

Driving Transformational Change

Doug Arent
2018 Annual Meeting
April 3, 2018



Logistics and Safety

- 1 WING A** evacuates north and gathers on road in front of S&TF
- 2 WING B AND C** evacuates east and gathers at the RSF Visitor Parking Lot

RSF Building Evacuation Routes

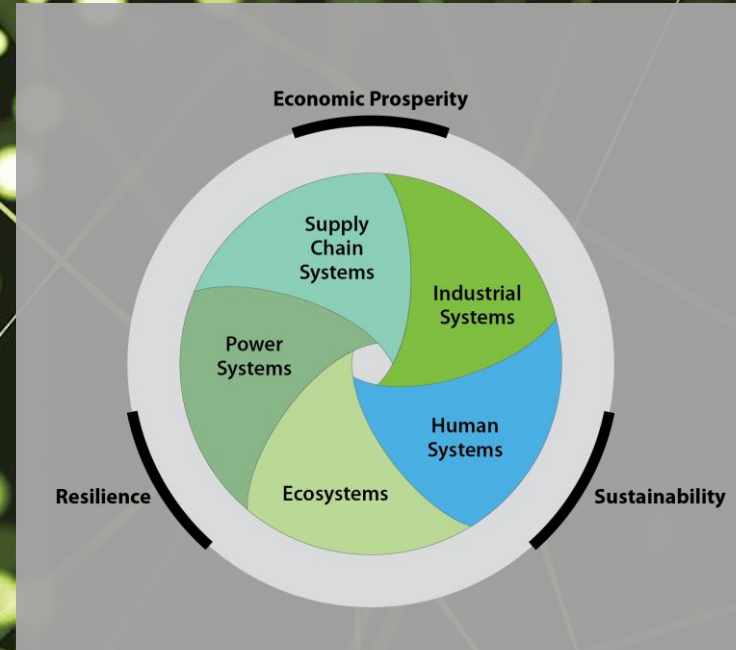


Recycling/Compost/Trash

Blue Bin – Recycling	Green Bin – Compost	Gray/Tan Bin – Trash
<ul style="list-style-type: none">• Plastics 1-7• Glass• Cans• Paper	<ul style="list-style-type: none">• Any food product• Paper Plates• Napkins, Paper towels, Kleenex• Compostable cups, plates, utensils• Tea bags	<ul style="list-style-type: none">• Foil and cellophane wrappers• Plastic bags• Styrofoam

JISEA's MISSION

Connecting technologies, economic sectors, and continents to catalyze the transition to the 21st century energy economy.



SYSTEMS SOLUTIONS

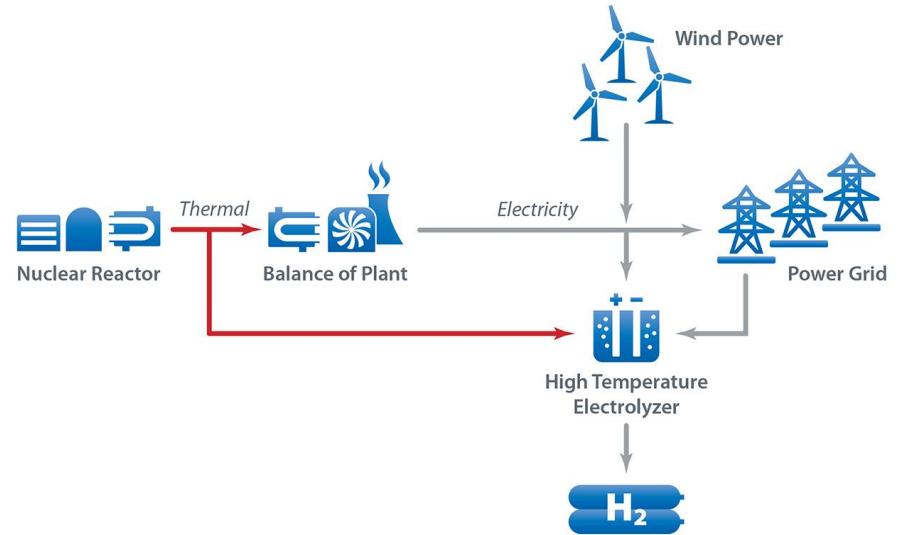
Integrated and coordinated energy solutions across power, thermal, buildings, industrial, and transportation sectors...in context of institutions, resources, earth and human systems..



SYSTEMS SOLUTIONS

Exploring nuclear-renewable hybrid energy systems:

- System configurations
- Operations, Product options
- Value Stream
- Economics & Investment Insights



NATURAL GAS

Improving life cycle surface land-use intensity for power generation; Prior work on Water and GHGs

ARTICLES
DOI: 10.1038/s41560-017-0044-0

nature energy

Understanding the life cycle surface land requirements of natural gas-fired electricity

Sarah M. Jordan^{1,2*}, Garvin A. Heath^{1,4}, Jordan Macknick^{1,4}, Brian W. Bush^{1,4,5}, Ehsan Mohammadi^{1,2}, Dan Ben-Horin^{1,4}, Victoria Urrea^{1,4} and Danielle Marceau¹

The surface land use of fossil fuel acquisition and utilization has not been well characterized, inhibiting consistent comparisons of different electricity generation technologies. Here we present a method for robust estimation of the life cycle land use of electricity generated from natural gas through a case study that includes inventories of infrastructure, satellite imagery and well-level production. Approximately 500 sites in the Barnett Shale of Texas were sampled across five life cycle stages (production, gathering, processing, transmission and power generation). Total land use (0.62 m² MWh⁻¹, 95% confidence interval ± 0.07 m² MWh⁻¹) was dominated by midstream infrastructure, particularly pipelines (24%). Our results were sensitive to power plant heat rate (88–100% of the base case), facility lifetime (69–169%), number of wells per site (16–100%), well lifetime (92–154%) and pipeline right of way (58–142%). When replicated for other gas-producing regions and different fuels, our approach offers a route to enable empirically grounded comparisons of the land footprint of energy choices.

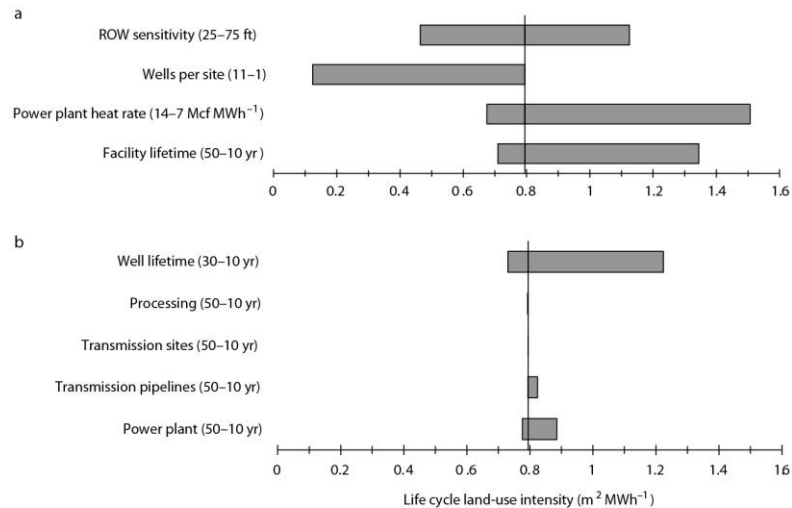
The combination of horizontal drilling and hydraulic fracturing has initiated a shale gas boom in the United States (US), resulting in a growing interest in better understanding the environmental risks of shale gas production. A coal-to-gas transition in the US power sector is one notable result of the increased availability and reduced price of natural gas. Life cycle assessment (LCA) has enabled consistent comparisons of the environmental impacts between energy technologies, including the relative merits of natural gas-fired electricity¹. For natural gas-fired power, LCAs consider the supply chain of the fuel (fuel cycle) as well as the end use (power plant). The fuel cycle for natural gas-fired electricity starts at the production well, and then proceeds through

Towards that aim, the goal of this study is to improve methods to estimate life cycle surface land-use intensity for electricity generation sources—natural gas, coal and nuclear—that use land in their fuel cycle. We develop a method with direct application to natural gas-fired electricity generation, but extensible to any non-renewable fuel. Using this method, we estimate surface land-use intensity across the life cycle of natural gas-fired electricity, focusing in our case study on natural gas extracted in the year 2009 in the most mature production basin for shale gas, the Barnett Shale in Texas. Land-use intensity is defined here as the surface area disturbed for the lifetime of infrastructure operation normalized per megawatt hour (MWh) of electricity generated. Results are reported for not

only that processes that gather and transport gas from the end user (which is supplementary Note 1). Natural gas LCAs have estimated^{2–4} and water used land use^{5,6}, most in line with empirical data. However, empirical challenges in accurate electricity with other sources of land consumption (which dominates as well as less well-charted) supply chain for non-renewable energy output. Historic energy sources was shown, our land use compared to shows that land disturbance on the methods used for developing consistent empirically robust comp

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BATTERY STORAGE HYBRIDS

Value Streams of Hybridization:

- Energy arbitrage
- Frequency regulation
- Spinning reserves
- Generation capacity
- Transmission deferral
- Demand charge reductions
- Resilience and reliability
- Decreased diesel generation

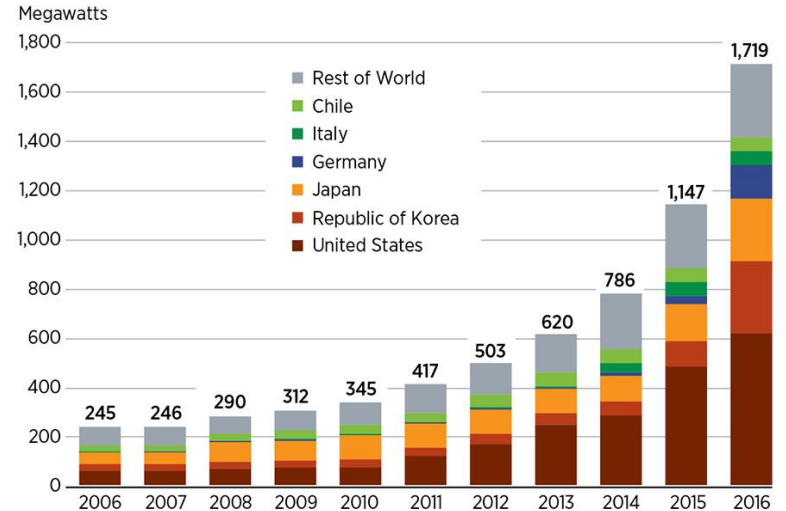


Hybrid Storage Market Assessment

A JISEA White Paper

Sean Ericson, Eric Rose, Harshit Jayaswal, Wesley Cole, Jill Engel-Cox, Jeffery Logan, Joyce McLaren, Kate Anderson, and Doug Arent
Joint Institute for Strategic Energy Analysis

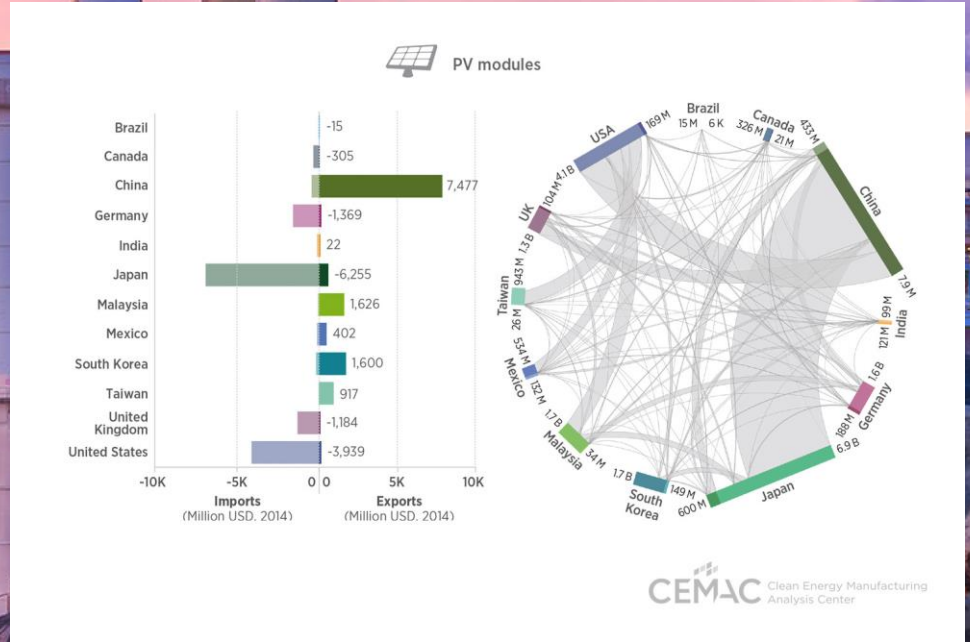
John Glassmire, Steffi Klawiter, and Dhiwaakar Rajasekaran
HOMER Energy



SUPPLY CHAINS

Analysis and Insights of the supply chains from critical materials to final products

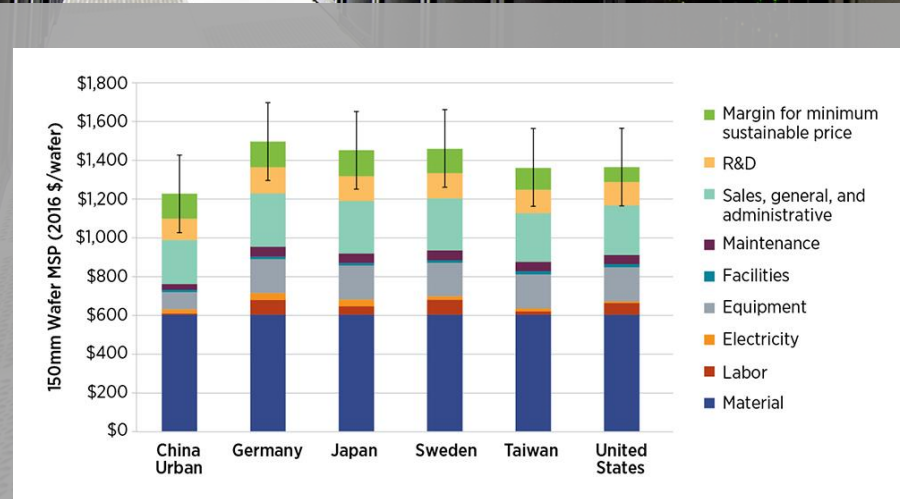
Bottom-up cost analyses of emerging global supply chains



WIDE BANDCAP SEMICONDUCTORS

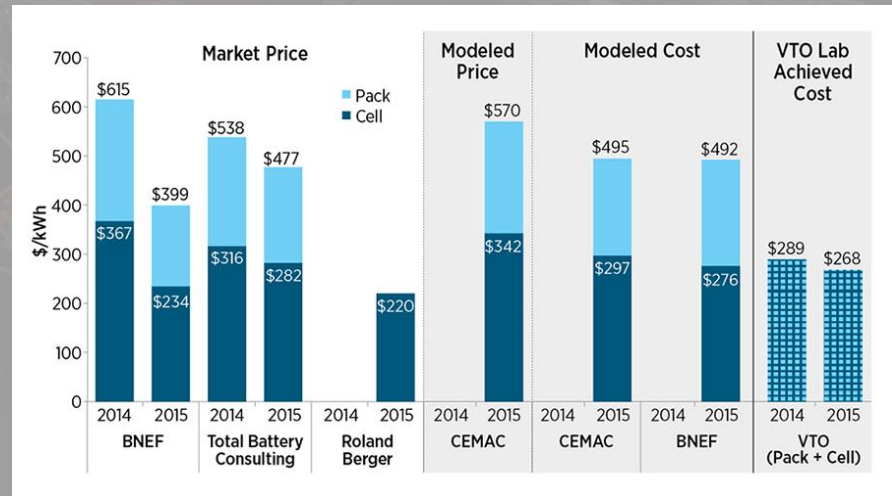
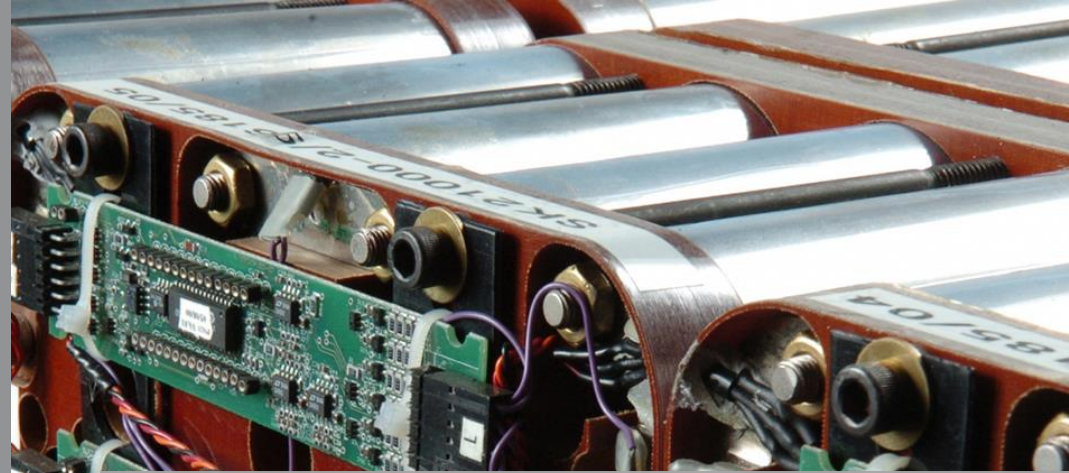
Wide bandgap semiconductor devices, notably silicon carbide (SiC) devices, show potential to:

- **Reduce energy lost** during power conversion
- Have a **smaller footprint, lighter weight**
- **Lower system cost** compared to traditional silicon devices
- Have the **largest energy impact**, followed by data centers, renewable generation, and EVs.



LITHIUM-ION BATTERIES

Cost Analysis & Market Dynamics



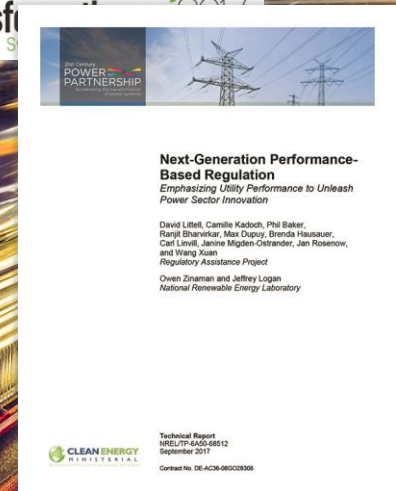
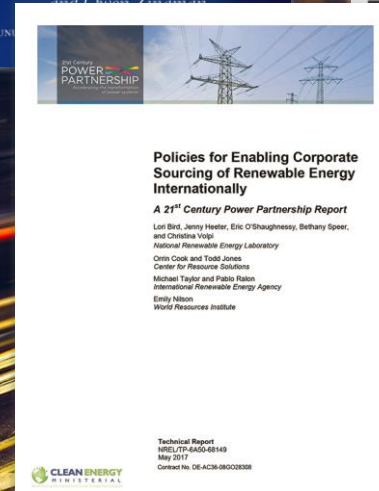
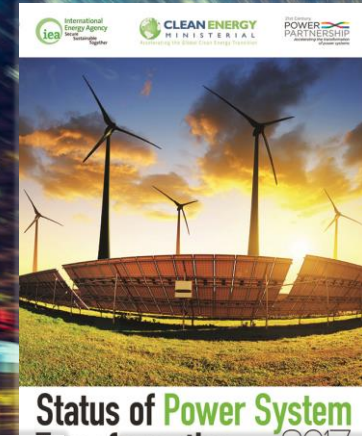
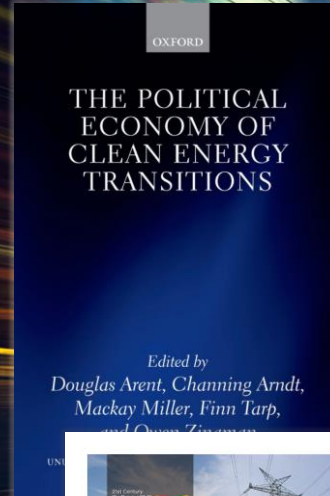
GLOBAL TRANSFORMATION

Serves as a platform to advance integrated policy, regulatory, financial, and technical solutions in power markets around the globe.



GLOBAL THOUGHT LEADERSHIP

Helping Inform Energy Planning,
Operations & Regulatory
Considerations...



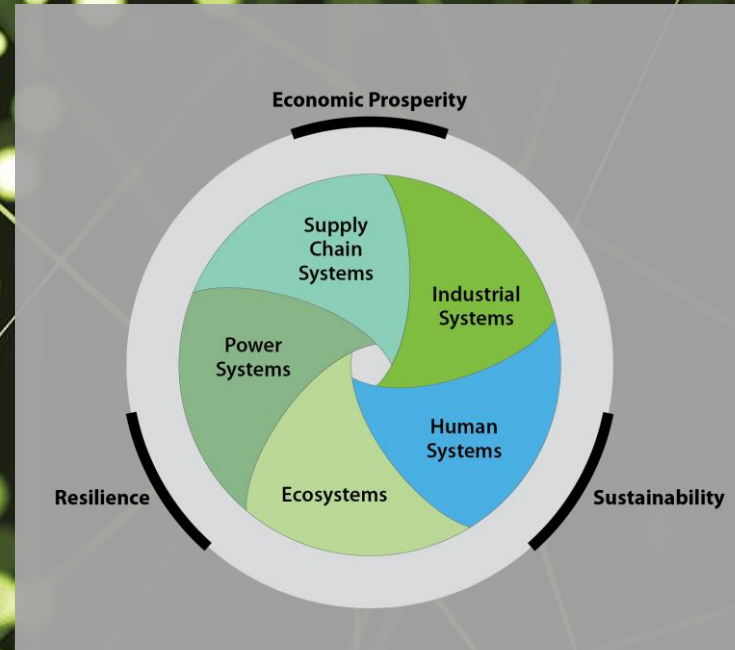
ACCELERATING TOWARD WHAT'S NEXT

- Co-simulate power and natural gas network operations.
- Define an “IEEE Standard” interconnected power and natural gas test system.
- Explore the potential coordination of day-ahead power and natural gas network operations.



Looking Forward

Connecting technologies, economic sectors, and continents to catalyze the transition to the 21st century energy economy.

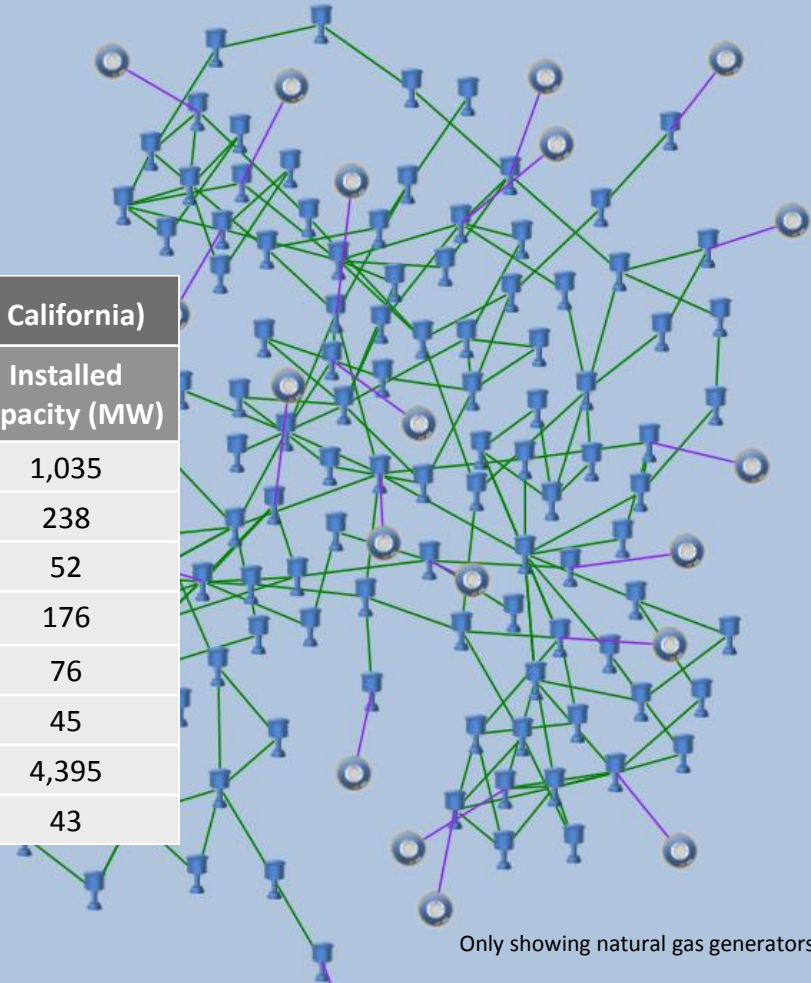


Backup slides

TEST SYSTEM (Power – IEEE 118)

- Day-Ahead (DA) & Real-Time (RT) Unit Commitment & Economic Dispatch
- Peak Load: 4,620 MW
- Regulation & Contingency Reserves
- Wind & Solar Penetration Scenarios: 20% - 30% - 40%

Generation Mix (similar to California)		
Type	# Generators	Installed Capacity (MW)
Hydro	4	1,035
Nuclear	1	238
Coal	2	52
Geothermal	3	176
Biomass	5	76
Biogas	2	45
Natural Gas	25	4,395
Oil	2	43



Only showing natural gas generators

TEST SYSTEM (Natural Gas – GNET90)

90 Nodes

46 Demand Nodes

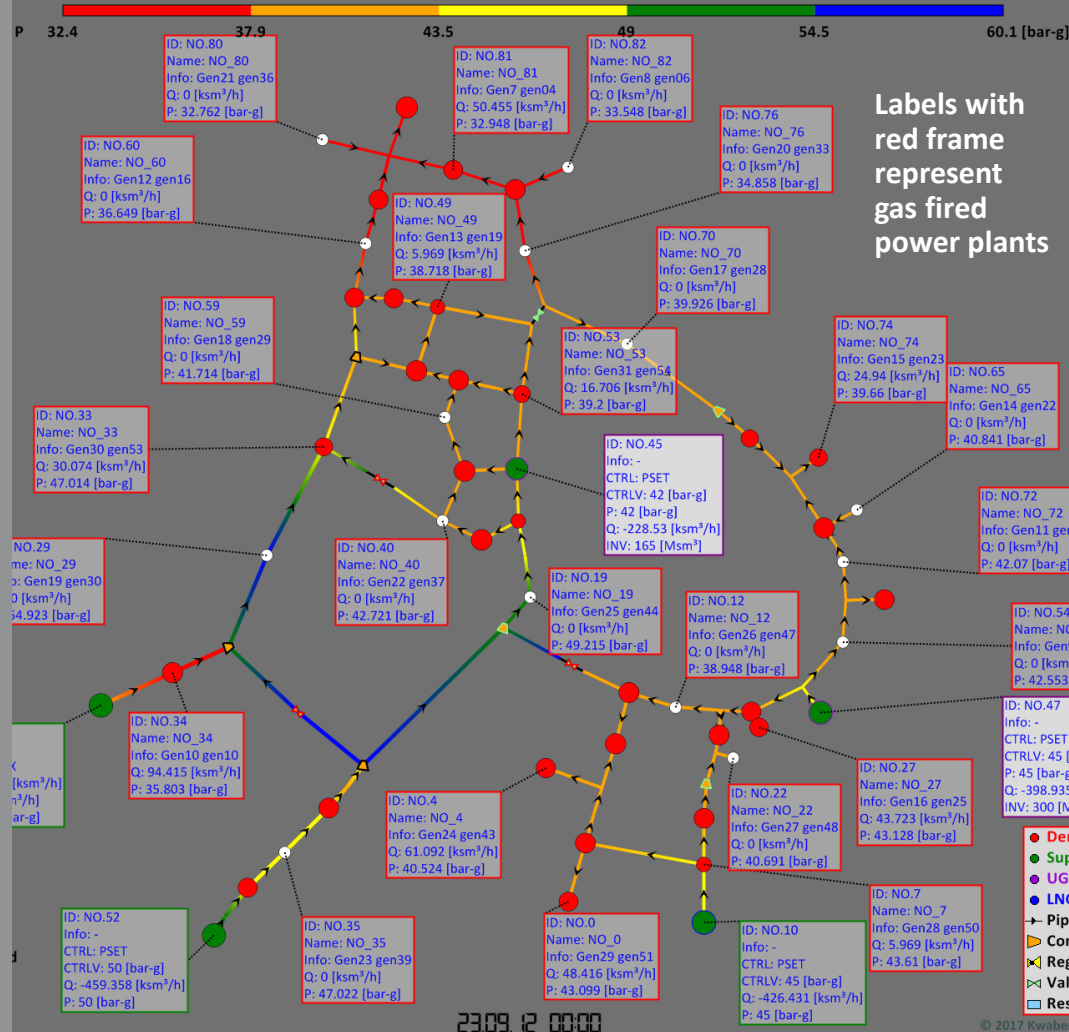
- 25 Gas Fired Power Plants (GPP)
 - Min Delivery Pressure 30 [bar-g]
- 17 City Gate Stations (CGS)
 - Min Delivery Pressure 16 [bar-g]

3 Supply Nodes

- 2 Cross Border Entry Stations
- 1 LNG Terminal
 - Max Inventory 80 [Msm³]

2 Underground Gas Storage Facilities

- Max Total Inventory 1000 [Msm³]



FUTURE WORK

- RT Coordination

