Just In-Time Energy Company

Combined Electric and Gas Storage System (CEGS)

7th annual, Thermal-Mechanical-Chemical Energy Storage Workshop

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What It Is

Just In-Time Energy Company

Combined Electric and Gas Storage System

1. A hybrid large-scale long-duration electric energy storage system.
2. Combined with a high deliverability natural gas storage system.
3. Includes a Liquefied Natural Gas (LNG) plant modified for once-a-day startup.
4. Electric energy is stored both as LNG and as molten salt.

What It Does

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Combined Electric and Gas Storage System

1. At night, stores natural gas and electric energy as LNG.
2. Stores additional electric energy as molten salt at night and other off-peak times.
3. At peak time, 93% of LNG is returned to the pipeline (remainder is used as fuel).
4. Concurrently, all the electric energy used to make the LNG and heat the molten salt is returned to the grid.
5. At a fuel rate significantly better than a modern combined cycle power plant.
6. At off-peak times, the electric generators are used to provide grid ancillary services.
7. Can supply both gas and electric power non-stop for over 4 days.

How It Does It

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Combined Electric and Gas Storage System

1. LNG is produced using a conventional electric motor-driven LNG plant modified for once-a-day start-up.
2. The electric energy is stored both as LNG and as molten salt.
3. The molten salt is produced using electric resistance heaters and stored in insulated carbon steel tanks.
4. The LNG is returned in gaseous form to the pipeline while generating electric energy using Just In Time Energy's patented technology (more in a minute).
5. An ORC optimizes the use of the molten salt and residual waste heat, increasing power production and improving fuel rate.

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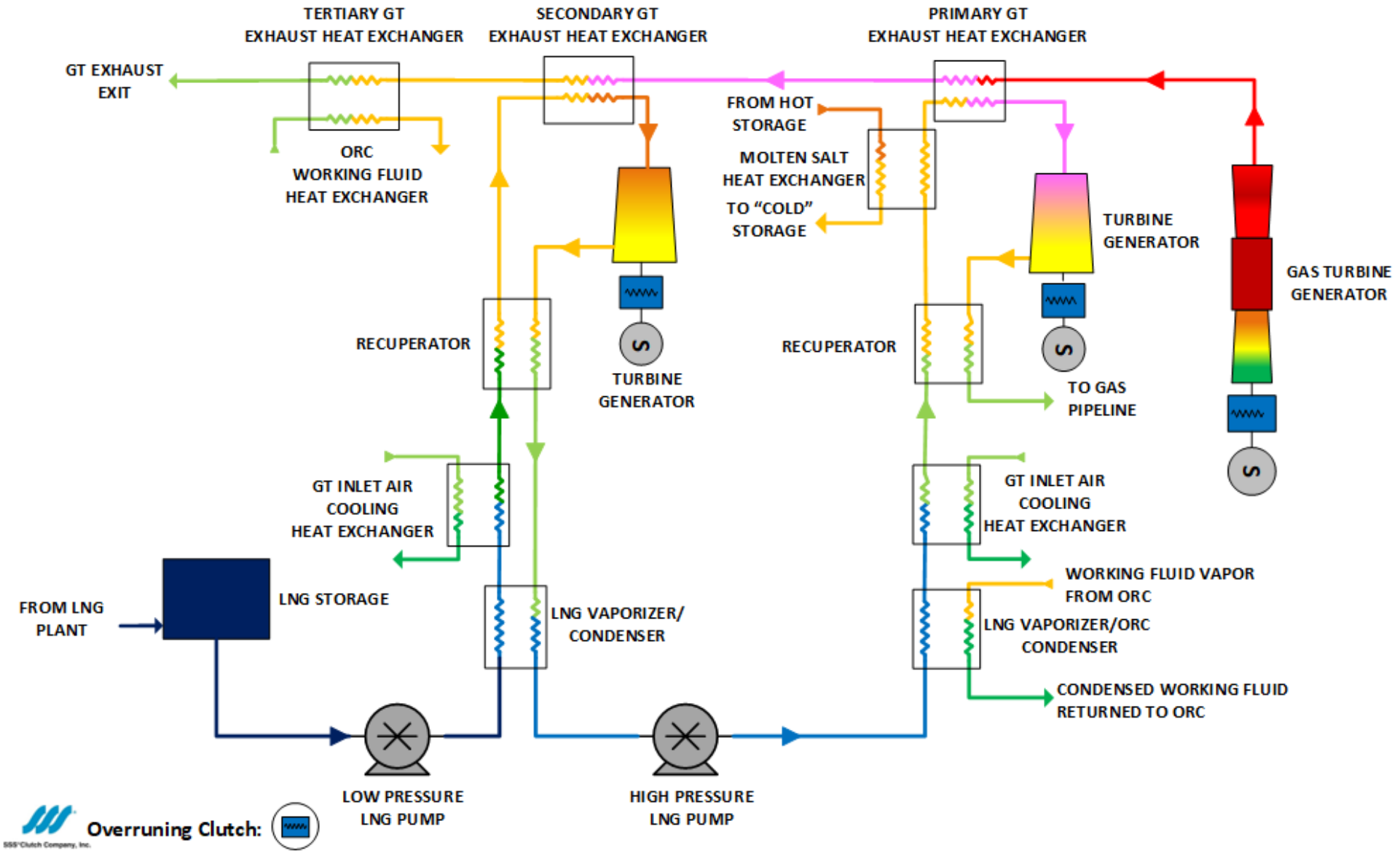
150 MW Combined Electric and Gas Storage/Recovery System



Why It's Needed

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Combined Electric and Gas Storage System

1. Peak electric load coincides with peak gas demand.
2. There is a need for more gas and electric energy at peak times, as renewables can't keep up with demand.
3. Many pipeline systems are at near capacity at peak times.
4. 80% of stored gas is in depleted gas or oil fields, not suited for meeting peak demands.
5. Plenty of gas is available at night as compressor stations are shut down as full line pack is achieved.
6. Excess wind power is available at night.
7. Renewable energy curtailment increases with penetration, leading to cheap energy to store.

Modes Of Operation

Normal Energy Storage/ Recovery Mode

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1. LNG plant and molten salt heaters operate at night and most of the weekend.
2. Salt heaters also operate at other times when excess power is available.
3. Gas and power recovery system runs during peak time,
    a) Generating electric power.
    b) Concurrently converting the LNG back to gaseous form at the required pipeline pressure.
    c) The hot molten salt enhances power production and lowers the fuel rate.
    d) Additional molten salt heating occurs during the daytime, storing short bursts of excess renewable energy.

Flex Mode

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1. 90% Design electric production with 50% of the design flow of gas returned to the pipeline.
2. Minor increase in fuel rate.
3. Maintains unity ER

Grid Ancillary Services Mode During Off-Peak Time:

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Combined Electric and Gas Storage System

1. SSS Clutches enable the generators to operate as synchronous condensers at off-peak times, providing:
   a) Grid voltage support.
   b) Power factor improvement.
   c) inertia to the grid, improving voltage stability, and increasing available short-circuit current.

2. Ancillary services have grown increasingly important and are often compensated by the grid operator.

Emergency Operating Mode (five or more consecutive days with no excess power available):

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1. The gas turbine or gas engine generators run at night, providing power to operate the LNG plant and exhaust heat to heat molten salt.
2. Allows the system to deliver full peak time power and gas to the grid and pipeline.

Who Needs It?

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Combined Electric and Gas Storage System

1. Owners of renewable energy systems – take full control of the sale of your energy, gain a new revenue stream, eliminate curtailment
2. IPP's and regulated electric utility companies, particularly those already contracting for gas storage or concerned about gas supply reliability
3. Gas pipeline companies, particularly those having difficulty meeting peak demands (19 GW of new CS power plants coming online by end of 2028)
4. Large distribution gas utilities
5. Owners of peak-shaving power plants
6. LNG import terminal owners

Typical Performance

Matched to an existing 140 MW site rated GE Frame 7 GT-generator at a peaking facility

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Combined Electric and Gas Storage System

1. 370 MW total system output.
2. Returning gas flow to pipeline – 300 lbm/s (25.6 MMSCFH).
3. Unity energy ratio.
4. 3900 BTU/KW-HR fuel rate.
5. LNG plant sized to liquefy 80 lbm/s of natural gas.
6. LNG and molten salt systems consume 93 MWH per hour on average during off-peak time.

Matched to eight 10 MW gas engines

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Combined Electric and Gas Storage System

1. 150 MW total system output.
2. Returning gas flow to pipeline – 82 lbm/s (6.7 MMSCFH).
3. Unity energy ratio.
4. 4400 BTU/KW-HR fuel rate.
5. LNG plant sized to liquefy 21 lbm/s of natural gas.
6. LNG and molten salt systems consume 38 MWH per hour on average during off-peak time.

What's the Big Deal?

Just In-Time Energy Company

Combined Electric and Gas Storage System

1. Long-duration electric energy storage (over 48 hours).
2. Combined with 48 hours of high-deliverability gas storage.
3. Limits the need for New Gas Pipelines and Compressor Stations.
4. Unity energy ratio and less than 4000 BTU/KW-HR.
5. Two major and one minor revenue streams.
6. Emergency operation with full electric power production and delivered gas as long as needed.