# Optimizing CSP Storage Capacity


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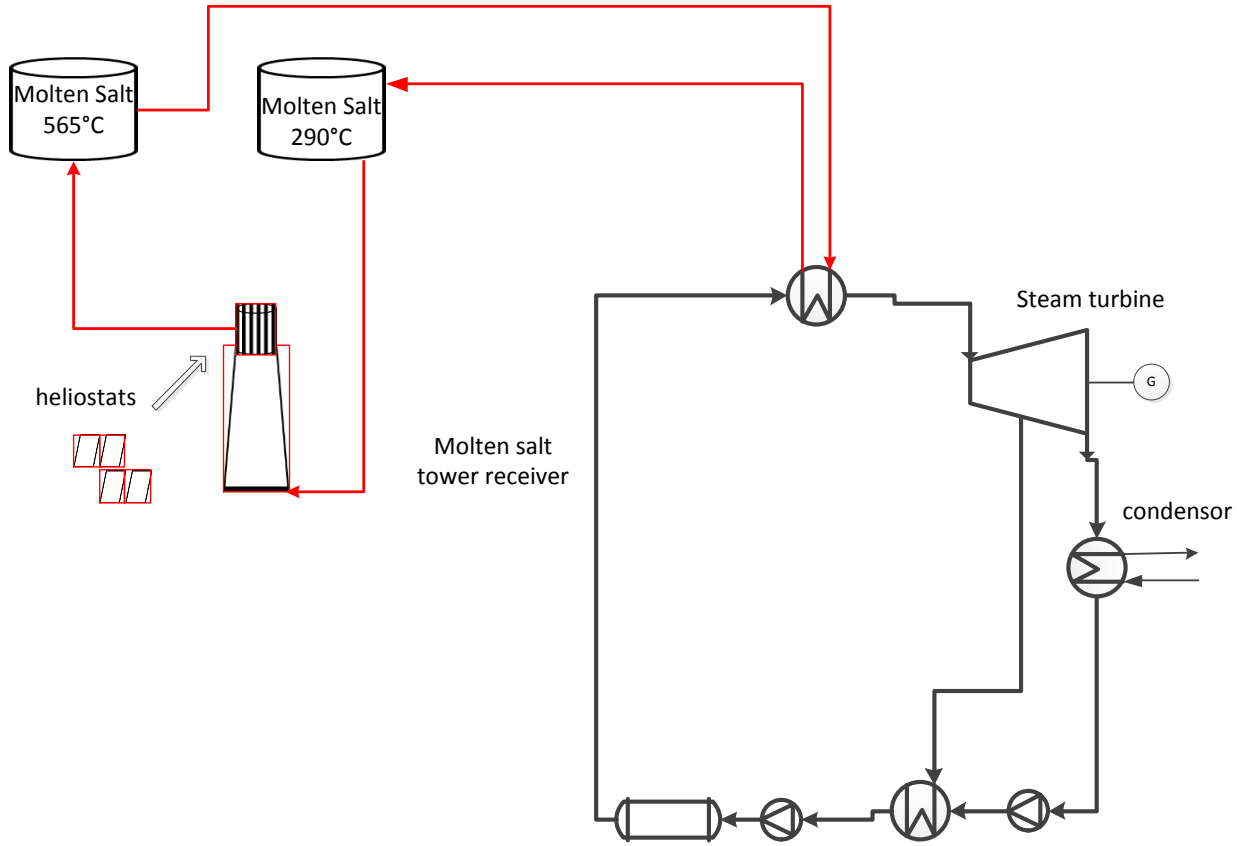
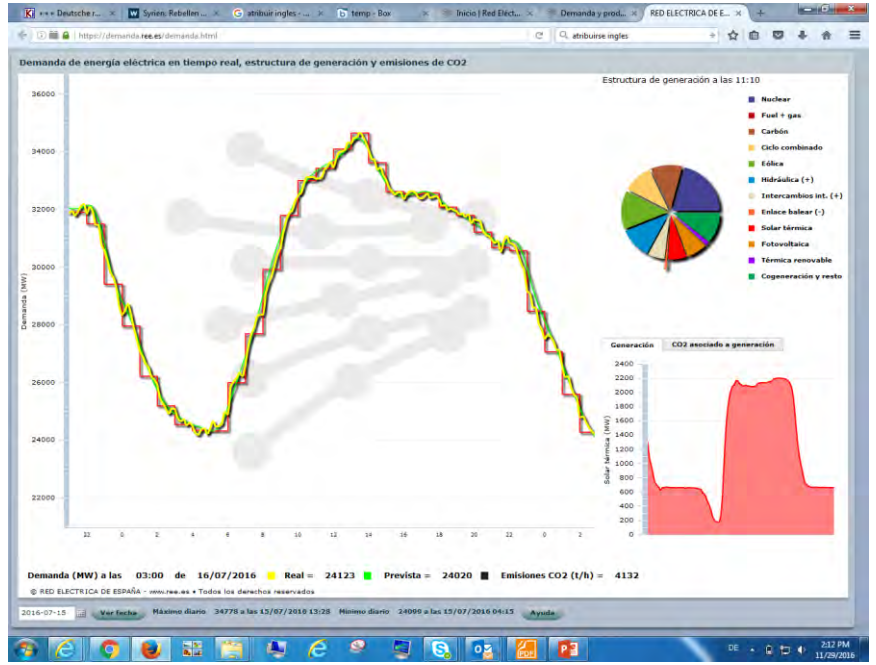
# Energy Storage Concept

# Using CSP capabilities to manage Intermitent Renewable Power

# Molten Salt Storage and power cycle well known from tower based CSP

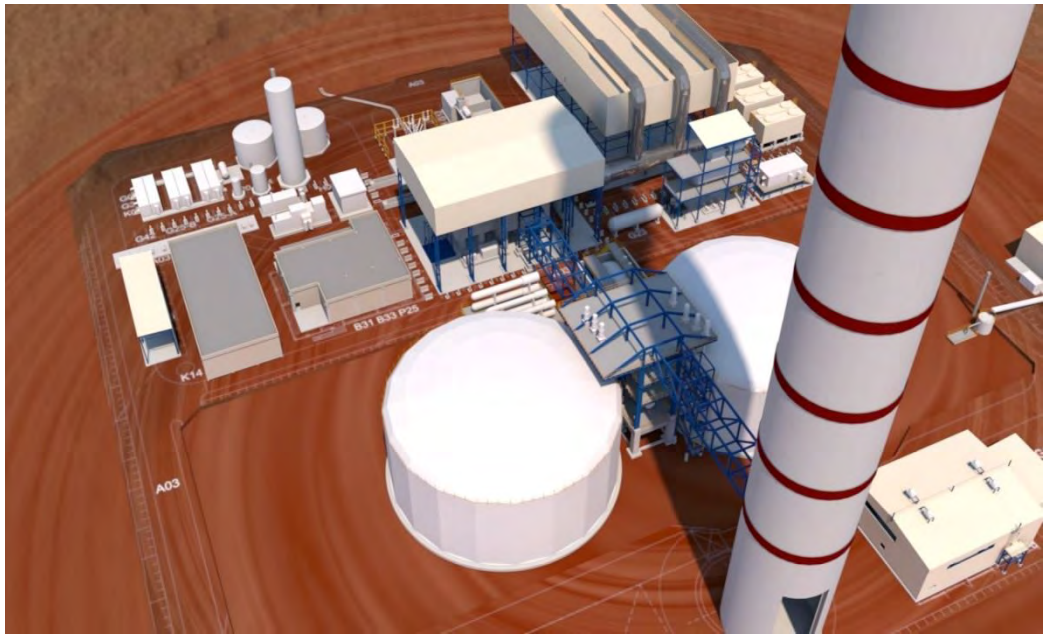
**Molten Salt - experience, references, low cost - industrially well known ($NaNO_3$ + $KNO_3$)**

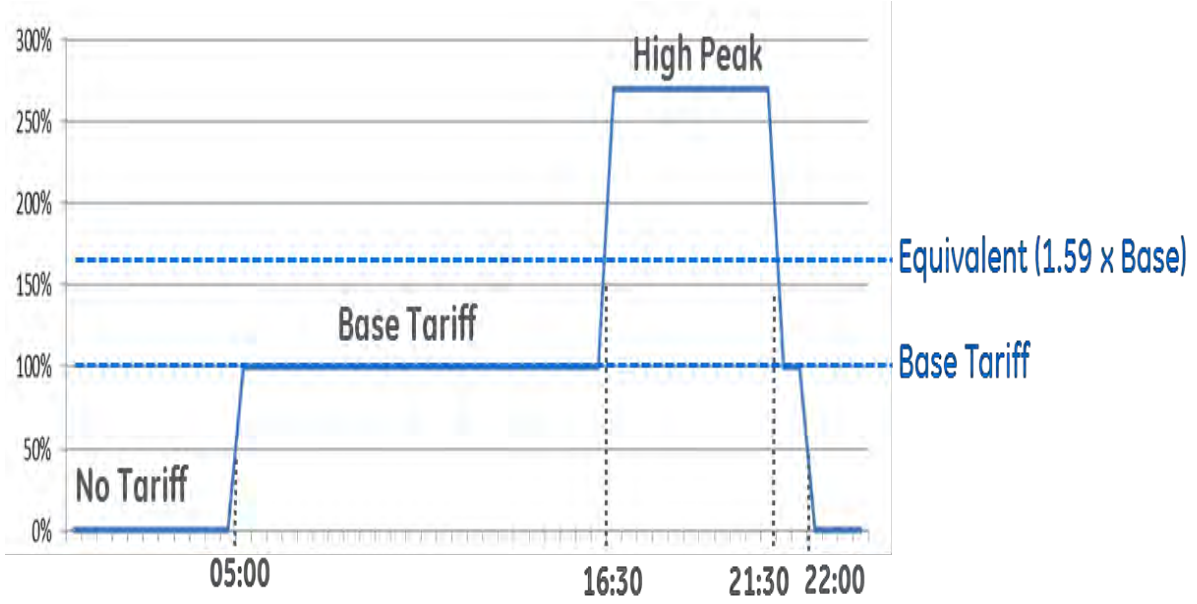



- Well known 2-tank solution in Spain.
- Non-toxic - 60% $NaNO_3$ + 40% $KNO_3$
- Used as fertilizer and in the petrochemical industry.
- Stable upto 565°C, freezes at 240°C.

# Currently only partly usage of assets – 7h stop

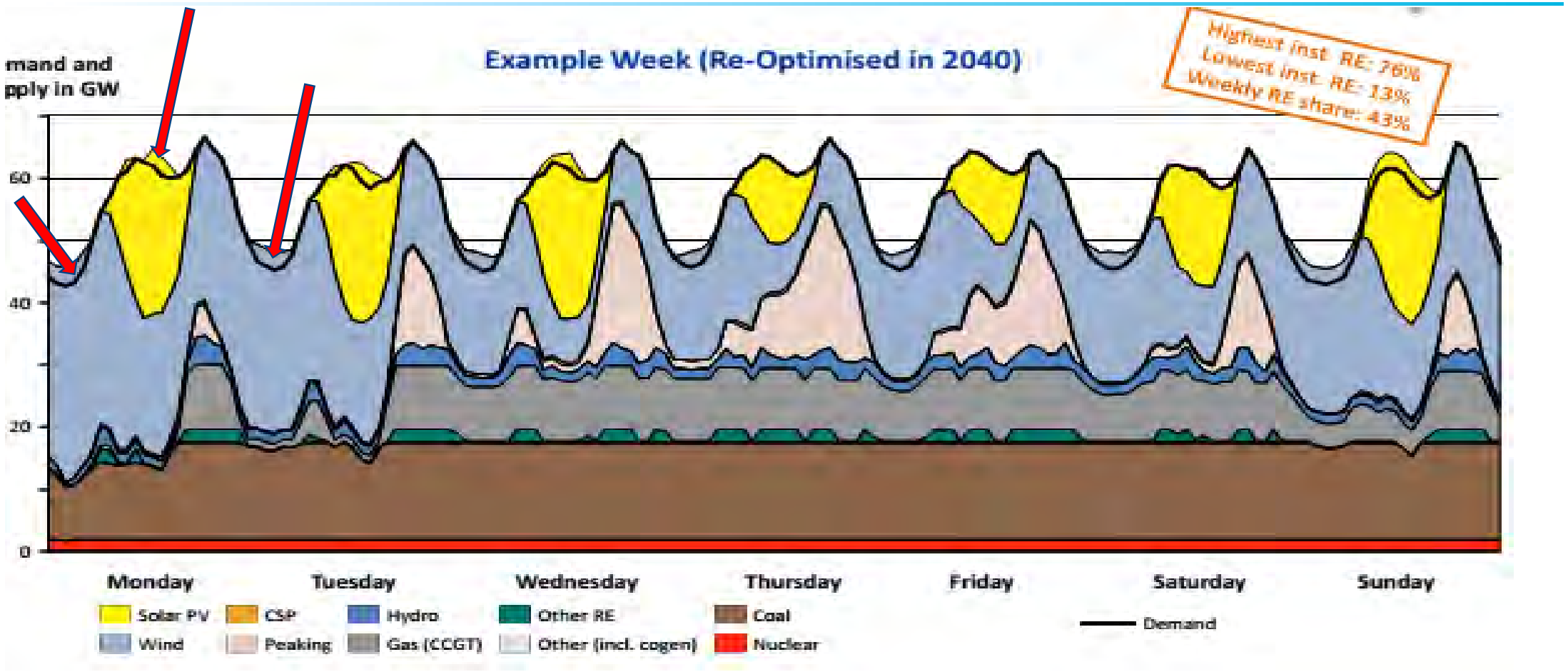




# Adding Intermitent Wind and PV to grid will require storage capabilities

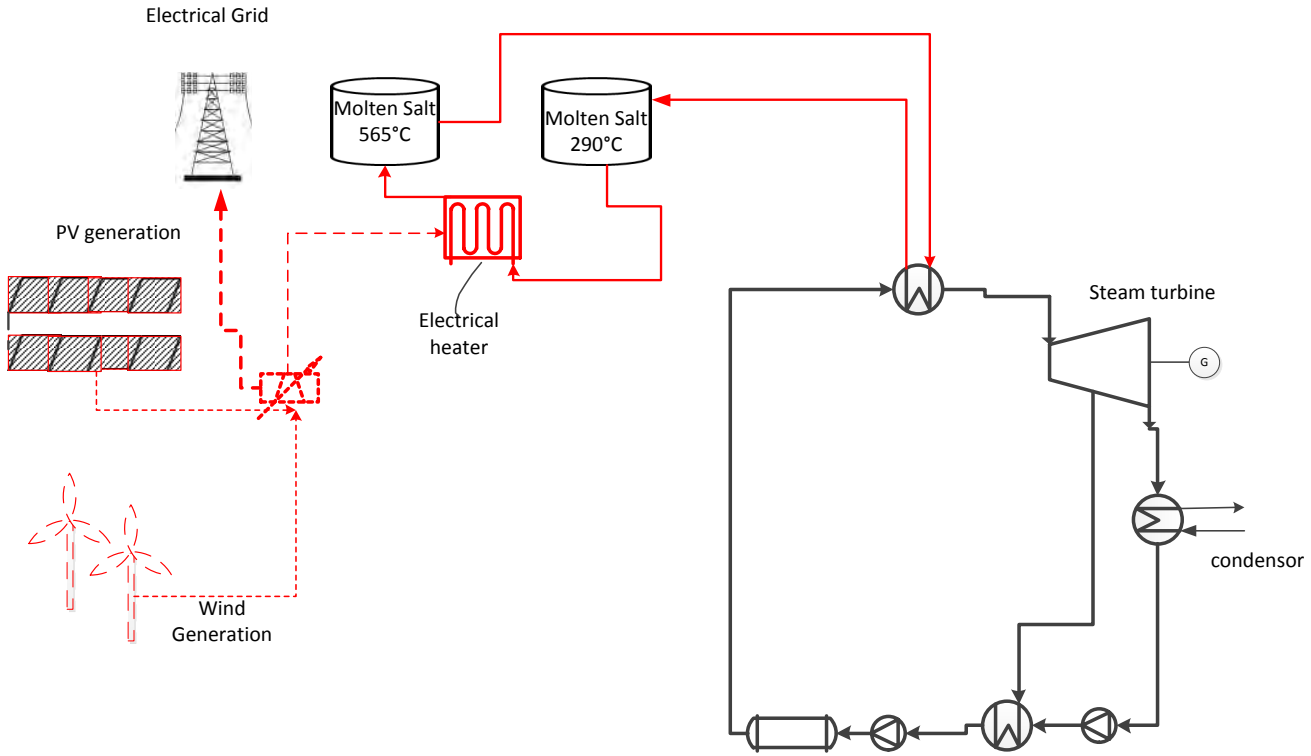
- Planned **17.6 GW PV** + **37.4 GW Wind** will add significant intermitent generation.
- Manage the grid will be a mayor challenge.
- Storage will be key.
- CSP will allow compact storage solution in line with PV and Wind development

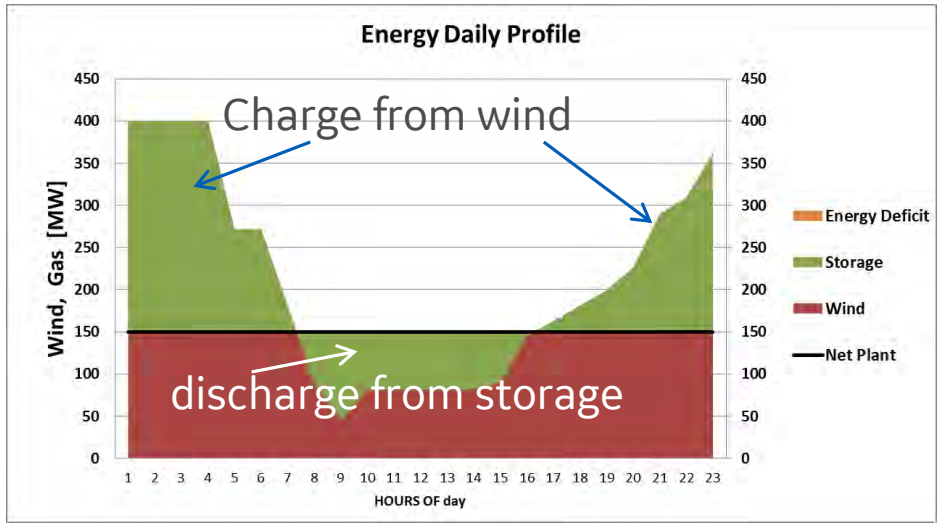
# CSIR Scenario – Need for storage for high RE mix



# Direct electrical heating of molten salt from Wind and PV installations

**Electrical heater integration for 5 - 400 MW possible**




Round trip efficiency corresponds to the heat to electricity efficiency of steam cycle.

# LCOE Comparison – Battery vs. Molten Salt System

| | | DoE | | Case 1 | Case 2 | Case 3 |
|---|---|---|---|---|---|---|
| **Hours of storage** | **h** | 3 | | 3 | 7 | 9 |
| **Hours of charging** | **h** | | | 21 | 4 | 4 |
| **Capacity** | **MW** | | | 150 | 150 | 150 |
| **Daily generation/discharge** | **MWh** | | | 450 | 1050 | 1350 |
| **Heater charging capacity** | **MW** | | | 51 | 625 | 804 |
| **Total EPC Storage cost** | **$ m** | | | 21 | 50 | 64 |
| **Total EPC Heater cost** | **$ m** | | | 10 | 125 | 161 |
| **Total EPC** | **$ m** | | | **32** | **175** | **225** |
| **LCOE** | **R/MWh** | **5615** | | **359** | **850** | **850** |
| | | **100%** | | **-94%** | **-85%** | **-85%** |

**Assumptions:**

Specific EPC price elctrical heaters: 200 $/KWe

Specific EPC price Molten Salst System: 20 $/KWhe

Efficiency Water Steam Cycle: 42%

O&M Cost / year: 2% of EPC price

**Assumptions according to DoE info:**

Discount Rate: 8.2%

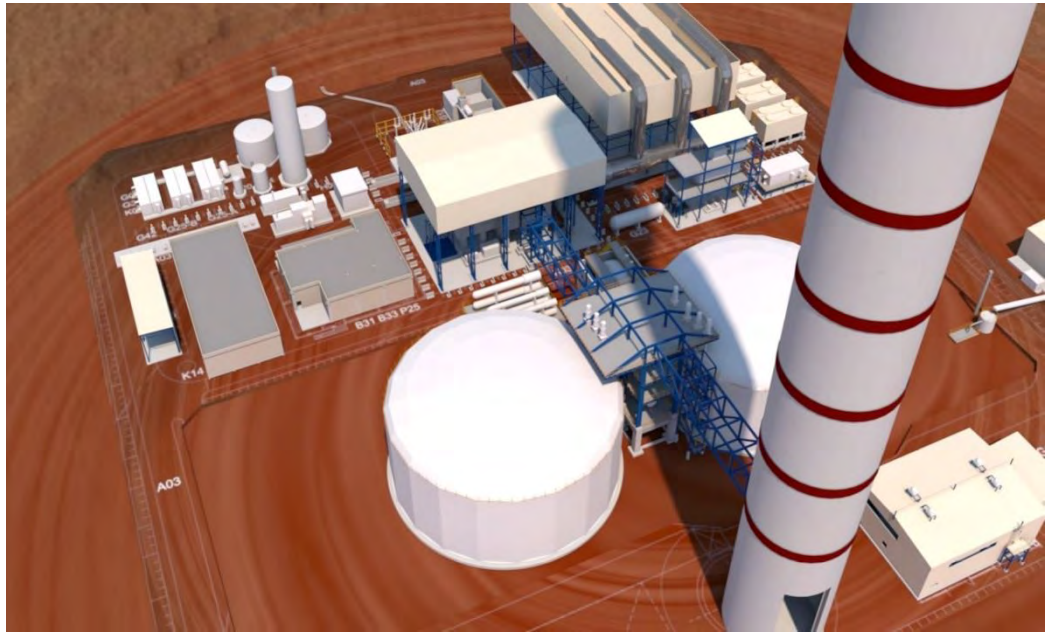
Tax: 28%

Other Tax: 2%

Equity/Debt: 40% / 60%

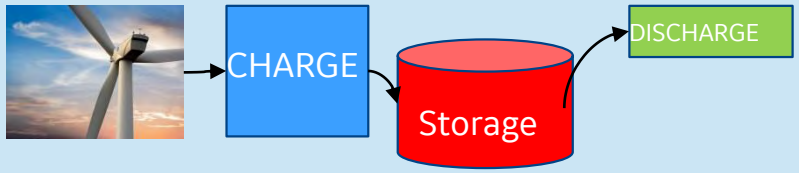
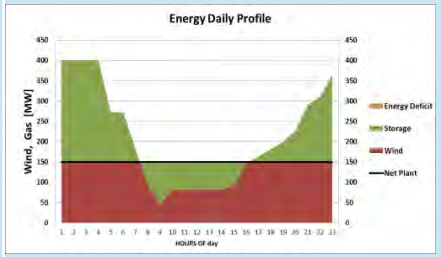
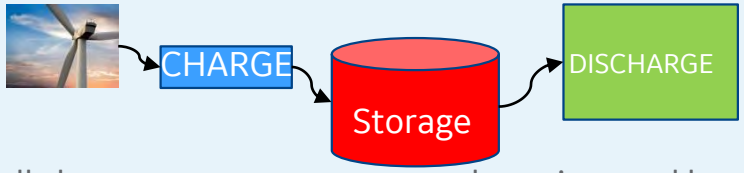
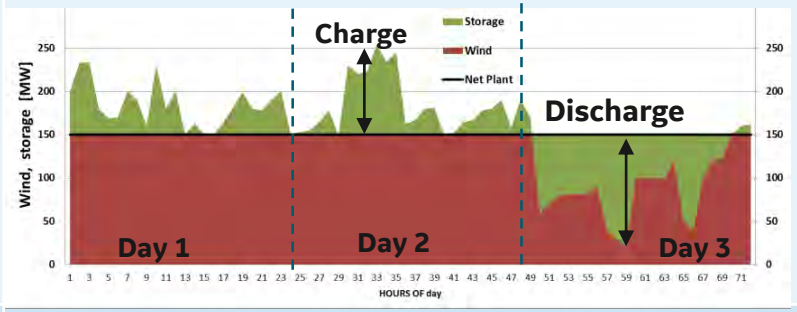
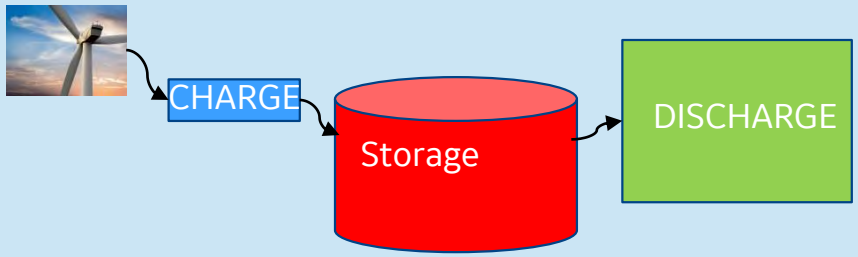
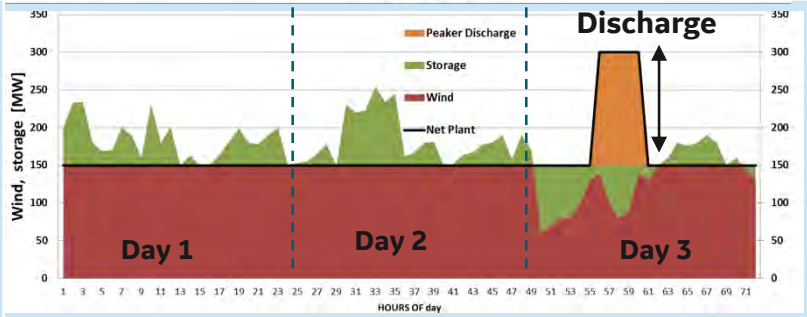
Duration: 30 years

# Advantages and Features of MS Energy Storage

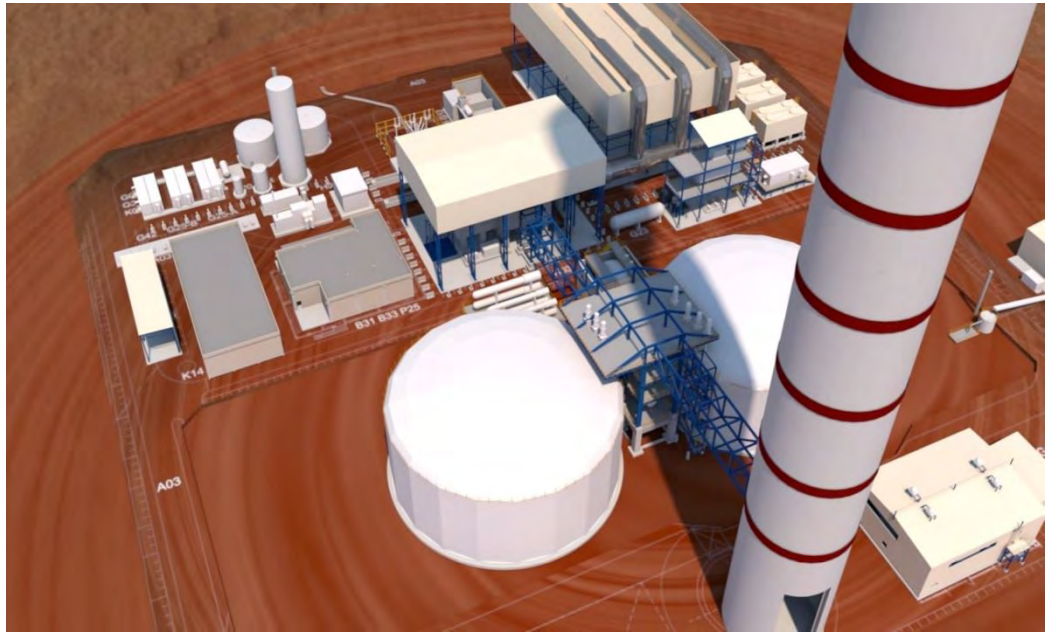


- Limited space requirement (1 ha /1000 MWhe) - 4-5 GWhe possible by increasing tank size or simply more tanks.
- Provides lower LCOE compared to Li-ion batteries.
- Better lifetime than Li-ion batteries - effectively no replacement during a 25-30 year lifetime.

# Applications for wind - sizing according to application

| Sizing | Application | Profile of wind+storage |
|---|---|---|
|  Charge power is approx- 2*discharge, storage is cycled daily | Daily load shifting |  |
|  Small charge power, stores over a long time and large discharge power | Charge-discharge cycle over multiple days (3 days shown) |  |
|  Large Steam plant to provide peaking duty with small excess wind power | Trickle charge over 2 days- peaker type on the third day |  |

# Take away



- Consider in the Generation mix the CSP with related storage capabilities.
- Consider CSP with additional buffer to store excess of electric energy of other intermitent renewable generation.
- Develop CSP parralel to PV and Wind.
- LCOE for extra storage capabilities magnitudes lower compared to other storage options (up to 94% lower than batteries).
- Depending on selection of operation mode the storage concept can be adapted to work as peaker with low LCOE.