Electrification and Renewable Energy Trends Rob Palmberg

DISCLAIMER

- Fossil Fuel @ Point of Use
 - > Apologies to Company's & Industries in that space Not intended to be threatening
 - ▶ Fossil energy still plays a significant role for the foreseeable future
- Trends discussed are evolutionary not revolutionary
 - > While it seems to be moving really fast, it will still be a decades long transition
- Not intentionally meant to be an Ad for the electricity industry
 - Sorry! Thought you would find the concepts interesting and enlightening
 - ▶ This will not be an advertisement for Tesla, SolarCity or anyone else
- This will not be a debate about climate change
 - Will discuss electrifications relationship to the issue

What is efficient or beneficial electrification (EBE)? It's already happening!

Efficient Electrification (EE)

- "Electrification" describes the adoption of electric end-use technologies
- "Efficient electrification" refers to opportunities across the economy that can...
 - ► SAVE CUSTOMERS MONEY
 - ► REDUCE ENVIRONMENTAL IMPACTS
 - ENABLE BETTER GRID MANAGEMENT

Environmentally Beneficial Electrification (EBE)

The use of electricity in end-uses that would otherwise be powered by fossil fuels (NG, propane, gas, fuel oil) to reduce greenhouse gas and other emissions

> Lawrence Berkeley National Lab finds The key to meeting GHG goals is "widespread Electrification of passenger vehicles, building Heating and industry heating"

There is a path to zero-carbon electricity, the same cannot be said of combustion fuels - David Roberts Vox

Why is Beneficial Electrification Possible Now?

- Adoption of stricter GHG and other emission public policy goals
- Declining electricity sector emission (NOx, SOx, Hg, metals including GHG's
- Increased efficiency of end-use products
 - ▶ 3rd wave of energy efficiency
 - ▶ Cell phone technology showing up in heaters, ranges, clocks, ... your fridge
- Technology advances
- Costs for renewables on a steep decline / competitive
- Production Tax Credit and other tax incentives has played a key role
 - Currently slated to be phased out





Electricity Change in capacity by technology

Long Term Outlook

- Coal decreases by 2/3
- Doubling of Natural Gas
 - Transitional Fuel
- 5X Increase in centralized and decentralized renewables
 - Some technologies 10X



Not just about CO2! 2030 Projections of Ozone Reductions Due to Electrification





Carbon Intensity of US Electric Generation 2005-2030 Despite Congressional (carbon tax) and EPA (Clean Po

Despite Congressional (carbon tax) and EPA (Clean Power Plan) failure to implement reduction policies



U.S. Energy Information Administration (EIA) Total carbon dioxide emissions from the electric power sector



Rapidly Changing Electricity Mix Dairyland Power Example

Resource Diversification: "Preferred Plan"



Xcel and all other utilities would have similar stories to tell

Grow • Build • Buy • Maintain • Sell • Optimize

DAIRYLAND POWER

A few problems... Intermittency - When the wind doesn't blow and the sun doesn't shine





- Production must match consumption every second of every day
- When load increases, generators must come on or ramp up instantly
- When load decreases, generators must go off or ramp down instantly
- When producers fail or go off, new sources must come on instantly or load needs to be shed
- Mother nature doesn't take direction!

Utility scale batteries and storage? Potential to change the game...address intermittency

- Not producers Shifters
 - Some limitations
- Technologies are advancing rapidly
- Costs are declining rapidly





California - The famous "duck curve" GOOGLE IT!



- More generation of solar during afternoon hours than there is demand
 - Paying customers to use energy
- Traditionally utilities tried to keep people off the afternoon peak so they wouldn't have to build new power plants
 - CA encouraging use on peak!
- Locally a bigger issue is wind which tends to blow in the off-peak

Distributed Generation and Micro Grids

How will this impact the traditional centralized utility model?





Beyond the definition of Efficient **Electrification – Some Examples**

Efficient Electrification

What is the Opportunity?

2018 NARUC Winter Policy Summit February 11-14, 2018



Dr. Arshad Mansoor Senior Vice President EPRI







© 2018 Electric Power Research Institute, Inc. All rights reserved

Winter Olympics 2018

15

More precise with less water use too! Better air quality in the arena! Have to expand your definition of energy efficient technology...emissions efficient, productivity efficiency and more

© 2018 Electric Power Research Institute, Inc. All rights reserved.

Clean Air...

Paper Mill – Infrared Drying

Typically done by a Steam (H2O) Dryer Steam produced by co-generation using fossil fuels If electricity use is powered by clearner sources?

Clean Air... Less Water... Clear Choice

© 2018 Electric Power Research Institute, Inc. All rights reserved.

P 10-1

Indoor Agriculture

Flexible load/Changing usage patters – addresses intermittency or duck curve Sometimes incremental Improvements, other times Revolutionary! More food with 90% less land And 90% less water

> Farm to table Less transport

Our presenter in March was Bonny

Goodenough from the Floating Gardens - Good Enough Farms.

Clean Air... Less Water... Less Land... Less Pesticide... More Yield... Clear Choice

© 2018 Electric Power Research Institute, Inc. All rights reserved.



17

Efficient Electrification – Expanding how we think about EE

Mobility

Heating and Cooling

New Applications



Bus systems are already rapidly moving to electric!





© 2018 Electric Power Research Institute, Inc. All rights reserved.

Efficient Electrification – Win...Win...Win

| METRIC ORTIONS | BENEFIT | | | | 8 |
|--|---|--------------|--------------|---|---------------------------------------|
| | CUSTOMER | UTILITY | SOCIETY | | II pro- |
| Economic EfficiencyIt costs less | \checkmark | \checkmark | \checkmark | | i i i i i i i i i i i i i i i i i i i |
| Energy Efficiency Uses fewer Btu overall | × | 1 | ~ | | Electric Process Heating |
| Economic Development Jobs creation and retention Development of community assets | ~ | 1 | ~ | | |
| Environment Emissions reduction, CO₂ savings, water savings | 1 | ~ | ~ | | Heat Pumps |
| Grid Flexibility | \checkmark | ~ | ~ | 1 | |
| Productivity Improvements Plant output increases Reduction in energy intensity Improved product quality | | | ~ | | |
| Worker Safety Improvements Reduced lost time and accidents | \checkmark | 3 | ~ | | Electric Lift Trucks |
| | COMPANY AND A | | | | |

© 2018 Electric Power Research Institute, Inc. All rights reserved.

20

Electricity Use Has Grown Faster than Total Energy for More than A Century...What Happens Next? Electricity introduced at

Worlds Fair – Chicago in 1893 ELECTRICITY'S SHARE OF TOTAL ENERGY CONSUMPTION, BY SECTOR IMPROVED QUALITY OF LIFE 1949-2015 (SOURCE: ELA AER 2016) 60% ELECTRICITY ACCOUNTS Commercial FOR NEARLY 50% Residential 40% **OF FINAL ENERGY IN 2015** 30% **ELECTRICITY GROWTH** 20% All Sectors Industrial 10% AVERAGE PER YEAR 1949-2015 Transportation 0% 1950 1955 1960 1980 1985 1995 2010 2015 1965 1970 1975 1990 2000 2005

What is the Future Opportunity for Efficient Electrification?

© 2018 Electric Power Research Institute, Inc. All rights reserved.



EPRI National Electrification Assessment

VARIABLES

EPRI MODEL INPUTS

SCENARIO TECHNOLOGY **FUEL COST** POLICY Slower Technology No Additional CO₂ CONSERVATIVE Flat Fuel Prices Change Policy No Additional CO₂ Rapid Technology REFERENCE **Rising Fuel Prices** Change Policy 40% Economy-Wide Rapid Technology PROGRESSIVE **Rising Fuel Prices** CO₂ Emissions Change Reductions by 2050 80% Economy-Wide Rapid Technology TRANSFORMATION **Rising Fuel Prices** CO₂ Emissions Change Reductions by 2050

Electric Generation Mix CO₂ Economy-Wide CO₂ Emissions Electric and Non-**Electric End-Use Energy Demands**

MODEL OUTPUTS



© 2018 Electric Power Research Institute, Inc. All rights reserved.

Scenario Impacts on Efficiency, CO₂, and Electric Load; 2015-2050

| 2013-2030 | | | | |
|---|-----------------------|-----------------|------------------|--|
| Electric growth like last 100 years! | 777 | C0 ₂ | 9 | |
| SCENARIO (Electricity Portion of Final Energy) | Total Final Energy | Economy Wide | Electric Load | |
| CONSERVATIVE (20%- 28%) | 13% | 22% | 21% | |
| REFERENCE (20%- 35%) | 22% | 27% | 38% | |
| PROGRESSIVE (20%- 40%) | 27% | 44% | 46% | |
| TRANSFORMATION (20%- 47%) | 33% | 69% | 56% | |
| Data does not account for air quality, productivity, water savings, health impacts | | | | |

© 2018 Electric Power Research Institute, Inc. All rights reserved.



Realizing the National Electrification Potential

| Economy-Wide Energy Efficiency Benefits | Efficient electrification, coupled with continued efficiency gains, leads to a decline in total energy consumption. | | Grid Modernization | Increasing electrification will require a more reliable, resilient and flexible electricity grid |
|---|--|---|---------------------------------|---|
| End-Use Increasingly Electrified | Driven by economic technology adoption and consumer choice; accelerated by policy and regulatory constructs. | | Grid Operations and Planning | Cars as a generator? Planning and Operation of the grid with connected efficient electric technologies as grid resource |
| Natural Gas Use Continues to Grow | May seem contrarian! Both for end-use applications across the economy and for electric generation. | > | Market Transformation | Fuel neutral energy efficiency policy, innovative rate structure, public charging infrastructure and customer awareness and education. |
| Society is a Clear Winner | GHG emissions reduced as generation continues to be clean and electrification growth increases. | | Technology Innovation | Innovation in energy storage, power electronics, and materials key to advance efficient electrification. |





ELECTRIFICATION 2018 INTERNATIONAL CONFERENCE & EXPOSITION www.electrification2018.com

SAVE THE DATE

AUGUST 20-23, 2018 LONG BEACH, CALIFORNIA

- To gain an understanding of the quantifiable customer and environmental benefits of efficient electrification
- To learn about best practices for implementing efficient electrification programs to maximize customer benefit
- To experience the latest electrification-related technologies in action
- To collaborate with industry, government, and academic leaders

For more information, contact Info@Electrification2018.com

Scan here for the latest EPRI Efficient Electrification newsletter



