SYSTEM RESOURCES

Commercially Available Technologies

System Resources – Commercially Available Technologies

Renewable	Storage	Firm/Dispatchable
Wind	BESS[1]	CTG[2]
Solar		CC[3]

1) Battery Energy Storage System (“BESS”)
2) Combustion Turbine Generator (“CTG”)
3) Combined Cycle (“CC”)

Xcel Energy’s Sagamore Wind Farm, NM.

Xcel Energy’s Sandhill Solar Farm, CO.

Hobbs Generation Station, NM.

Xcel Energy’s Jones Station, TX.

Source Image: CESI

System Resources – Commercially Available Technology Modeling Benefits

- Current market established cost and production profiles
  - Actionable near-term modeling results (this decade) - Predictable
  - Cost established
  - Time to market established
  - Current infrastructure certainty – Reuse of existing interconnections beneficial
- Solves near term needs with today's technology
  - Leaves opportunity for "horizon" planning and integration of emerging technologies

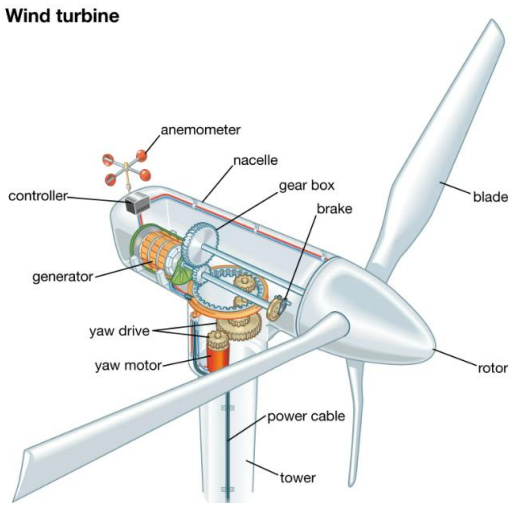
System Resources – Commercially Available Technology Attributes

Attribute	Wind	Solar	BESS[3]	Long Duration BESS[4]
Firm and Dispatchable	No	N0	Yes	Yes
Limited Duration	N/A	N/A	Yes	Multi-day
Proposed Accreditation Method	ELCC[2]	ELCC[2]	ELCC[2]	TBD
Summer Capacity Accreditation	~20%	~75%	>95%	TBD
Winter Capacity Accreditation	~20%	<5%	~80%	TBD
Construction Cost ($/kW)	1,200-2,400	1,200-2,400	1,500-2,100	TBD
Heat Rate (MMBtu/kWh)	N/A	N/A	N/A	N/A
Expected Capacity Factor (%)	45-55	28-35	N/A	N/A
CO_2 Free	Yes	Yes	N/A	N/A

1) PBA – Performance Based Accreditation
2) ELCC – Effective Load Carrying Capability
3) BESS – Battery Energy Storage System – Round Trip Efficiencies: ~ 80% - 85%
4) BESS – Longer Term Durations – Round Trip Efficiencies: ~ 40% - 50%

System Resources – Renewable – Wind

- Convert's the wind energy into electricity
- Large, three-bladed Wind Turbine Generators ("WTGs") aggregated to produce hundreds of MWs
- Intermittent resource
- Capacity factors range from 45%-55% in eastern New Mexico.
- Moderate capacity accreditation due to noncoincidental peak generation profiles.
- Land use:125 acre/MW
- PTC/ITC Eligible



Source Image: Encyclopedia Britannica, Inc.


Xcel Energy's Sagamore Wind Farm, NM.

System Resources – Renewable – Solar (PV)

- Convert's the sun's energy (photons of light) into electricity
- Several forms: Photovoltaic ("PV"), concentrating PV, or concentrating solar power
- Intermittent resource
- Capacity factors range from 30%-35% in eastern New Mexico
- Max output occurs prior to load peak, therefore, less capacity accreditation than nameplate
- Available during the daytime. Generation rises and falls with the sun barring any sky cover such as clouds or fog
- Land use: 8 acre/MW
- PTC/ITC Eligible

Xcel Energy's Sandhill Solar Farm, CO.

System Resources – Storage – BESS

- Power from Electrochemical Process, or other Potential Energy Sources (springs, gravity, etc.)
- Various battery chemistries available, Lithium-ion most currently most prevalent
- Storage typically ranges in size from 10 MW to over 250 MW for durations from 2 to 8 hours
- Balances the intermittent nature of wind and solar
- Dispatchable
- Longer term storage durations in development

Source Image: CESI

System Resources – Storage – Long Duration BESS

- Battery Energy Storage (“BESS”) Long Duration:
- Long duration, multi-day
  - Form Energy’s Iron-air BESS – 10MW/100-hour storage duration
  - Xcel Energy has two pilot projects underway planned for our Northern and Colorado sister utilities
  - Uses electricity to form elemental iron; when the iron rusts again, it releases energy in the form of electricity that can be put back on the grid

System Resources – Commercially Available Technology Attributes

Attribute	CTG	CC	Future CTG[2,3]	Future CC[2,3]
Firm and Dispatchable	Yes	Yes	Yes	Yes
Limited Duration	No	No	No	No
Proposed Accreditation Method	PBA[1]	PBA[1]	PBA[1]	PBA[1]
Summer Capacity Accreditation	>95%	>95%	>95%	>95%
Winter Capacity Accreditation	>95%	>95%	>95%	>95%
Construction Cost ($/kW)	500-750	~1000	TBD	TBD
Heat Rate (MMBtu/kWh)	10	6	TBD	TBD
Expected Capacity Factor (%)	0-25	25-80	0-25	25-80
CO_2 Free	No	No	TBD	TBD

1) PBA – Performance Based Accreditation
2) Hydrogen Capable
3) Carbon Capture and Storage

System Resources – Thermal – CTG

- Typically referred to a simple-cycles because they operate on a single thermal cycle known as the Brayton Cycle
- Operate utilizing several established fuel sources but are traditionally fired with natural gas with a backup fuel such as fuel oil
- Available in a wide capacity range from 4 MW to over 400 MW
- Provide extremely fast start capabilities and ramp rates, excellent load following
- Firm and dispatchable
- Technological advancements have allowed utilization of carbon-free H2, currently blended (38% blend achieved currently)
- Carbon capture an option in the future

Xcel Energy's Jones Station, TX.

System Resources – Thermal – CC

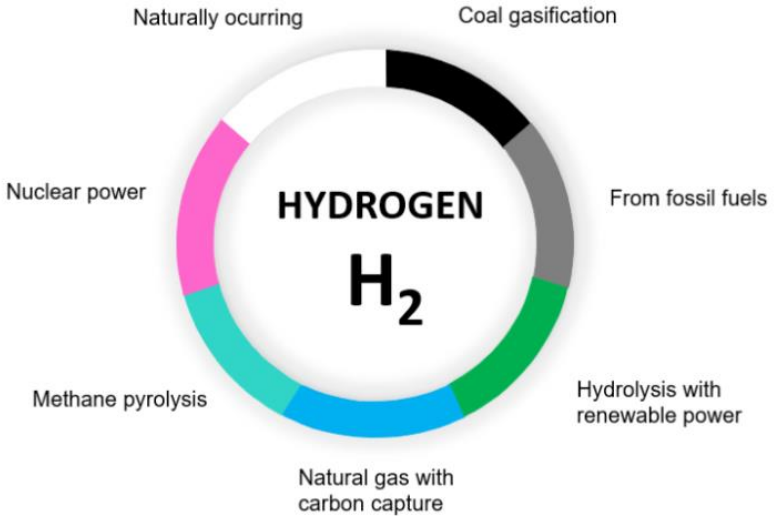
- Utilize CTGs in conjunction with Heat Recovery Steam Generators (“HRSGs”) and a Steam Turbine Generator (“STG”)
- Referred to as CCs because they combine the thermodynamic Brayton and Rankine Cycles
- Exhaust heat from the CTG(s) are ducted through the HRSG(s) to generator steam used by the STG
- Operate in multiple configurations, i.e., 1-on-1, 2-on-1, 3-on-1, etc.
- Operate on various established fuel sources
- Come in a variety of sizes that can range from 100 MW to 1,600 MW
- Efficient due to the “waste” heat is used to generate electricity
- Excellent at load following, Firm and dispatchable
- Hydrogen capable
- Carbon capture an option in the future

Hobbs Generation Station, NM.

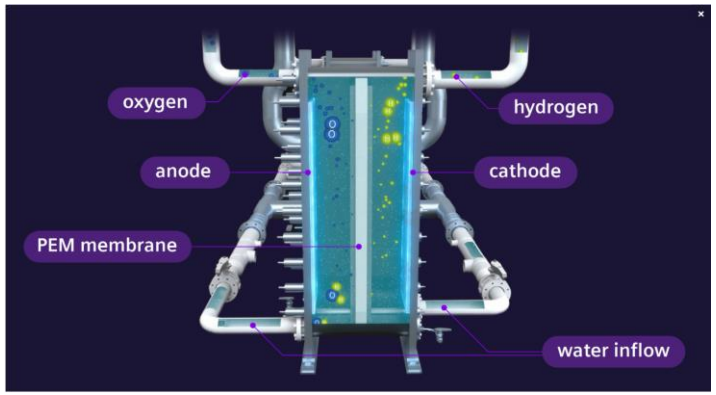
System Resources – Emerging Technologies

Hydrogen (H2):

- Green
  - Hydrogen produced using surplus renewable energy resources, such as solar or wind power, to power an electrolyzer which splits water into hydrogen and oxygen (process known as electrolysis)
- Blue
  - Hydrogen produced from natural gas and supported by carbon capture and storage. The CO2 generated during the manufacturing process is captured and stored
- Pink
  - Hydrogen produced using surplus nuclear energy to power an electrolyzer.



Source Image: Society of Petroleum Engineers



Source Image: Siemens Energy

System Resources – Emerging Technologies

Carbon Capture and Storage/Sequestration (“CCS”):

- Carbon Dioxide (CO2) chemically separated from combustion exhaust
- Capable of exceed 95% efficiency
- Often stored in geological formations or other forms for reuse in other processes

System Resources – Emerging Technologies

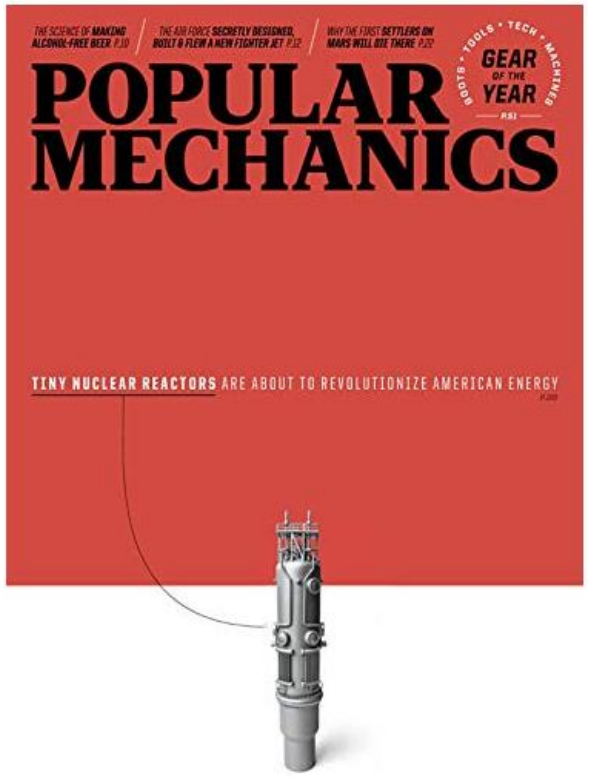
Emerging Technologies:

- The following discussion is not an exhaustive list nor are major technical details discussed
- Material is meant to inform at a high level of some of the emerging technologies that might be of interest to stakeholders.
- If more information is required, Xcel Energy would be happy to provide

System Resources – Emerging Technologies

Nuclear – Small Modular Reactors (SMRs):

- As the name implies, modular scale of proven nuclear reactor designs
- Fully factory fabricated power modules (~77 MW)
  - E.g. - NuScale plants from ~ 230 MW – 900 MW
  - Reduces the financial risks associated w/ conventional builds
- Carbon free energy production



Source Image: Popular Mechanics Jan/Feb 2021

System Resources – Emerging Technologies

Linear Generators

- Reaction vs combustion
- Modular
  - ~1.5MW/module
- Natural gas or biogas fuels
- 100% H2 Capable

Source Image: Mainspring Energy

System Resources – Modeling Emerging Technology

- “Place holders” representative of technology types available for the model to select
- What would stakeholders prefer to model, need suggestions by July 6 preferably

QUESTIONS ?