Ingenergio

SYNERGY INNOVATION, WIN – WIN COOPERATION

# Electrical Heat Exchangers Application

# About

Ingenergio

**1. Engineering Service**

- Project Promotion
- Concept Engineer
- Engineering Service

**2. Commissioning Suport+logic Support**

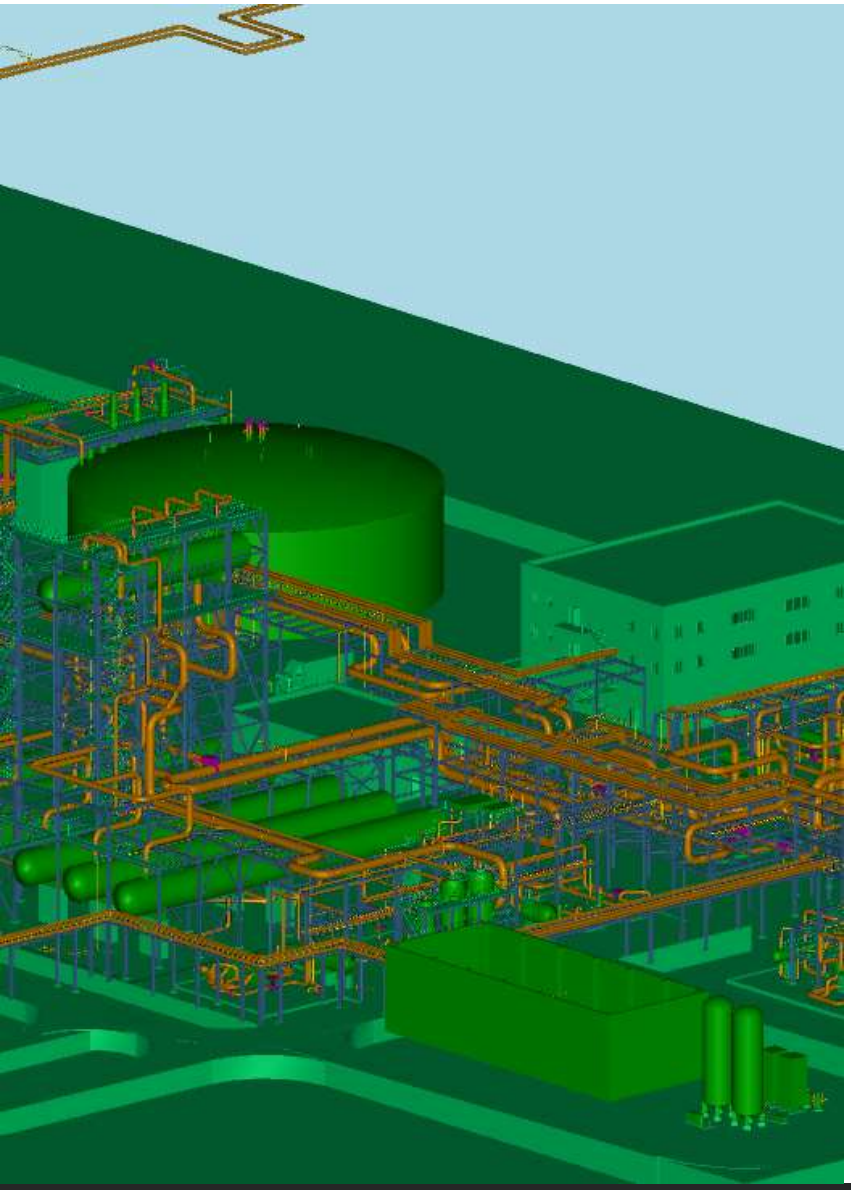
- Commissioning Supervision
- Commissioning Procedures
- Operation and maintenance manuals
- Control Logic (LOC+SCS+DCS)

**3. Project Optimization**

- Reduce the O&M cost
- Increase the efficiency

**4. Project Finance**

- Project Financing Assistant



# Services

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**Project Promotion**

- Conceptual engineering in order to fulfill all administrative and legal requirements
- Survey project local component localization

**Conceptual Engineering**

- Obtaining of typical meteorological year based on satellite data and meteorological stations
- Feasibility studies and annual electrical generation simulations
- Conceptual engineering
- Financial analysis

**Engineering Services**

- Basic engineering
- Purchase engineering: technical specifications and quotation technical economical evaluations
- Detail engineering
- Technical assistance during construction
- Commissioning Procedures
- Operation and maintenance manuals

# Product Development

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**Solar Field**

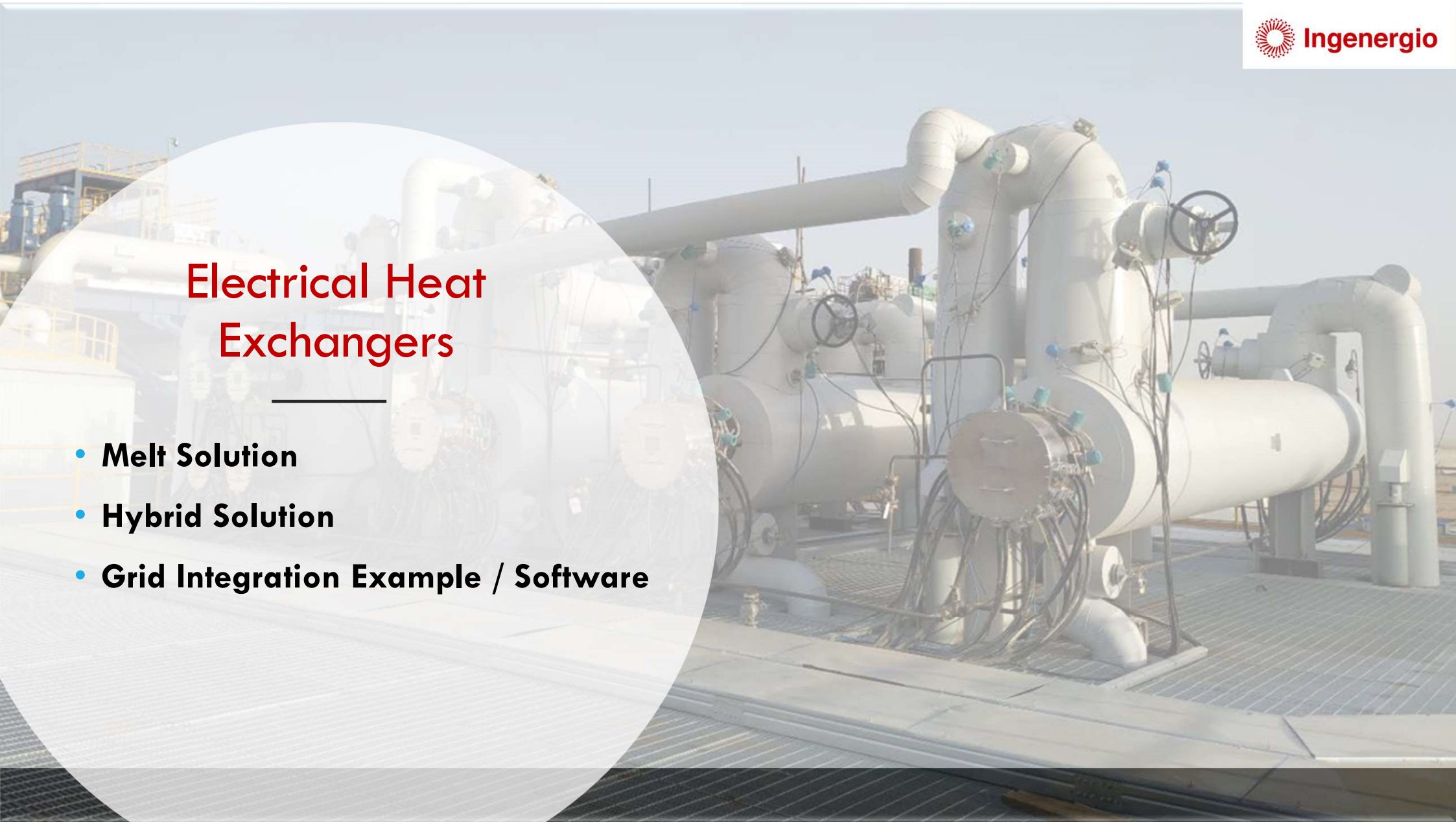
- HCE tubes
- Mirrors
- Balancing Valves
- Ball Joint Insulation
- Hydraulic Unit

**HTF System**

- HTF Fluid

**TES System**

- Molten Salts Valves
- Tank Insulation
- Tank Preheating
- Melting System
- Electrical Heat Exchangers



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# Electrical Heat Exchangers

- **Melt Solution**
- **Hybrid Solution**
- **Grid Integration Example / Software**

# Electrical Heat Exchangers Application / Melt Solution

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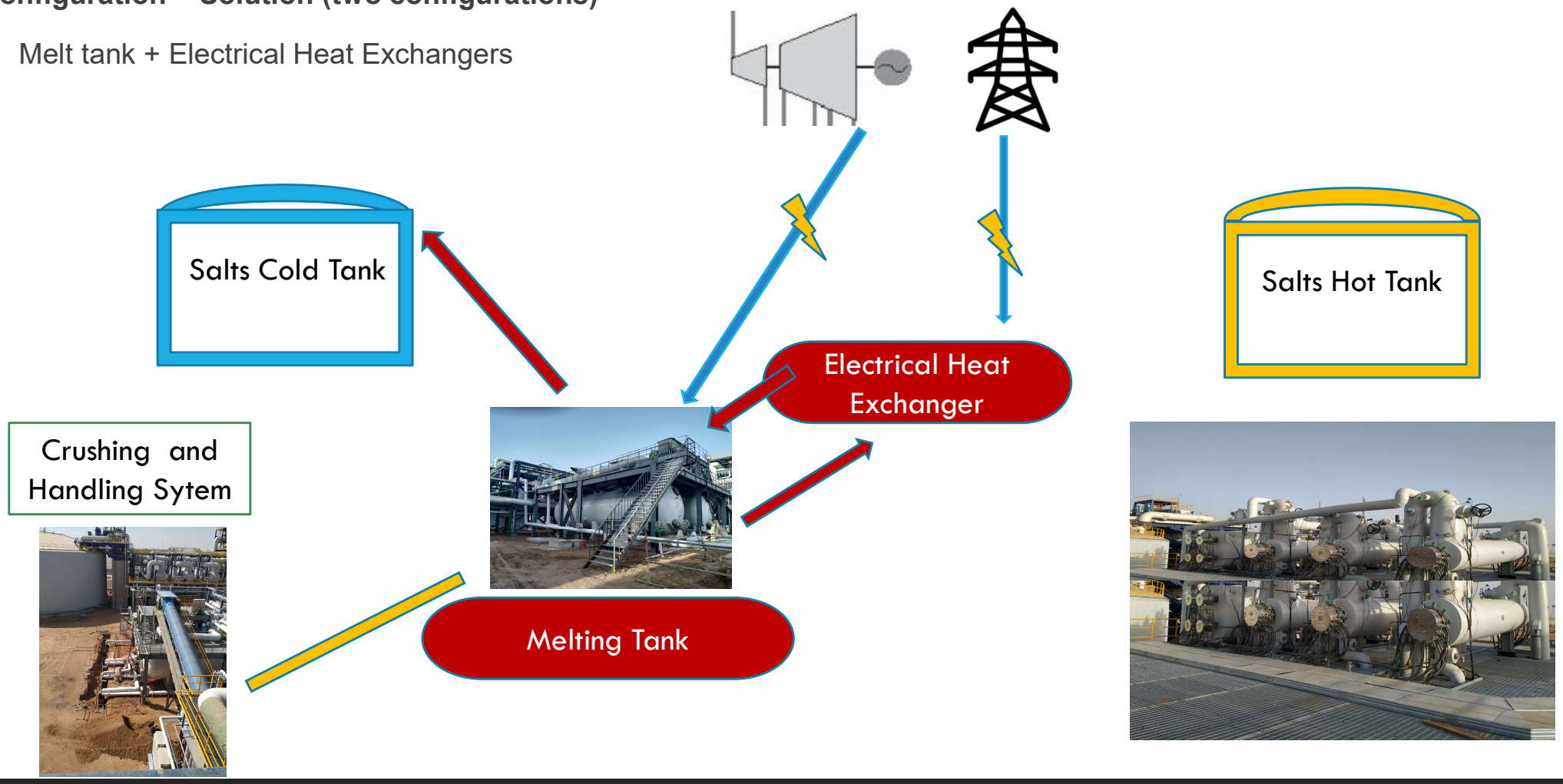
**Configuration – Solution (two configurations)**

- Melt tank + Electrical Heat Exchangers

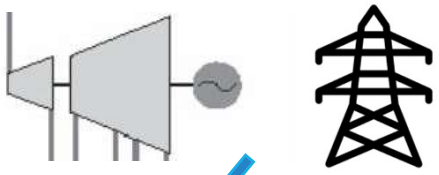


# Electrical Heat Exchangers Application / Melt Solution

**Configuration – Solution (two configurations)**

There are feasible two configurations:

- Melt tank + HTF - MS Heat Exchangers





Salts Cold Tank

Salts Hot Tank

MS - HTF Heat Exchanger

Crushing and Handling Sytem

Melting Tank

HTF Boilers

Solar Field

# Electrical Heat Exchangers Application / Melt Solution

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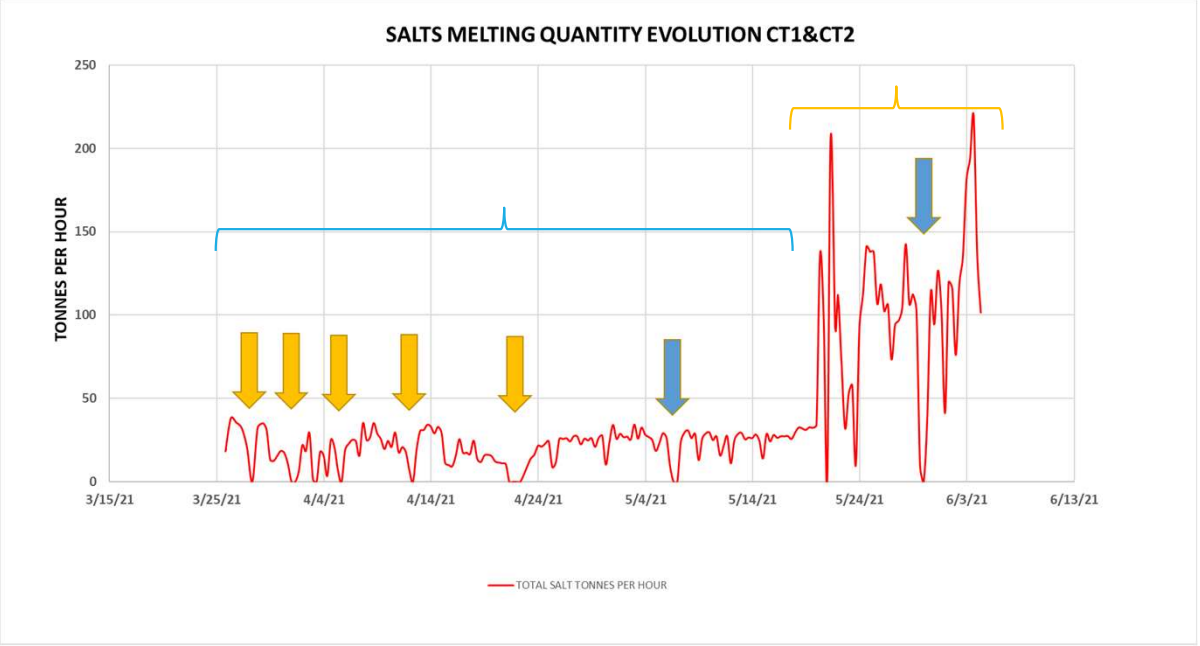
## Advantages

| | |
|---|---|
| ❖ More robust system | Simple Storage, Crushing and Handling System |
| ❖ Less Gas consumption | Greener solution |
| ❖ Consumption Optimization | Possibility to consume own thermal power or electrical generation generated |
| ❖ Electrical Heat Exchangers | Not leasing, use for hybrid purpose |

## Urat Data Melting Process

- 1st phase, Melt Tank + Elec HX (3)
  - Average Ratio 504 ton/day
- 2nd phase, Melt Tank + MX-HTF HX
  - Average Ratio 2424 ton/day
- Melt Process
  - Average: 986 ton/day
  - Peak: 4756 ton/day



# Electrical Heat Exchangers Application / Melt System

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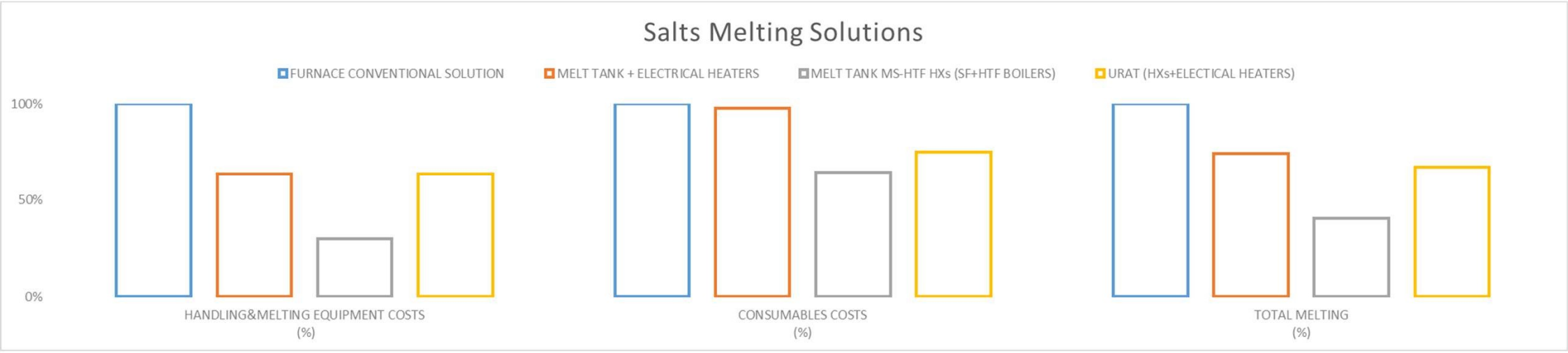
## Cost Comparative




***Remarks:***

- Most of equipment´s use in Salts Melting System, included Electrical Heat Exchangers, are used for Hybridization Thermal Storage.
- Electrical HX cost included in comparative as leasing but remain as power plant value, so amortization done just compare with conventional furnace solution

# Hybrid Solution

**Advantages**

- Get dump energy at low cost, valley hours preferably.
- In case of mandatory decrease of turbine load, increase self-consumption.
- Increase Efficiency at Partial Loads.
- Increase Efficiency in Peak Hours, using Booster configuration in Steam Turbine.
  - Steam Turbine necessary to be configured for booster configuration.

**Dis - advantages**

- Medium Voltage area need to be configured properly since basic design phase.
- Detail design with piping, valves, tracing,… of complete solution, not focus only on Electrical Heat Exchangers.
- Electrical Heat Exchangers low experience in market.

# Hybrid Solution, Charge Storage – Normal Operation

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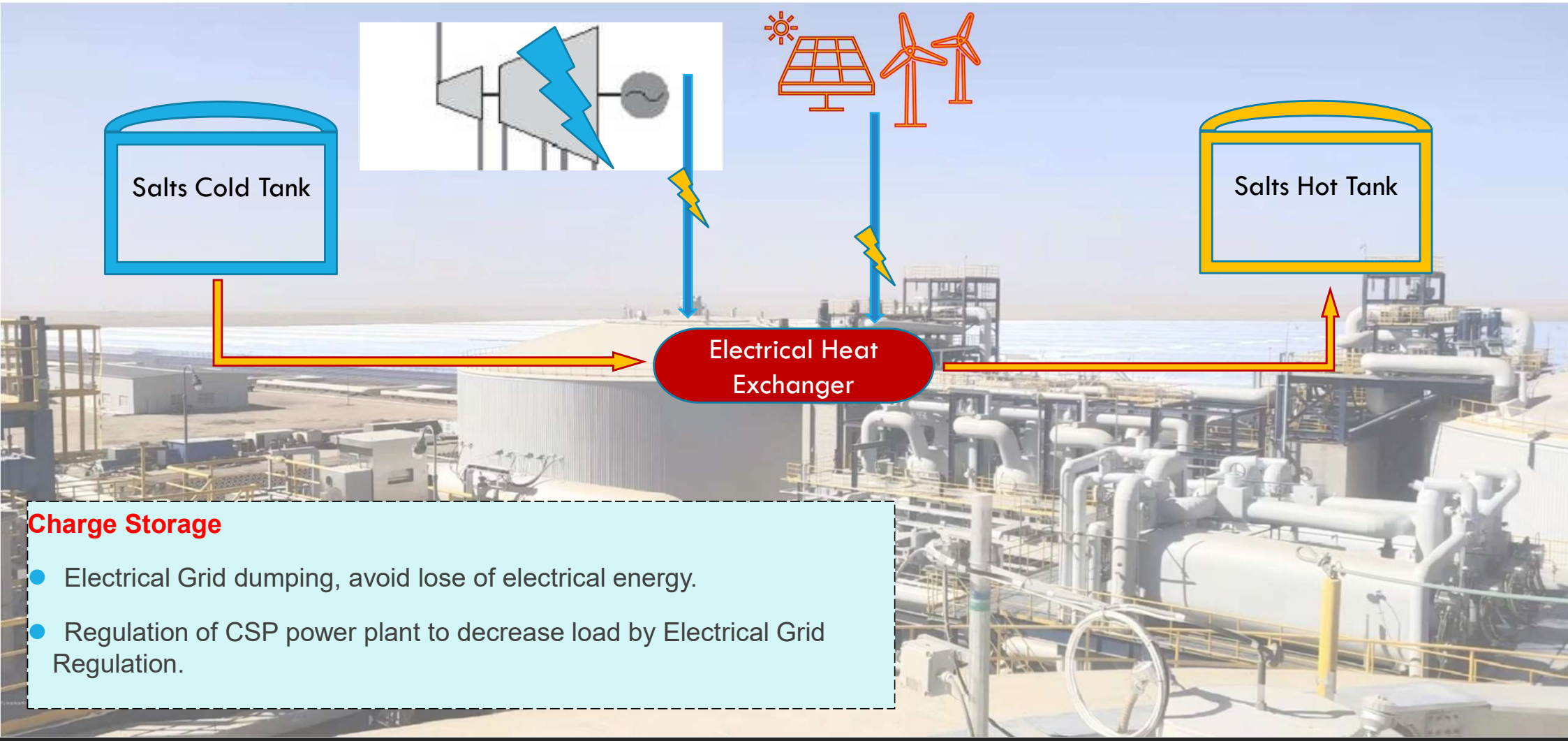


**Charge Storage**

- Electrical Grid dumping, avoid lose of electrical energy.
- Regulation of CSP power plant to decrease load by Electrical Grid Regulation.

# Hybrid Solution, Charge Storage – Booster Operation

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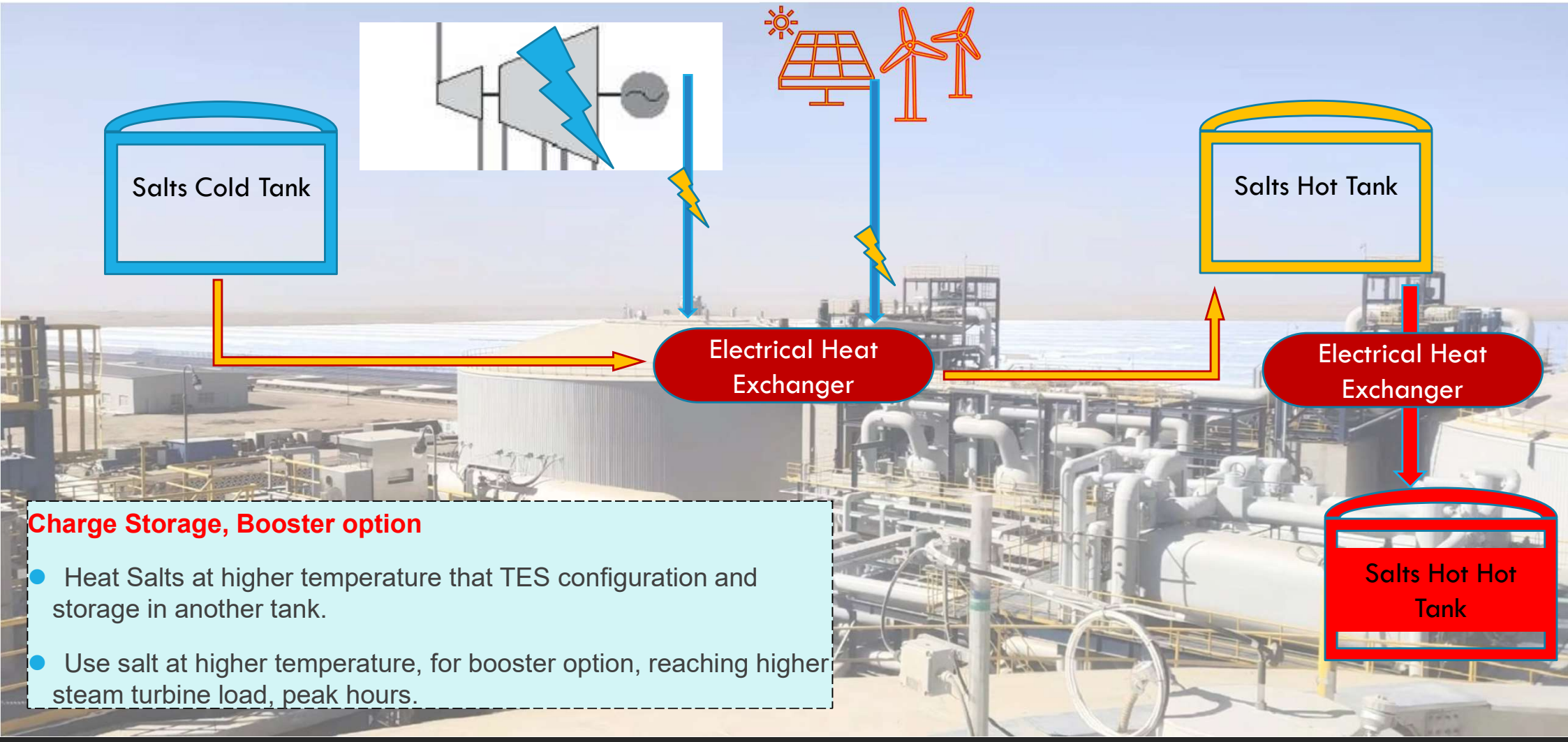


**Charge Storage, Booster option**

- Heat Salts at higher temperature that TES configuration and storage in another tank.
- Use salt at higher temperature, for booster option, reaching higher steam turbine load, peak hours.

# Hybrid Solution, Discharge Storage, Booster

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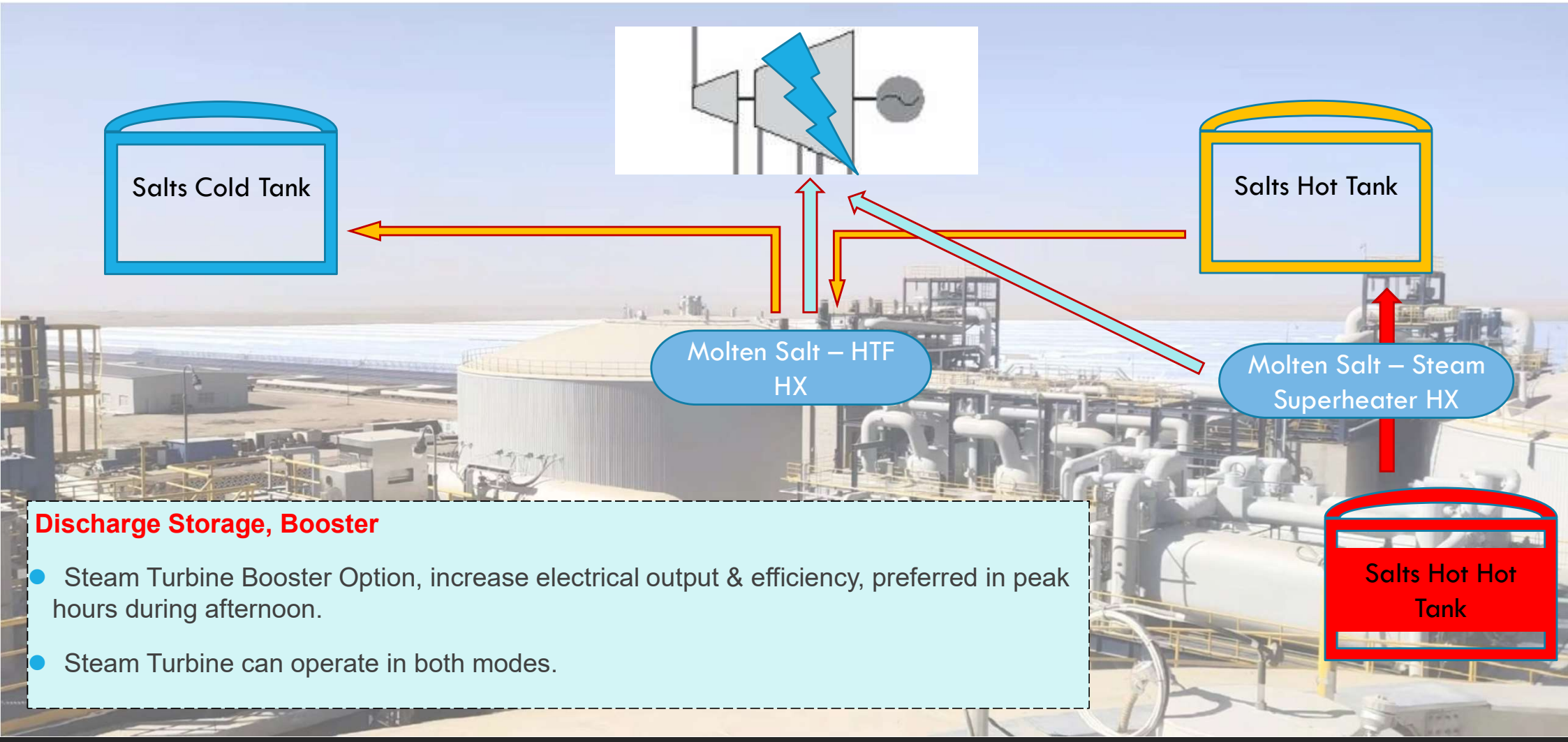


**Discharge Storage, Booster**

- Steam Turbine Booster Option, increase electrical output & efficiency, preferred in peak hours during afternoon.
- Steam Turbine can operate in both modes.

# Grid Integration / PV-Wind Dumping

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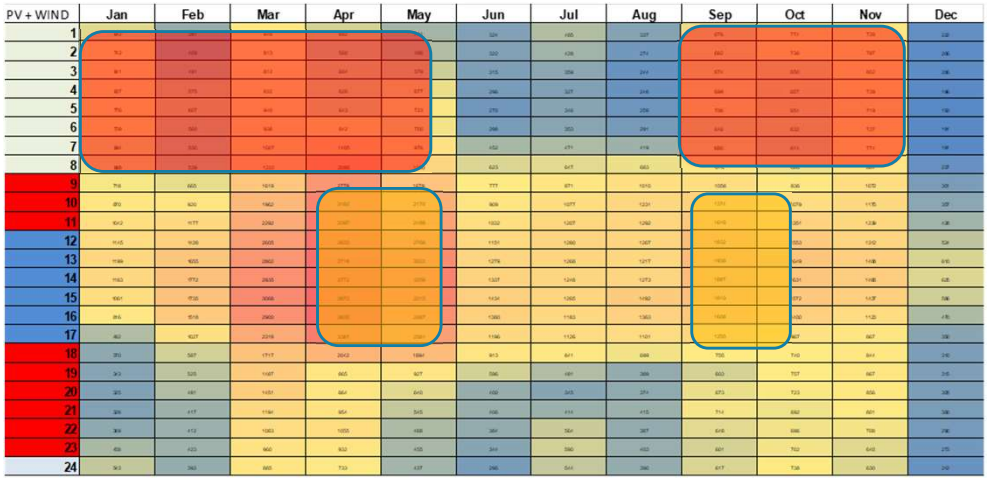
**Software**

- Weather forecast - Dump
- Dispatchability policy – Operation Guide.

## Dump Energy, PV - Wind



| PV + WIND | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | |

Dump Energy

Increase Selfconsuption (Market Regulation)

## Without Electrical Heat Exchangers, TMY Annual Electrical Generation

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valley | 1 | 0 | 0 | 21 | 30 | 42 | 31 | 25 | 35 | 33 | 2 | 0 | 0 |
| | 2 | 0 | 0 | 14 | 30 | 38 | 26 | 23 | 30 | 27 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 7 | 24 | 35 | 16 | 18 | 17 | 18 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 4 | 16 | 27 | 13 | 13 | 11 | 8 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 | 0 | 6 | 11 | 6 | 0 | 0 | 0 | 0 | 0 |
| | 6 | 0 | 0 | 0 | 0 | 21 | 8 | 9 | 3 | 0 | 0 | 0 | 0 |
| | 7 | 0 | 0 | 0 | 31 | 56 | 48 | 48 | 48 | 12 | 0 | 0 | 0 |
| | 8 | 0 | 1 | 23 | 67 | 71 | 62 | 69 | 70 | 36 | 0 | 0 | 0 |
| | 9 | 3 | 45 | 56 | 86 | 78 | 70 | 75 | 74 | 62 | 52 | 4 | 0 |
| Peak | 10 | 48 | 82 | 75 | 92 | 81 | 78 | 83 | 79 | 71 | 78 | 41 | 45 |
| | 11 | 80 | 90 | 76 | 93 | 79 | 82 | 87 | 82 | 68 | 80 | 63 | 77 |
| | 12 | 75 | 88 | 78 | 90 | 81 | 86 | 83 | 85 | 71 | 79 | 63 | 63 |
| Normal | 13 | 67 | 82 | 79 | 88 | 84 | 83 | 88 | 78 | 70 | 80 | 58 | 42 |
| | 14 | 67 | 83 | 80 | 87 | 82 | 77 | 85 | 81 | 72 | 78 | 50 | 46 |
| | 15 | 75 | 82 | 80 | 88 | 81 | 74 | 83 | 80 | 72 | 77 | 55 | 62 |
| | 16 | 75 | 82 | 76 | 83 | 77 | 72 | 78 | 75 | 67 | 76 | 42 | 45 |
| | 17 | 32 | 66 | 70 | 79 | 75 | 72 | 69 | 71 | 64 | 69 | 13 | 0 |
| | 18 | 15 | 51 | 64 | 76 | 74 | 65 | 68 | 70 | 60 | 55 | 6 | 0 |
| Peak | 19 | 9 | 40 | 52 | 63 | 65 | 57 | 56 | 65 | 56 | 49 | 5 | 0 |
| | 20 | 4 | 35 | 49 | 51 | 59 | 51 | 44 | 62 | 50 | 35 | 3 | 0 |
| | 21 | 0 | 26 | 44 | 45 | 55 | 46 | 38 | 56 | 44 | 29 | 0 | 0 |
| | 22 | 0 | 15 | 36 | 44 | 52 | 41 | 34 | 46 | 42 | 20 | 0 | 0 |
| | 23 | 0 | 5 | 31 | 40 | 48 | 36 | 32 | 43 | 35 | 13 | 0 | 0 |
| | 24 | 0 | 0 | 29 | 34 | 45 | 35 | 29 | 41 | 31 | 6 | 0 | 0 |

## PV-Wind Dump Analysis, Electrical HX

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.2 | 1.6 | 4.4 | 2.3 | 1.8 | 1.5 | 1.1 | 0.7 | 3.0 | 1.5 | 4.1 | 1.1 |
| 2 | 1.5 | 1.6 | 4.4 | 2.3 | 2.5 | 1.1 | 0.7 | 0.7 | 3.0 | 1.8 | 4.5 | 0.7 |
| 3 | 1.8 | 2.0 | 5.1 | 3.0 | 2.2 | 1.1 | 1.1 | 1.5 | 2.6 | 1.8 | 3.8 | 1.1 |
| 4 | 1.5 | 1.6 | 4.7 | 3.0 | 2.9 | 0.8 | 0.7 | 1.8 | 1.9 | 1.8 | 3.8 | 1.1 |
| 5 | 1.5 | 2.0 | 4.0 | 2.6 | 2.2 | 1.1 | 1.5 | 1.5 | 1.9 | 1.5 | 3.8 | 1.5 |
| 6 | 1.5 | 1.6 | 3.6 | 2.3 | 1.8 | 0.8 | 1.8 | 1.5 | 2.3 | 1.8 | 3.8 | 1.5 |
| 7 | 1.5 | 0.8 | 1.5 | 1.5 | 1.1 | 0.4 | 0.7 | 1.5 | 1.1 | 0.7 | 3.0 | 1.1 |
| 8 | 0.4 | 0.8 | 1.1 | 1.5 | 1.5 | 0.8 | 0.4 | 0.7 | 1.9 | 2.2 | 3.1 | 1.5 |
| 9 | 0.4 | 1.2 | 1.5 | 0.4 | 1.6 | 0.4 | 0.4 | 1.5 | 1.9 | 0.4 | 3.8 | 0.4 |
| 10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 12 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 13 | 0.4 | 0.4 | 1.5 | 0.4 | 1.1 | 0.8 | 0.0 | 1.1 | 2.3 | 1.1 | 1.1 | 0.0 |
| 14 | 0.7 | 0.4 | 1.5 | 1.0 | 1.1 | 0.8 | 0.0 | 1.5 | 1.5 | 1.1 | 1.5 | 0.0 |
| 15 | 0.7 | 1.2 | 0.7 | 1.1 | 1.5 | 0.4 | 0.0 | 0.7 | 1.9 | 1.1 | 1.5 | 0.0 |
| 16 | 0.7 | 0.8 | 1.1 | 1.5 | 1.7 | 0.8 | 0.1 | 1.1 | 1.5 | 1.1 | 1.5 | 0.0 |
| 17 | 0.7 | 0.8 | 1.5 | 1.9 | 2.2 | 0.8 | 0.7 | 0.7 | 1.9 | 1.5 | 1.5 | 0.7 |
| 18 | 1.1 | 0.8 | 1.1 | 1.1 | 2.2 | 0.4 | 0.4 | 0.7 | 1.1 | 1.5 | 1.5 | 1.1 |
| 19 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 21 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24 | 2.2 | 2.4 | 3.6 | 3.0 | 1.8 | 1.1 | 1.5 | 1.1 | 3.4 | 2.2 | 4.1 | 1.8 |

# Grid Integration / Results

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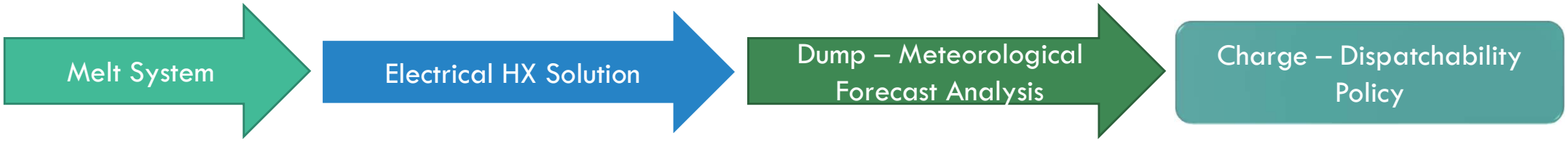
### Increase of Annual Electrical Generation, Normal Operation

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 3 | 6 | 8 | 3 | 3 | 0 | 0 | 0 | 0 |
| 7 | 0 | 1 | 12 | 15 | 7 | 4 | 3 | 3 | 10 | 1 | 0 | 0 |
| 8 | 1 | 9 | 20 | 7 | 4 | 1 | 1 | 3 | 8 | 12 | 5 | 0 |
| 9 | 15 | 11 | 5 | 2 | 0 | 2 | 3 | 3 | 1 | 4 | 22 | 13 |
| 10 | 5 | 2 | 2 | 2 | 0 | 0 | 0 | 3 | 1 | 0 | 8 | 6 |
| 11 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 3 | 0 |
| 12 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Increase of Annual Electrical Generation, Booster Operation

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 1 | 4 | 4 | 1 | 2 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 9 | 5 | 4 | 4 | 2 | 3 | 2 | 0 | 0 | 0 |
| 8 | 1 | 5 | 5 | 4 | 4 | 3 | 0 | 3 | 5 | 5 | 4 | 0 |
| 9 | 5 | 5 | 5 | 3 | 0 | 2 | 0 | 1 | 2 | 5 | 5 | 9 |
| 10 | 12 | 2 | 2 | 2 | 0 | 0 | 1 | 2 | 2 | 0 | 10 | 10 |
| 11 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | -1 | 10 | 8 | 8 | 5 | 5 | 4 | 4 | 5 | 5 | 7 | 0 |
| 20 | 0 | 0 | 9 | 6 | 2 | 0 | 1 | 0 | 3 | 6 | 6 | 0 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |

- Increase Dispatchability of plant.
- Efficiency Energy Dump Charge vs Extra Energy Generated > 70% (close to BESS system)
  - Increase thermal load of Steam Turbine at beginning of day, substantial increase of efficiency of cycle. (5% or more)
  - At low load not enough for steam turbine, storage available to increase, cloudy season winter.
- Booster Option, increase efficiency of turbine, higher impact.
- Depending on dumping, and steam turbine load, there are a limitation of electrical heat exchangers size.



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# QUESTIONS?

# THANK YOU


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