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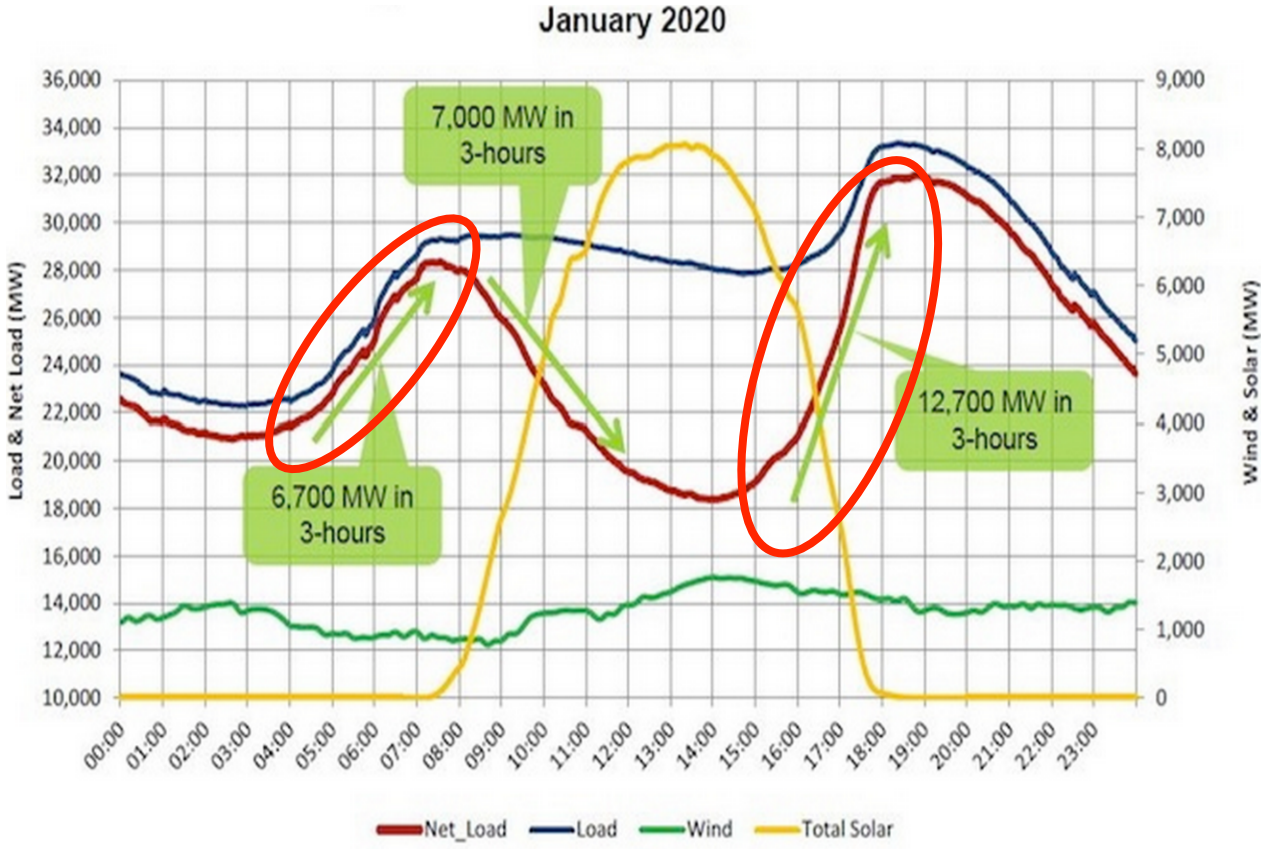
Integrating Renewable Generation With Energy Storage And Gas Turbine Generation

Renewable Generation Challenges

Renewable generation :

- Is not always predictable causing load balancing challenges
- Times of Peak Generation not always aligned with times of Peak Demand
- Requires nearly equal amount of conventional generation as backup
- Require ability for backup generation sources to ramp quickly as demand and renewable generation supply vary

Generation Source versus Demand



Grid Connected Energy Storage Solution

- What if I could store off peak power?
- What if I could use that stored power during morning and evening peak demand?
- What if I could multiple that stored power up to 200% by integrating it with conventional gas turbine generation?
- What if this additional power was available within seconds of demand?
- What if this capability was available at a fraction of the life cycle cost of current conventional storage systems?

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Energy Storage and GT Power Augmentation

Four Main Systems:

- CAES/Thermal Storage – off peak power is stored as compressed air and thermal energy (heated graphite)
- LP/HP Compressors – used to charge compressed air system
- Expanders – used to extract energy from compressed and heated air during power cycle
- GT Air Injection – heated air from expanders and LP compressor injected into GT to increase mass flow and power output during the power cycle

Energy Storage Cycle Consumes 8 MWs

Compressed Air

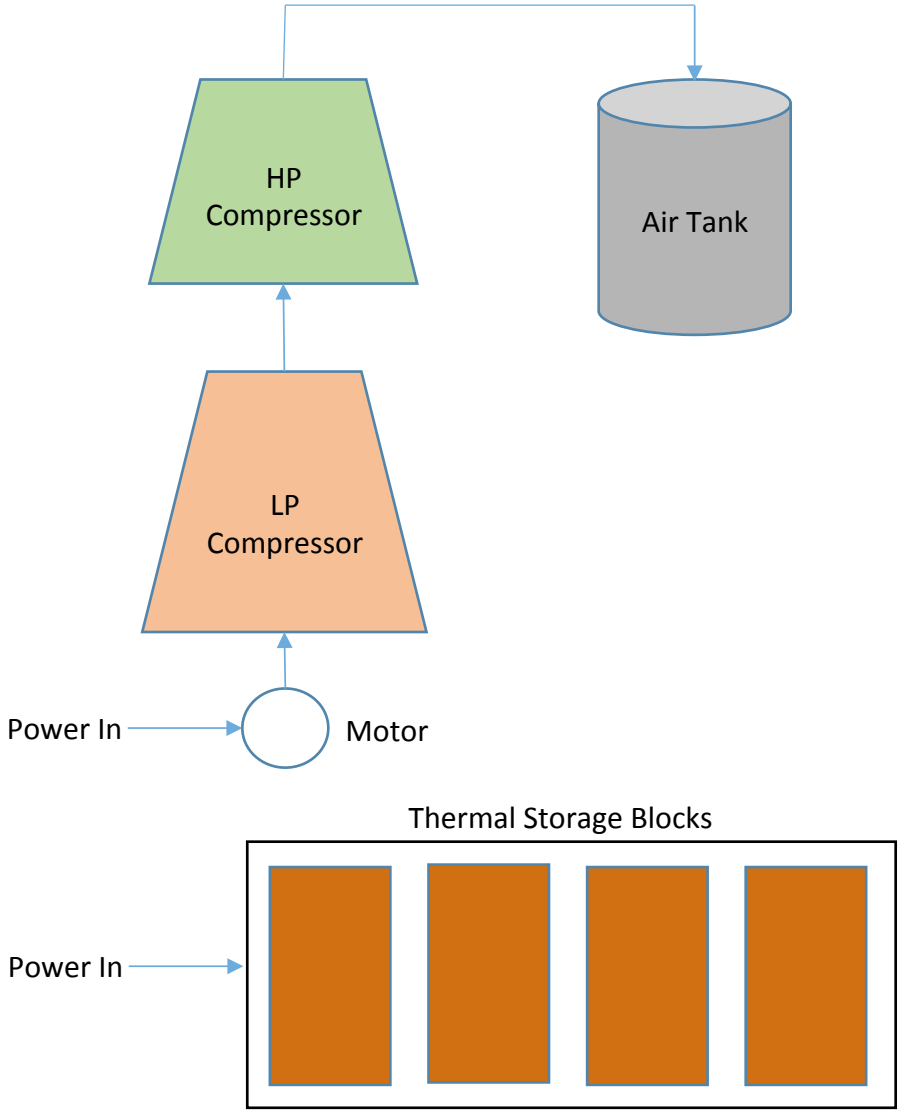
- Off peak power used to drive motor to compress air
- Stored in one or more air tanks

Thermal Storage

- Off peak power used to heat thermal storage media
- Heated up to 815 degC
- Useful thermal charged maintained for up to thirty (30) days

Notes

- Storage cycle requires **8MW to charge the system**
- System designed to supply air/heat for four (4) hours of continuous discharge (longer discharge cycles available)
- Actual charging power required can vary rapidly and provide grid regulation during the storage cycle.



Energy Discharge Cycle Delivers 16 MWs Net Power

Process

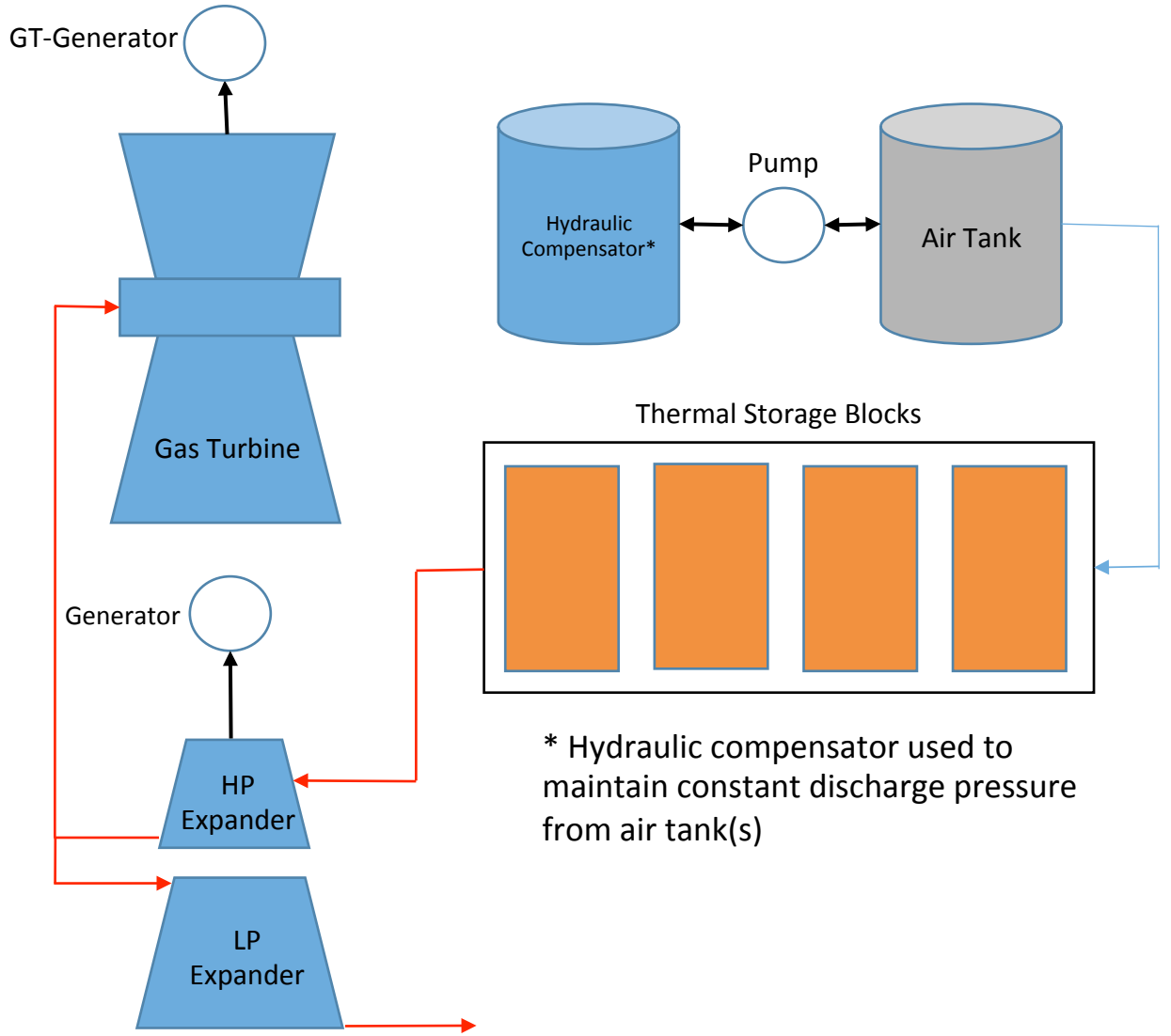
- Compressed air released and heated by thermal storage media
- Hot/compressed air passed through expander train to generate MW's
- Slightly cooled air injected into gas turbine (GT) at compressor discharge conditions (temperature and pressure)

Performance

- Increased mass flow in GT and power from Expander provide **16MW net output** for up to 4 hours

Notes

- If GT is not running, hot/compressed air passed through both HP and LP Expanders, generating 4.5MW net output
- Designed for two (2) Charge/Discharge cycles daily
- Discharge power can vary to support load firming and grid regulation



Summary

- Renewables present load firming challenges.
- Peak Load demands continue to grow.
- Off peak storage and flexible/fast ramp discharge solution required.
- Integrating storage solutions with conventional gas turbine generation has distinct advantages.
- PowerPHASE FASTLIGHT a Powerphase company system addresses key challenges and requirements – High Power Output at low investment by using existing assets

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Thank You