

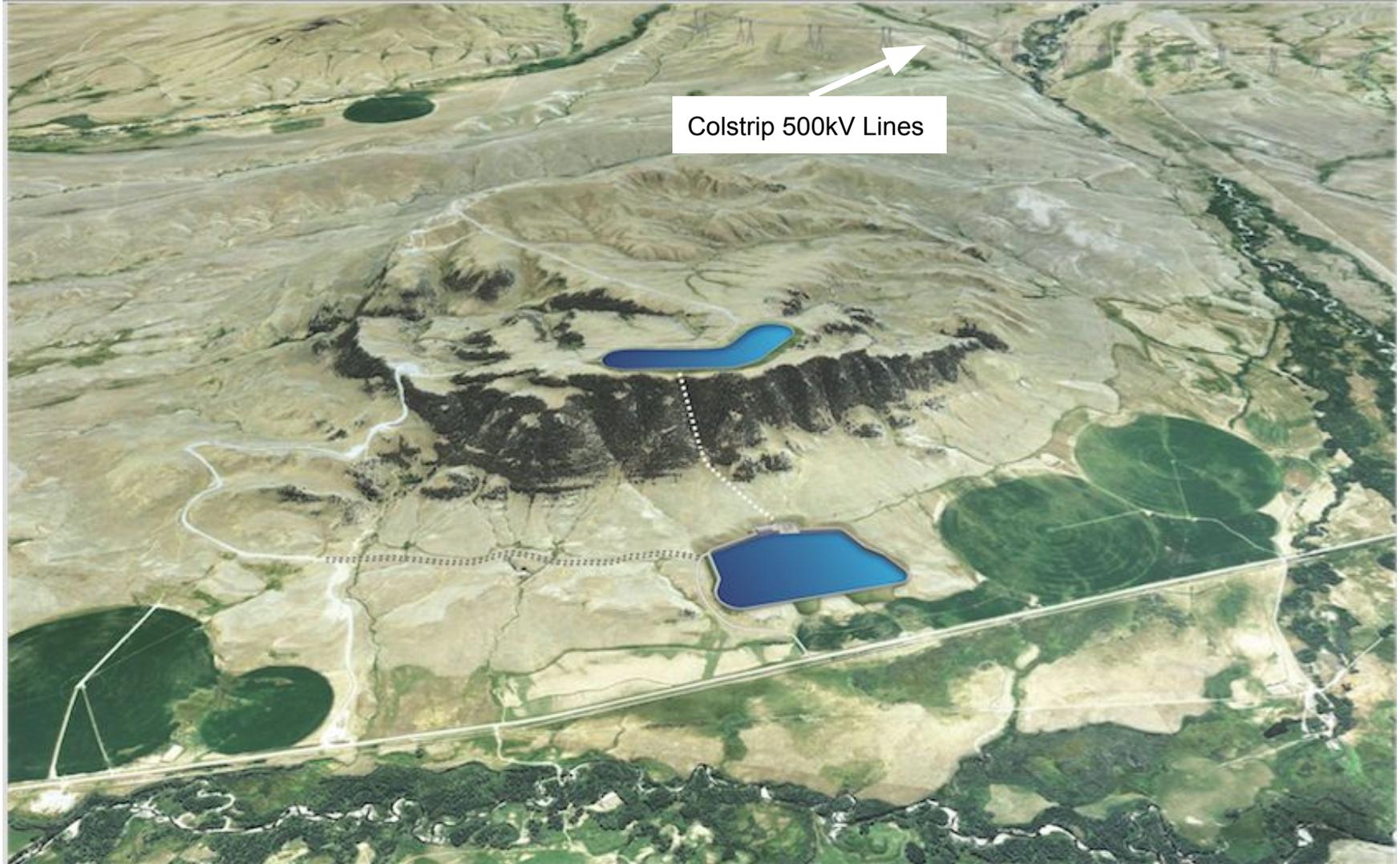


GORDON BUTTE PUMPED STORAGE HYDRO PROJECT

FERC Project No. P-13642

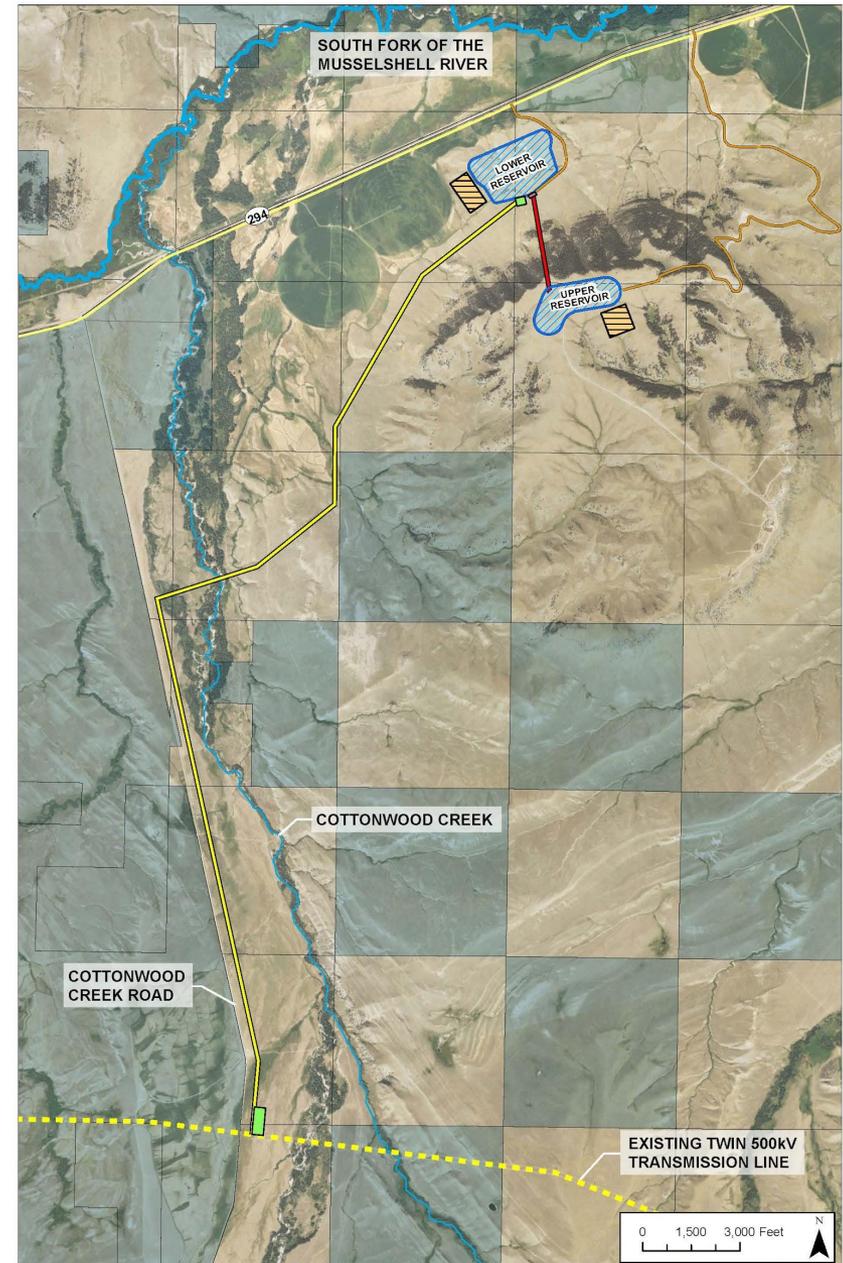
Absaroka Energy LLC

GORDON BUTTE PSH

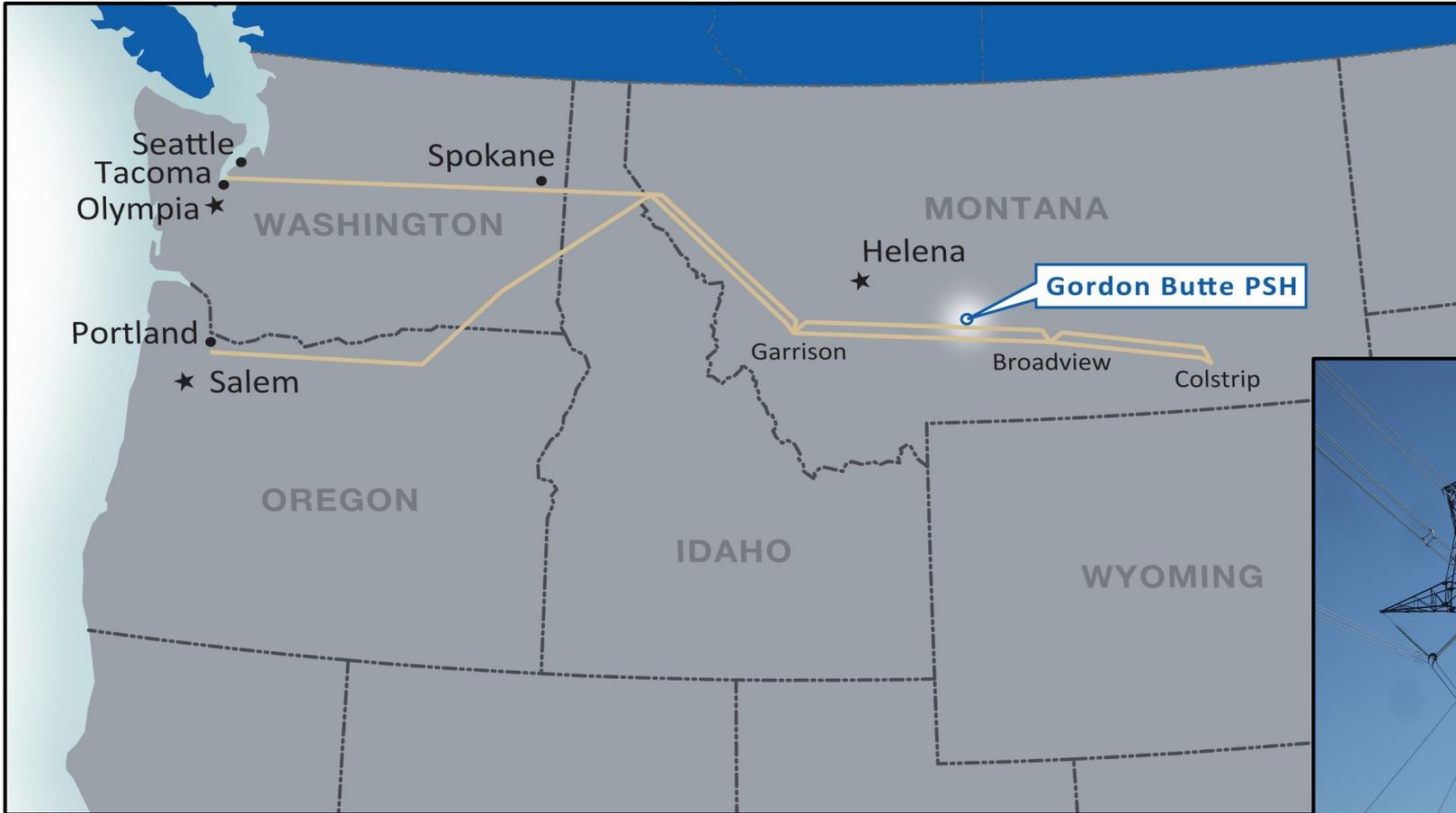


PROJECT HIGHLIGHTS

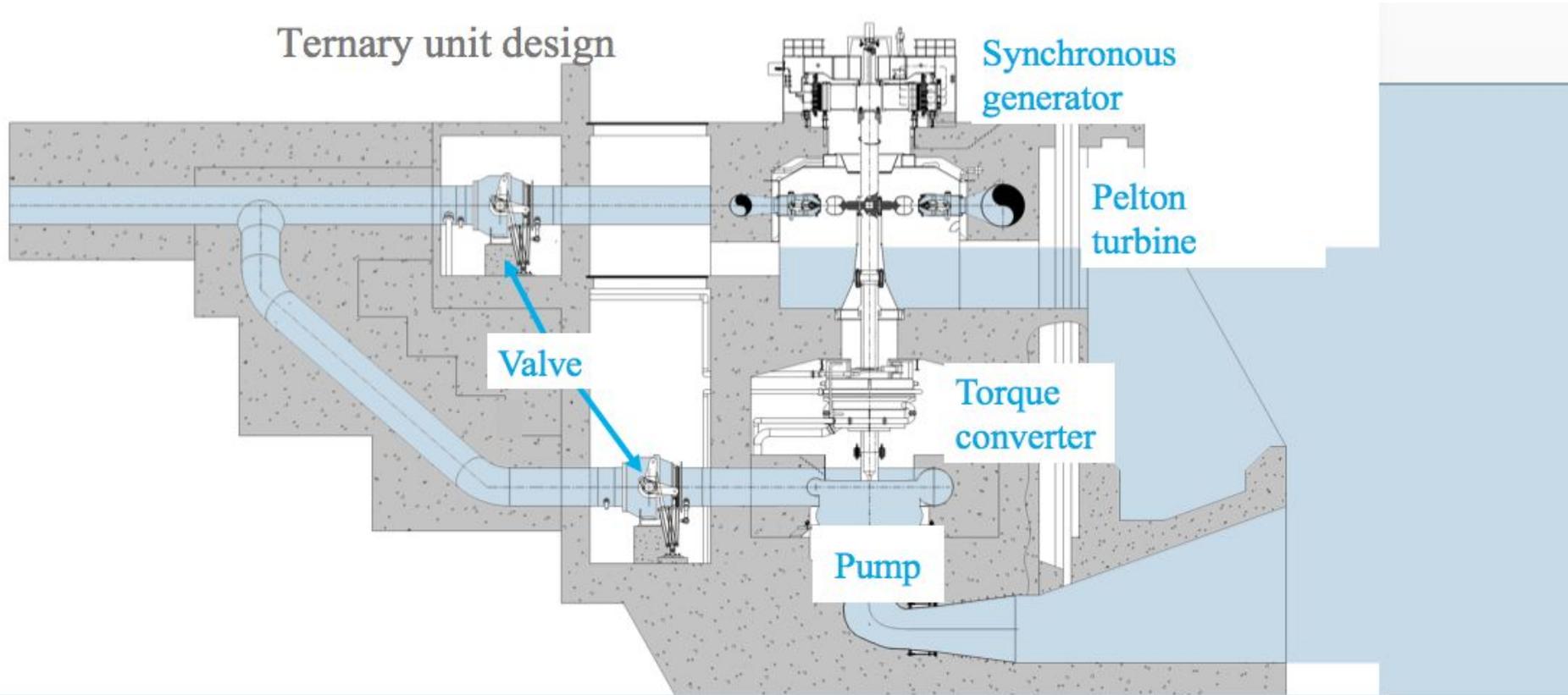
- Installed Capacity: **400 MW**
- Flexible Capacity: **800 MW**
- Estimated storage: **8.5 hours**
- Ternary pump/turbine units: **3**
- Distance from Colstrip twin 500 kV transmission lines: **5 miles**
- Off-stream, closed-loop
- Single private landowner
- Martinsdale, Montana



PROJECT LOCATION

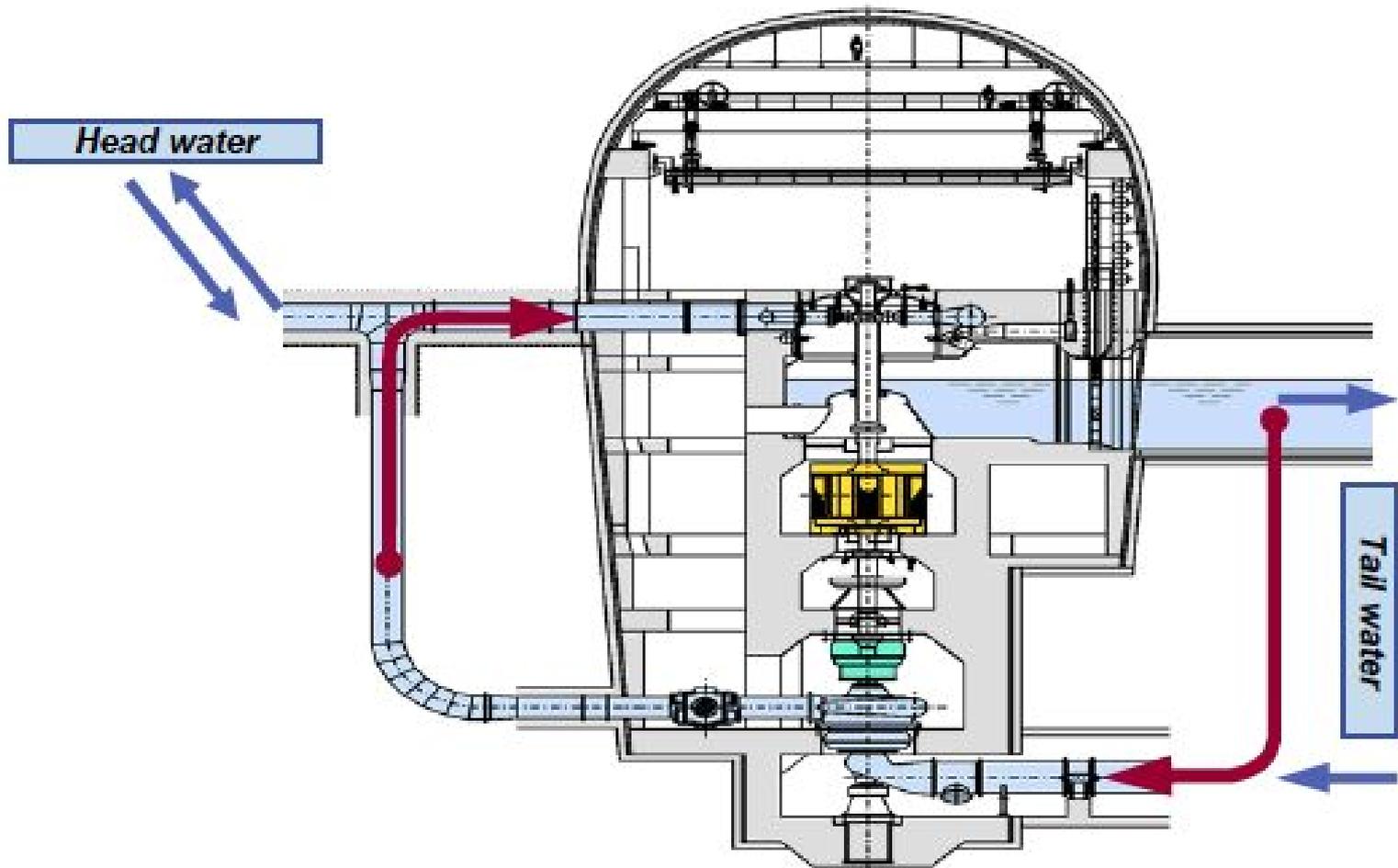


PROVEN TECHNOLOGY



Courtesy of GE Renewable Energy

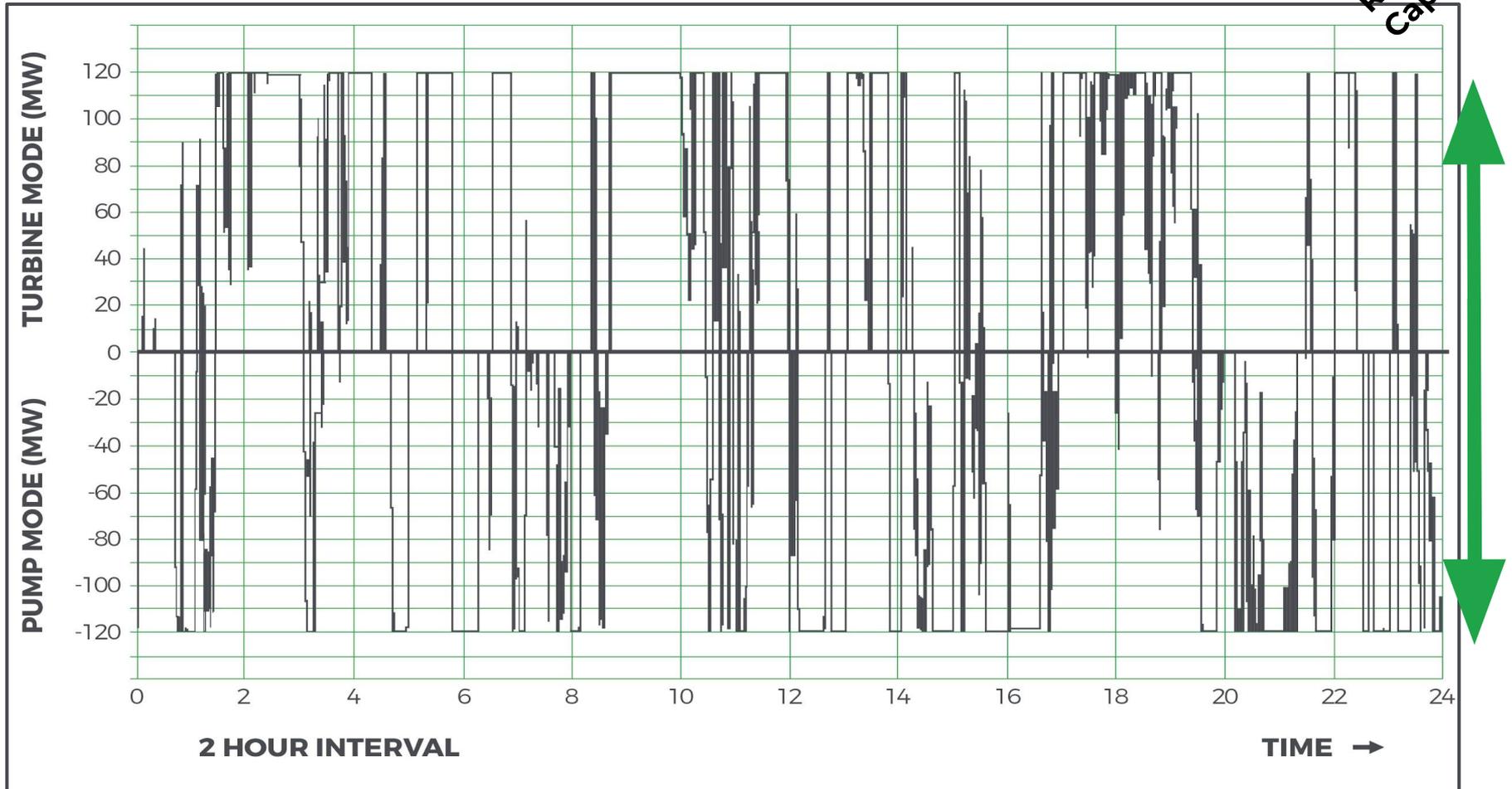
HYDRAULIC SHORT CIRCUIT



ULTIMATE FLEXIBLE CAPACITY

PSH can move faster (20 MW/sec) than gas (40 MW/min)

Regulation
Capacity





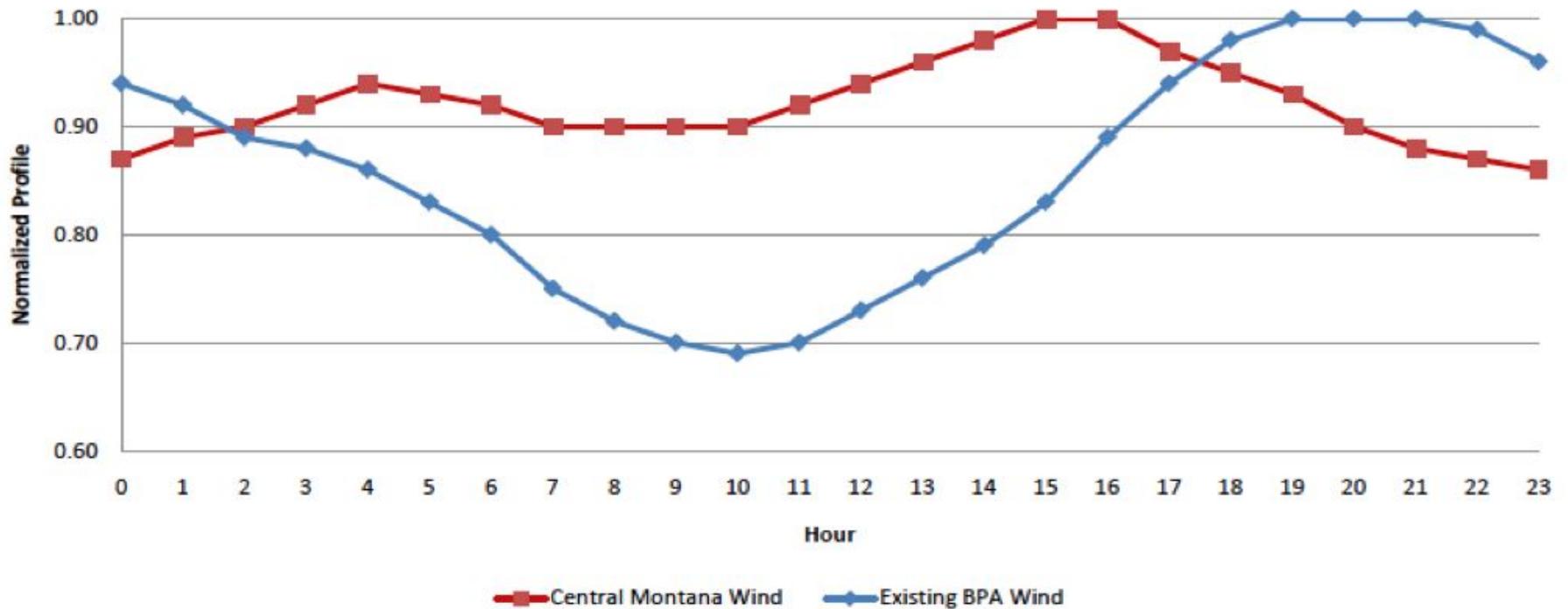
Results – With Wind Capacity Value

+ MT Alternative provides substantial benefits to PSE ratepayers:

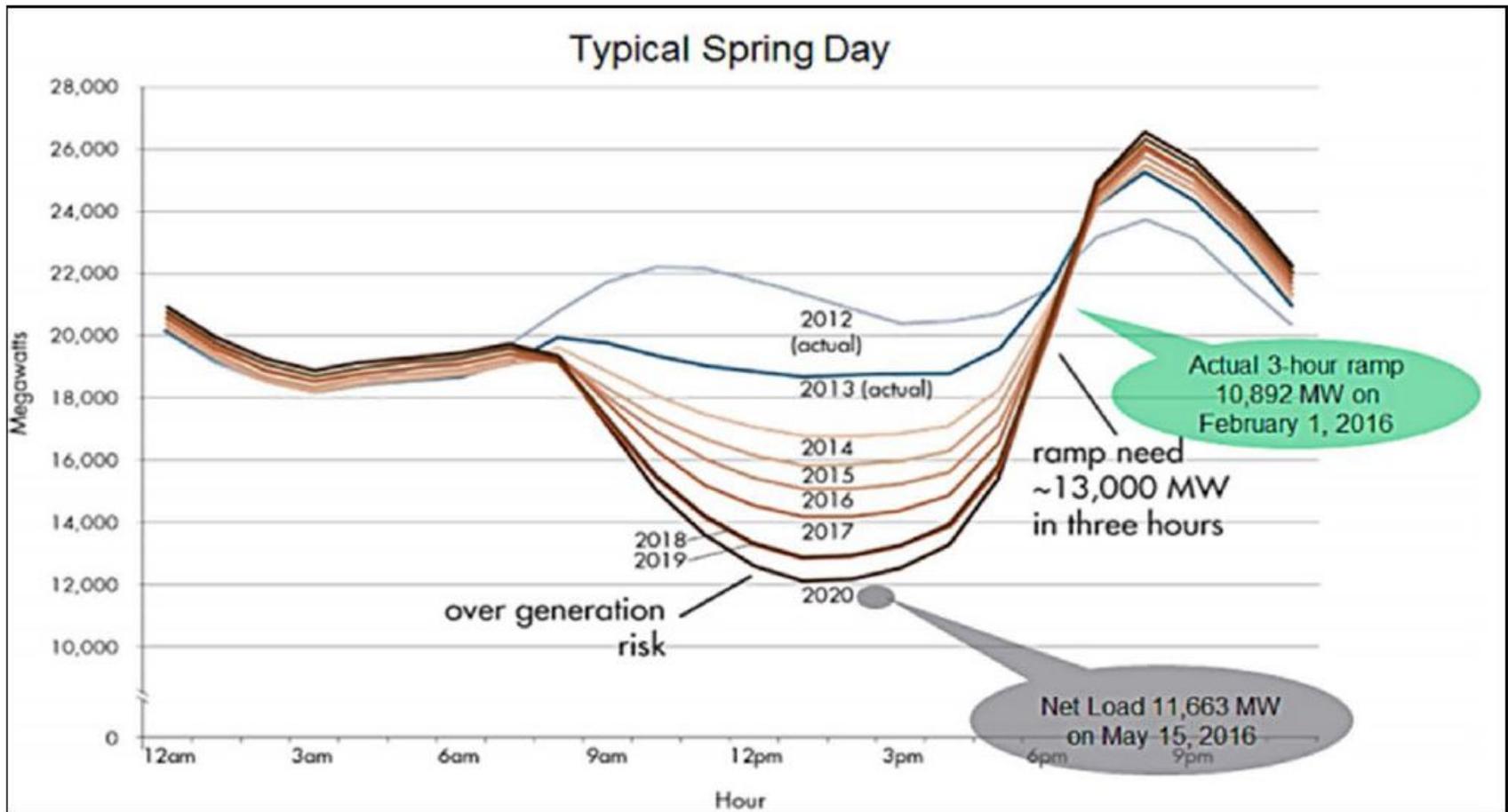
- **\$300 million** reduction in capital costs
- **\$53 million** reduction in levelized annual costs
 - **\$481 million** NPV over 25 years
- **\$24/MWh** reduction in levelized energy costs (250 aMW)



MONTANA / WASHINGTON WIND COMPARISON



CALIFORNIA DUCK CURVE

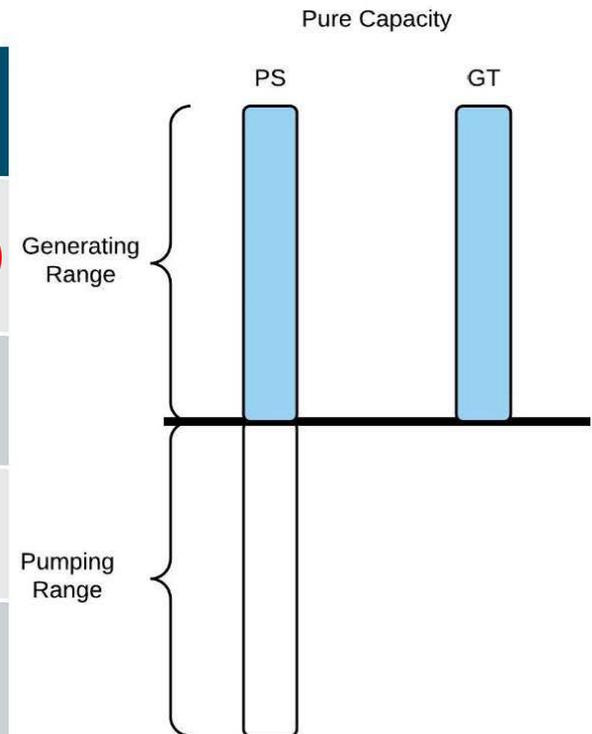




Nameplate Capacity

- Usable capacity provided by the unit (as listed in the NWE Procurement Plan)
- Reflects the unit's contribution to reserve margins / system capacity
- Amount of capacity available to meet peak capacity needs

	Capacity Assumptions	Capital Costs (2018 \$/kW)
PS	Generation rated power = 150 MW Pumping rated load = 150 MW	\$2,439
ICE	Generation rated power = 18 MW	\$1,756
Aero	Generation rated power = 93 MW	\$1,684
Frame	Generation rated power = 79 MW	\$1,459

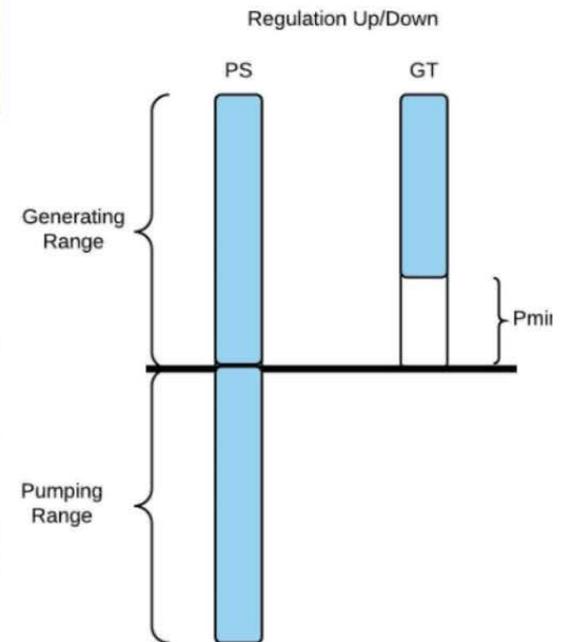




Flexible Capacity: Regulation Up/Down

- Secondary control - occurs within seconds to minutes via automatic generation control
- Provided by generators who are online and have capacity to increase or decrease output

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 \$/kW)
PS	<ul style="list-style-type: none"> • Capacity to increase/decrease system output by reducing/increasing generation or load • Fast switching between modes doubles the effective range unit. 	200%	\$1,220
ICE	Capacity of conventional generators to provide regulation up and down is limited by ramp rate and minimum power generation levels.	79%	\$2,223
Aero		47%	\$3,583
Frame†		87%	\$1,677



*Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]

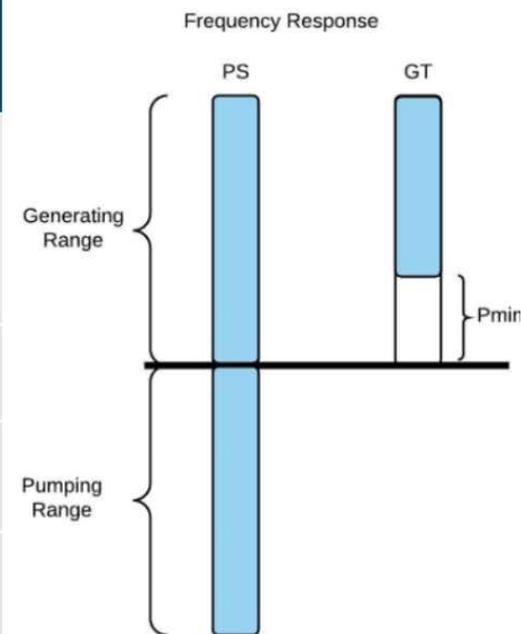
†Frame units are not usually used for Regulation given their limited operating flexibility



Flexible Capacity: Frequency Response

- Primary control - most immediate response to deviations in grid frequency
- Served by generator inertia
- Provided primarily by frequency responsive loads and synchronous generators

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 \$/kW)
PS	<ul style="list-style-type: none">• Inertia of turbine and generator provides frequency response• Some markets offer fast-frequency regulation products	200%	\$1,220
ICE		79%	\$2,223
Aero	<ul style="list-style-type: none">• Primary response requirement for generators with governor function may exist	47%	\$3,583
Frame	<ul style="list-style-type: none">• WECC specifies droop settings for conventional generators	87%	\$1,677



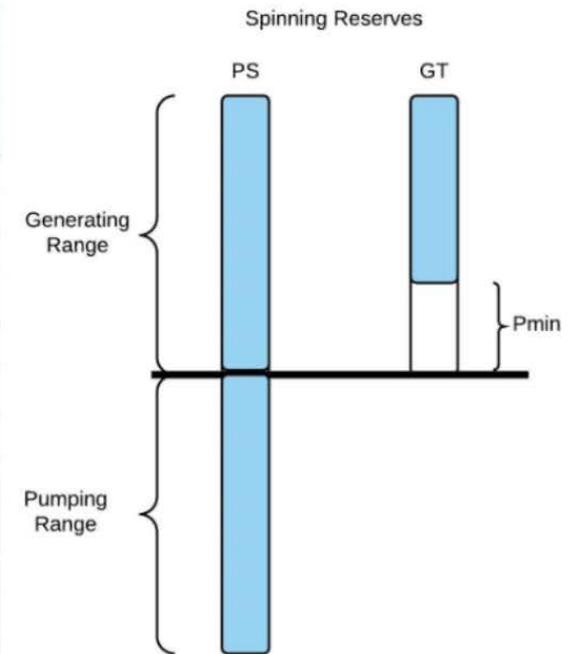
*Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]



Flexible Capacity: Spinning Reserves

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that are synchronized to the grid and able to ramp up within specified time frame

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 \$/kW)
PS	<ul style="list-style-type: none"> • Fast ramp rate and mode switching allows for fast response to operator dispatch • Unit in generation, idling, or pumping mode • Can increase/decrease load or generation • Can switch from one mode to another 	200%	\$1,220
ICE		79%	\$2,223
Aero	<ul style="list-style-type: none"> • Limited by ramp rate, start-up times (hot-start) 	47%	\$3,583
Frame		87%	\$1,677



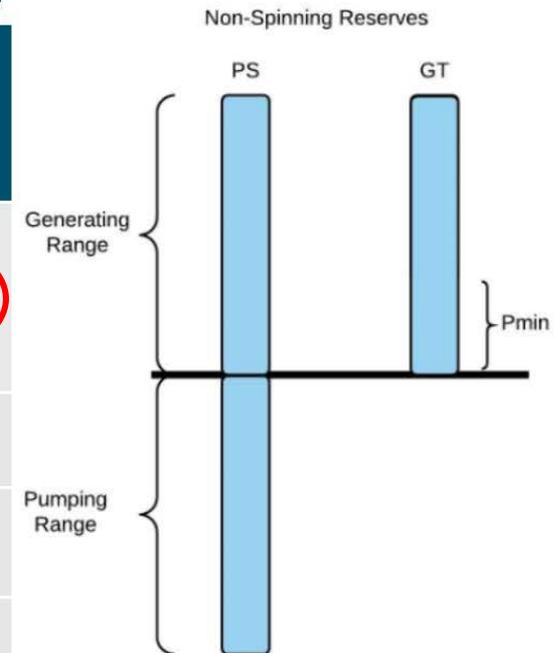
*Assuming operating state is at optimal position for providing frequency response [ex. PS pumping, GT at Pmin]



Flexible Capacity: Non-Spinning Reserves

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that *are not necessarily* synchronized to the grid, but able to ramp up generation within specified time frame
- Required response time is slower than spinning reserves

	Capacity Assumptions	Usable Capacity Range (% of Nameplate)*	Capital Costs (2018 \$/kW)
PS	<ul style="list-style-type: none">• Unit in standby mode• If dispatched, can quickly ramp up capacity	200%	\$1,220
ICE	<ul style="list-style-type: none">• Capacity and participation limited by ramp rate, start up time (cold-start)	100%	\$1,756
Aero		100%	\$1,684
Frame		100%	\$1,459



*Assuming operating state is at optimal position for providing frequency response [ex. PS pumping, GT not on]

PROJECT MILESTONES



- Site Control
- Water Right Permit
- Environmental Assessment
- Geotechnical
- 401 Water Quality Certification
- Interconnection Feasibility Study
- EPC Team
- FERC License

Gordon Butte Team

EQUIPMENT



GE Renewable Energy

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