3-Shift Industrial	0.0000	0.0563	0.0586	0.0605	0.0680	0.0778	0.0795	0.0816	0.0838	0.0837	0.0846	0.0838
Commercial-Ref.warehouse-Refrig	Cold Storage	0.0000	0.0567	0.0590	0.0608	0.0683	0.0773	0.0792	0.0812	0.0834	0.0834	0.0842	0.0834
SIC 20-IND_SIC 20	Food Products	0.0000	0.0566	0.0588	0.0607	0.0682	0.0770	0.0788	0.0809	0.0831	0.0830	0.0838	0.0830
SIC 24-IND_SIC 24	Wood Products	0.0000	0.0561	0.0583	0.0602	0.0677	0.0766	0.0784	0.0805	0.0827	0.0826	0.0834	0.0826
SIC 26-IND_SIC 26	Pulp & Paper	0.0000	0.0550	0.0573	0.0591	0.0666	0.0751	0.0769	0.0789	0.0812	0.0811	0.0819	0.0811
SIC 28-IND_SIC 28	Chemicals	0.0000	0.0547	0.0569	0.0588	0.0663	0.0748	0.0766	0.0787	0.0809	0.0808	0.0815	0.0808
SIC 29-IND_SIC 29	Oil & Petroleum	0.0000	0.0542	0.0565	0.0583	0.0658	0.0746	0.0764	0.0785	0.0806	0.0806	0.0813	0.0806
SIC 33-IND_SIC 33	Primary Metals	0.0000	0.0549	0.0571	0.0589	0.0665	0.0750	0.0769	0.0789	0.0811	0.0810	0.0818	0.0811
SIC 37-IND_SIC 37	Transportation & Equipment	0.0000	0.0554	0.0577	0.0595	0.0670	0.0762	0.0780	0.0800	0.0822	0.0821	0.0829	0.0822
Other SICs-IND_Other SICs	Other Industrial	0.0000	0.0554	0.0577	0.0595	0.0670	0.0762	0.0780	0.0800	0.0822	0.0821	0.0829	0.0822
S-All-Lgt-Streetlight-All-All-U	Street Lighting	0.0000	0.0585	0.0606	0.0623	0.0701	0.0746	0.0767	0.0788	0.0811	0.0809	0.0816	0.0810
Commercial-college-AirComp	College Compressed Air	0.0000	0.0627	0.0652	0.0671	0.0746	0.0862	0.0878	0.0900	0.0922	0.0921	0.0930	0.0923
Commercial-college-Cook	College Cooking	0.0000	0.0616	0.0641	0.0660	0.0735	0.0846	0.0863	0.0885	0.0907	0.0906	0.0915	0.0907
Commercial-college-Cool	College Cooling	0.0000	0.0710	0.0735	0.0754	0.0829	0.0948	0.0966	0.0987	0.1008	0.1010	0.1019	0.1009
Commercial-college-ExtLight	College Exterior Lights	0.0000	0.0581	0.0601	0.0619	0.0696	0.0747	0.0767	0.0788	0.0811	0.0809	0.0816	0.0810

Updates for the 2016 IRP

- Refreshed measure assumptions
- Incremental measure definitions
- Better treatment of codes & standards
- New approach to emerging technologies

Incremental Measure Definition

Numbers are for illustrative purposes only

Emerging Technologies

- Include some emerging technologies
- Factor in changing performance, cost over time
- Use risk factors to hedge against uncertainty

	Risk Factor for Emerging Technologies				
Risk Category	**10%**	**30%**	**50%**	**70%**	**90%**
Market Risk (25% weighting)	**High Risk:** • Requires new/changed business model • Start-up, or small manufacturer • Significant changes to infrastructure • Requires training of contractors. Consumer acceptance barriers exist.			**Low Risk:** • Trained contractors • Established business models • Already in U.S. Market • Manufacturer committed to commercialization	
Technical Risk (25% weighting)	**High Risk: Prototype in first field tests. A single or unknown approach**	**Low volume manufacturer. Limited experience**	**New product with broad commercial appeal**	**Proven technology in different application or different region**	**Low Risk: Proven technology in target application. Multiple potentially viable approaches.**
Data Source Risk (50% weighting)	**High Risk: Based only on manufacturer claims**	**Manufacturer case studies**	**Engineering assessment or lab test**	**Third party case study (real world installation)**	**Low Risk: Evaluation results or multiple third party case studies**

Emerging Technologies

Residential	Commercial	Industrial
• LED Lighting • CO2 Heat Pump Water Heaters • Advanced Heat Pumps • Home Automation/Controls • Advanced window and insulation technologies • Heat Pump clothes dryers	• LED Lighting • Advanced Rooftop Unit A/C • Evaporative coolers • Energy Recovery ventilators • Advanced refrigeration technologies • Smart/Dynamic windows	• LED Lighting • Advanced refrigeration controllers • Advanced motor technologies

Example Measure: Residential Heat Pump Water Heater- Tier 1, Heating Zone 1

Key Measure Inputs:

- Baseline: 0.9 EF Water Heater ($590)
- Measure Cost: $1,230-$1,835 ($600 RETC)
- Competing Measures: Tier 2 HPWH, CO_2 HPWH
- Lifetime:12 years
- Conventional (not emerging, no risk adjustment)
- Customer Segments: SF, MF, MH
- Program Type: Replacement
- Savings: 1,516-1,530 kWh
- Density, saturation, suitability
- No Non-Energy Benefits or O&M savings

Example Measure: Residential Heat Pump Water Heater- Tier 1, Heating Zone 1

Mid Value - Cost-effective Achievable Potential

mid

Mid Value of Cost-effective Achievable Potential (MWh, MW, MM Therms)

Selected Replacement Type: «Totals»

Savings Type: MWh

Selected Utilities: PGE

Selected Customer Segment: «Totals»

Selected Measures ☑ Totals

Simulation Year (year) ☐ Totals

	2017	2018	2019	2020	2021	2022	20
Res Bathroom Faucet Aerators, 1.0 gpm- Gas	0	0	0	0	0	0	
Res Bathroom Faucet Aerators, 1.5 gpm- Electric	0	0	0	0	0	0	
Res Bathroom Faucet Aerators, 1.5 gpm- Gas	0	0	0	0	0	0	
Res Kitchen Faucet Aerators, 1.5 gpm- Electric	24.71K	24.53K	24.34K	24.16K	23.98K	23.8K	23.6
Res Kitchen Faucet Aerators, 1.5 gpm- Gas	0	0	0	0	0	0	
Res Kitchen Faucet Aerators, 2.0 gpm- Electric	0	0	0	0	0	0	
Res Kitchen Faucet Aerators, 2.0 gpm- Gas	0	0	0	0	0	0	
Res Showerheads - Elec DHW	85.68K	85.04K	84.4K	83.77K	83.14K	82.52K	81.
Res Showerheads - Gas DHW	2545	2526	2507	2489	2470	2451	24
Res Smart Devices Home Automation (NEW)	727.4	1441	2146	2841	3464	4096	47
Res Smart Devices Home Automation (RET)	46.11K	44.72K	43.35K	41.99K	40.66K	39.34K	38.0
Res Tankless Gas Hot Water Heater-Z1							
Res Tankless Gas Hot Water Heater-Z1 (NEW ONLY)							
Res Tankless Gas Hot Water Heater-Z2							
Res Tankless Gas Hot Water Heater-Z2 (NEW ONLY)							
Res Tier 1 Heat Pump Water Heater- Z1	8026	15.38K	22.13K	28.31K	33.98K	39.17K	43.9
Res Tier 1 Heat Pump Water Heater- Z2							
Res Tier 2 Heat Pump Water Heater-Z1	0	0	0	1095	5519	13.2K	20.2
Res Tier 2 Heat Pump Water Heater-Z1 (NEW ONLY)	3167	6369	9645	13K	15.88K	19K	22.
Res Tier 2 Heat Pump Water Heater-Z2							
Res Tier 2 Heat Pump Water Heater-Z2 (NEW ONLY)							
Totals	2.575M	2.636M	2.687M	2.752M	2.822M	2.869M	2.97

Example Measure- Tier 1 HPWH

CE Achievable Potential x Deployment Curves = Deployed DSM Savings

Cost Effective Achievable Potential from RA model (MWh)

	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tier 1 HPWH Z1- Manuf.	782	1,500	2,157	2,760	3,312	3,818	4,282	4,708	5,098
Tier 1 HPWH Z1- Multifamily	3,060	5,865	8,436	10,792	12,953	14,933	16,749	18,413	19,938
Tier 1 HPWH Z1- Single Family	4,184	8,019	11,535	14,758	17,712	20,420	22,903	25,178	27,264
Total	**8,026**	**15,384**	**22,128**	**28,310**	**33,977**	**39,172**	**43,934**	**48,299**	**52,300**

Deployment Curves	2017	2018	2019	2020	2021	2022	2023	2024	2025
Com-NEW	145%	130%	130%	95%	90%	85%	85%	70%	90%
Com-RET	10%	9%	9%	8%	7%	6%	6%	5%	5%
Com-ROB	90%	90%	90%	90%	90%	90%	90%	90%	90%
Ind-RET	9%	9%	10%	9%	8%	7%	7%	6%	6%
Ind-ROB	85%	85%	85%	85%	85%	85%	85%	85%	85%
RES-NEW	80%	80%	80%	80%	80%	80%	80%	80%	80%
RES-RET	11%	11%	10%	7%	6%	5%	4%	4%	4%
RES-ROB	85%	85%	85%	85%	85%	85%	85%	85%	85%
RES-CFL	4%	4%	5%	5%	5%	5%	5%	5%	5%

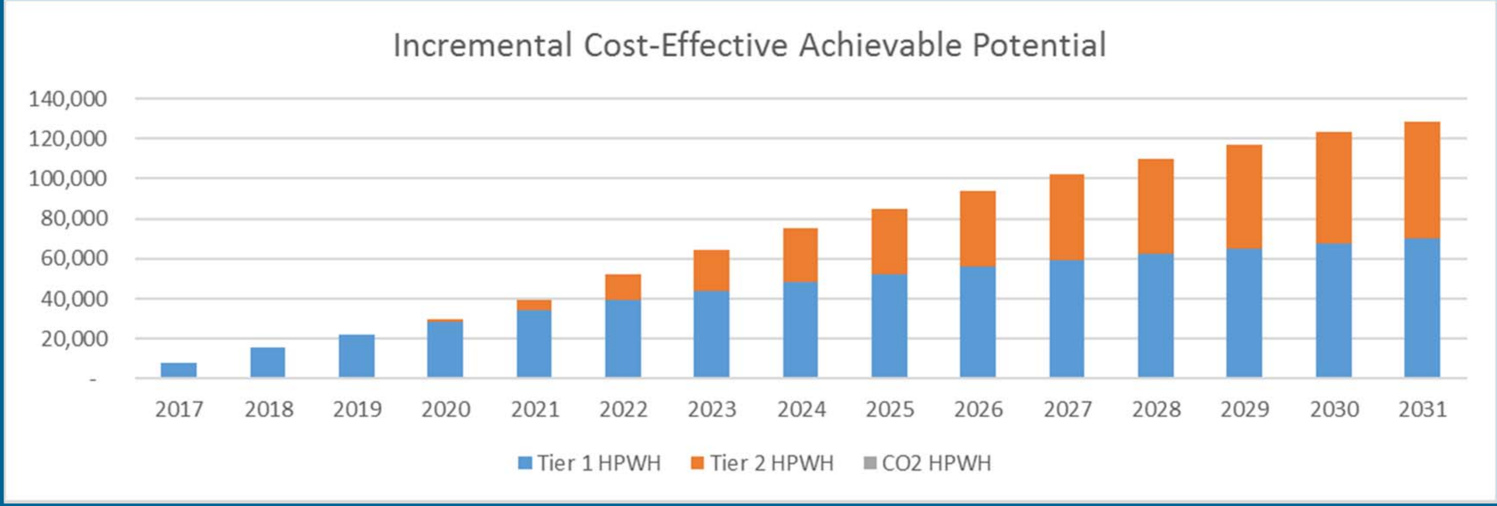
Deployed Savings (MWh)

	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tier 1 HPWH Z1- Manuf.	665	1,275	1,833	2,346	2,815	3,246	3,640	4,002	4,333
Tier 1 HPWH Z1- Multifamily	2,601	4,985	7,170	9,174	11,010	12,693	14,236	15,651	16,947
Tier 1 HPWH Z1- Single Family	3,556	6,817	9,805	12,544	15,055	17,357	19,467	21,401	23,174
Total	**6,822**	**13,076**	**18,809**	**24,063**	**28,880**	**33,296**	**37,344**	**41,054**	**44,455**

Example Measure- Incremental Savings

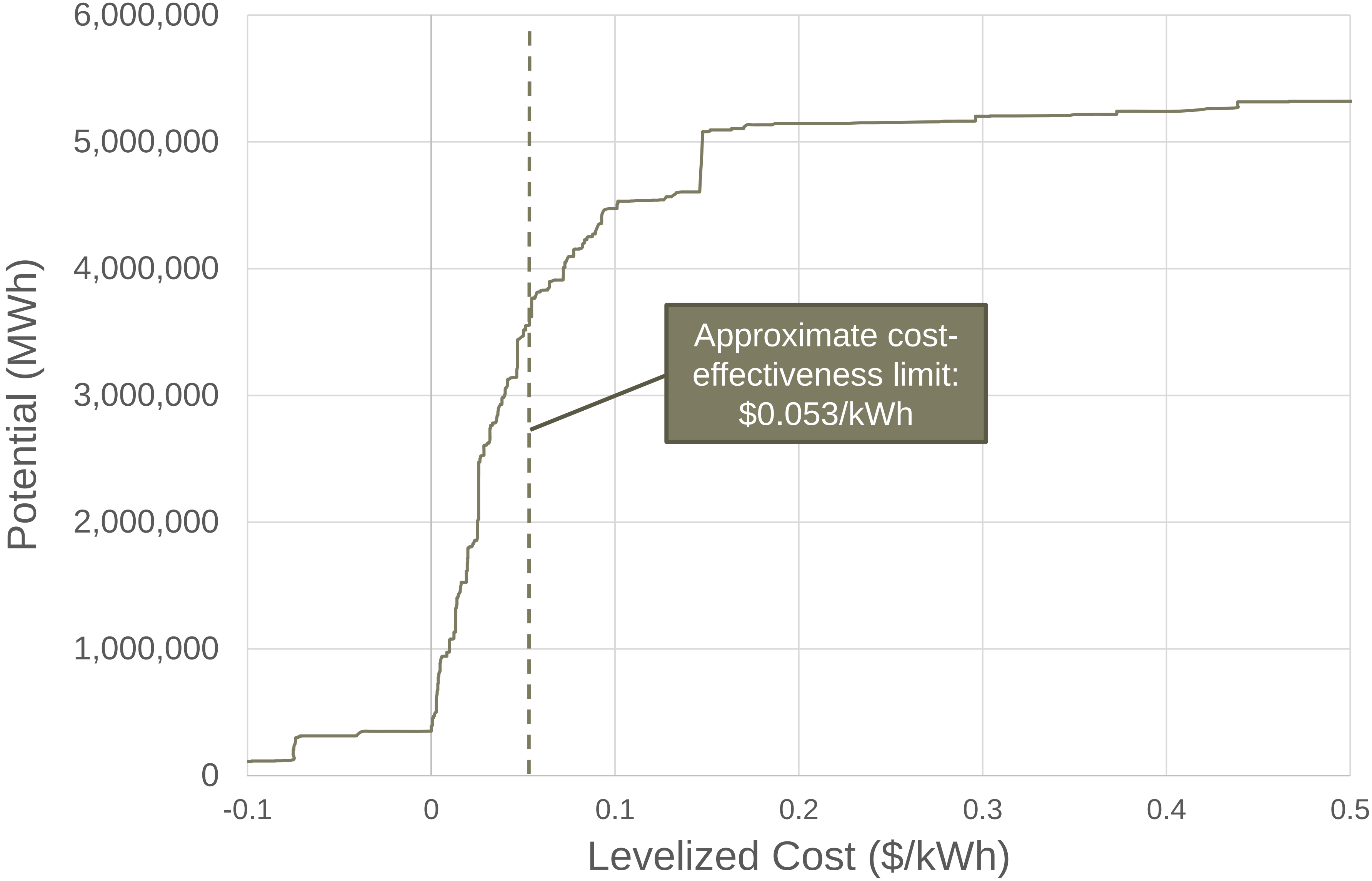
Tier 1 Z1 Residential HPWH Measures	TRC	Cumulative CE Potential (MWh)	2017	2018	2019	2020	2021	2022	2023
Tier 1 HPWH Z1- Manuf.	2.66	7,741	782	1,500	2,157	2,760	3,312	3,818	4,282
Tier 1 HPWH Z1- Multifamily	2.70	30,274	3,060	5,865	8,436	10,792	12,953	14,933	16,749
Tier 1 HPWH Z1- Single Family	2.51	41,398	4,184	8,019	11,535	14,758	17,712	20,420	22,903
Total		**71,672**	**8,026**	**15,384**	**22,128**	**28,310**	**33,977**	**39,172**	**43,934**

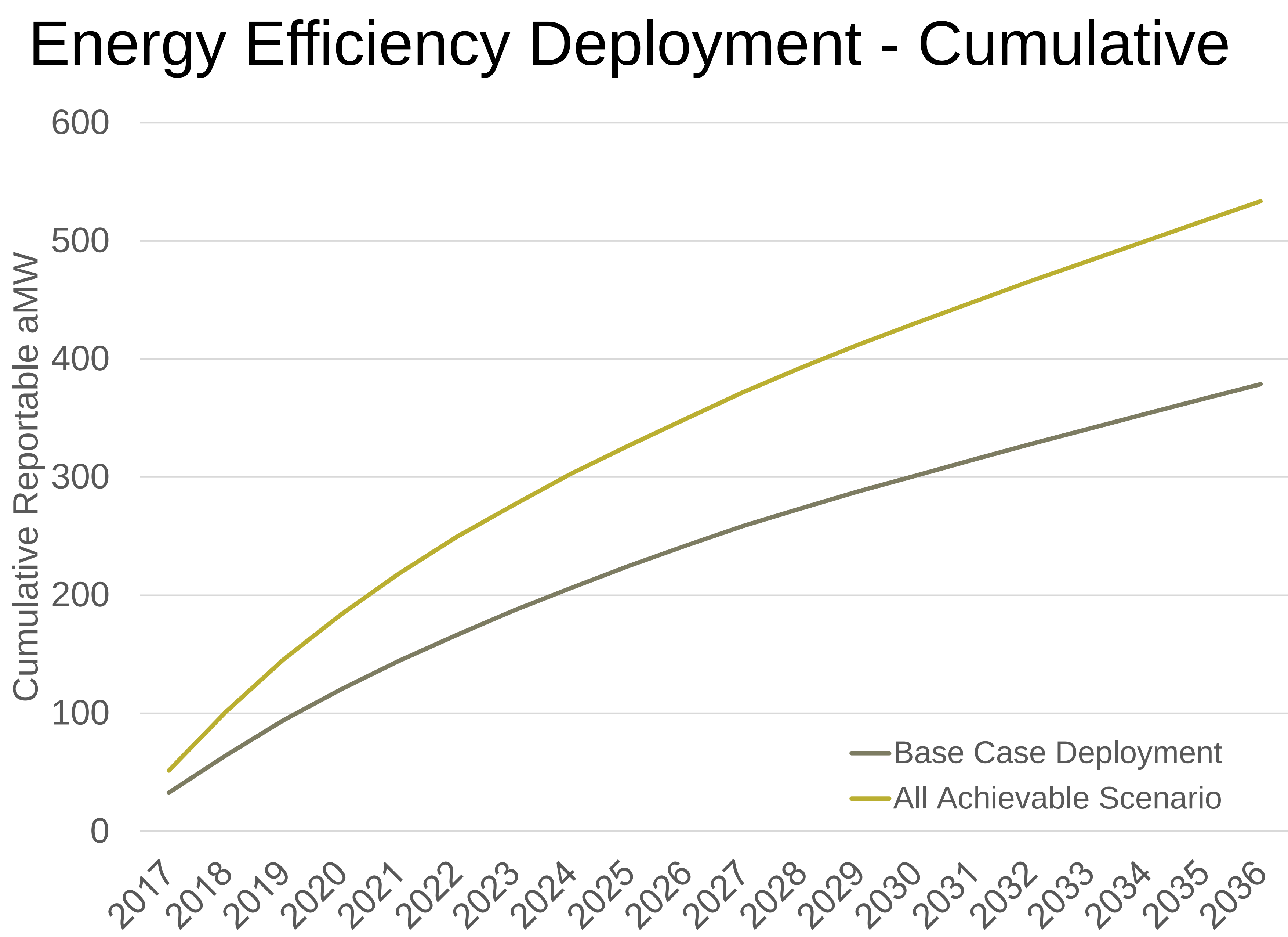
Competing Measures	TRC	Cumulative CE Potential (MWh)	2017	2018	2019	2020	2021	2022	2023
Tier 2 HPWH Z1- Manuf.	1.10	9,957		-	-	1,095	2,099	3,019	3,863
Tier 2 HPWH Z1- Multifamily	1.06	29,621		-	-	-	3,420	6,554	9,428
Tier 2 HPWH Z1- Single Family	1.04	31,753		-	-	-	-	3,630	6,958
Advanced CO2 HPWH Z1- Manuf	0.22	-	-	-	-	-	-	-	-
Advanced CO2 HPWH Z1- Multifamily	0.22	-	-	-	-	-	-	-	-
Advanced CO2 HPWH Z1- Single Family	0.22	-	-	-	-	-	-	-	-



Results

Energy Efficiency Supply Curve

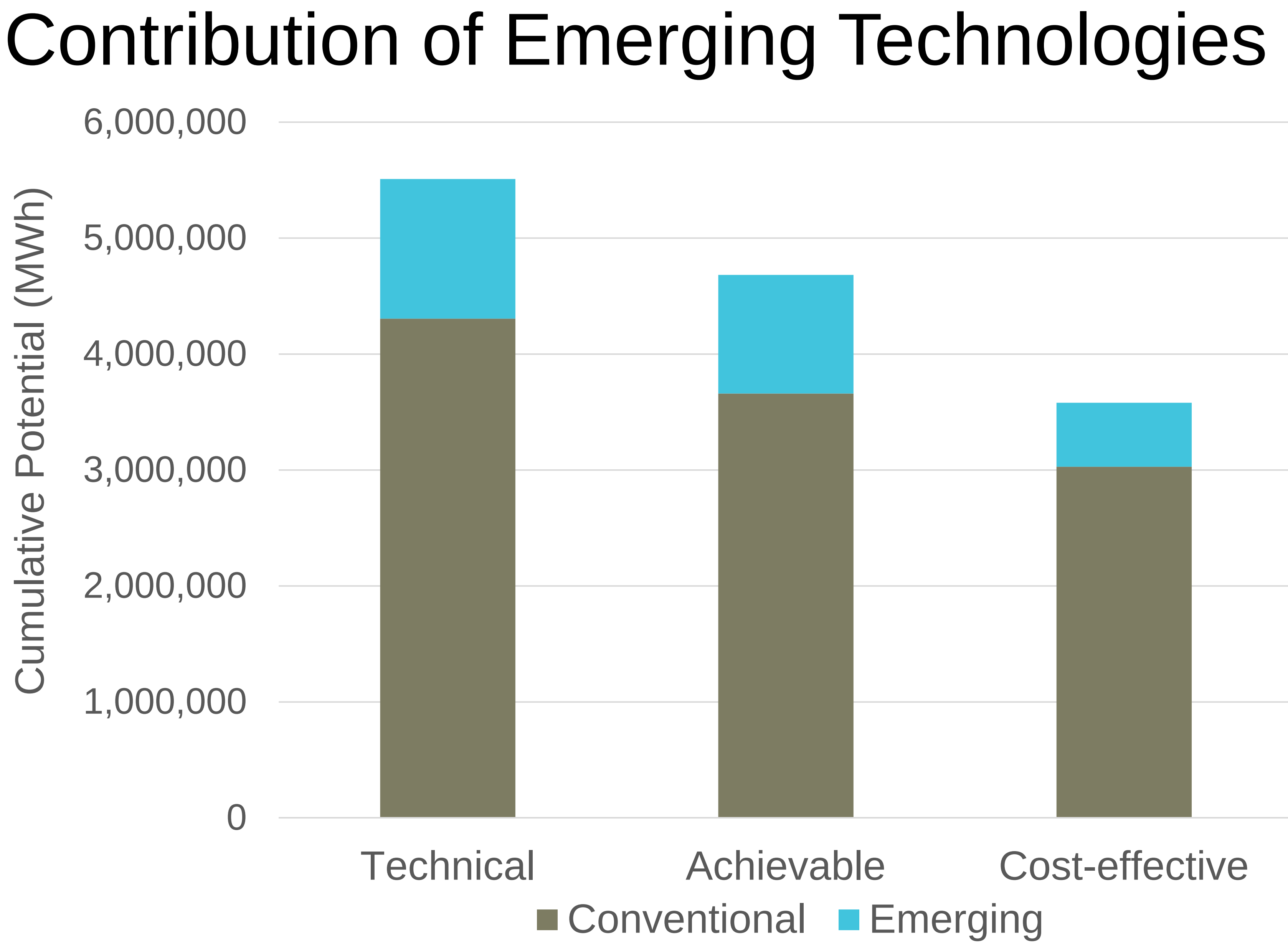




Energy Efficiency Deployment - Cumulative
Cumulative Reportable aMW
600
500
400
300
200
100
0
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
Base Case Deployment
All Achievable Scenario

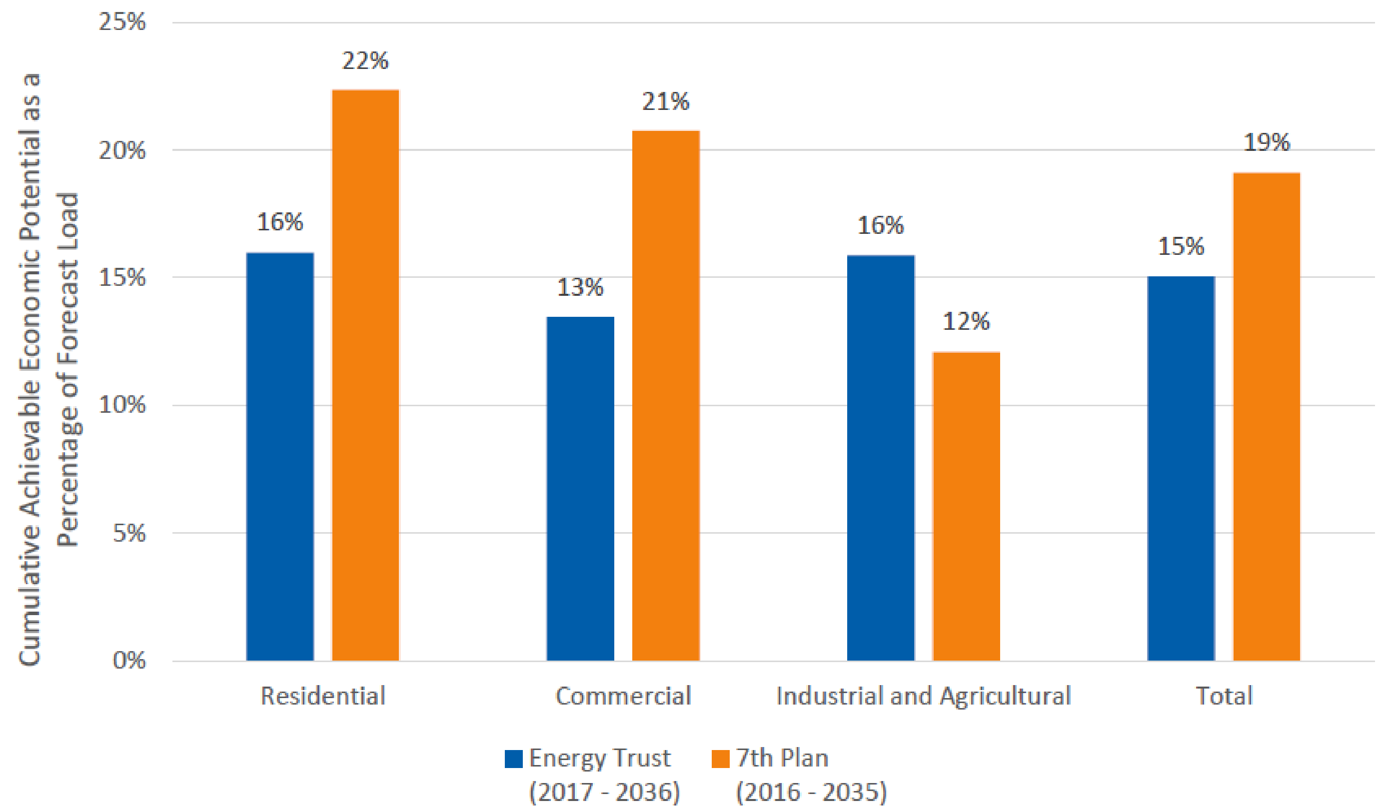
Highest-Saving Cost-effective Measures

Residential	Commercial	Industrial
• CFL & LED lighting • Efficient new homes • Heat pump water heaters • Showerheads/aerators • Refrigerator recycling • Behavior Savings • Advanced power strips • Smart thermostats	• Strategic energy management • HVAC controls • Ventilation controls • LED lighting • Showerheads • Energy management systems	• Fan & pump system controls • Strategic energy management • LED lighting • Compressed air demand reduction • HVAC O&M


Contribution of Emerging Technologies
Cumulative Potential (MWh)
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
Technical
Achievable
Cost-effective
Conventional
Emerging

Comparison to 7th Power Plan

Figure 3. Comparison of Energy Trust and 7th Plan Economic Potential as a Percentage of Forecast Load



Energy Trust compared to 7th Power Plan

Energy Trust has;

- Higher measure saturations than the region as a whole
- Lower electric space & water heat saturation
- Fewer savings from codes and standards
- More savings in the near term, fewer in out years

Thank You

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