Optimization of solar fields for centrifugal receivers and chemical plants

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BrightSource

Agenda

- BrightSource Energy
- Optimization of Receiver height and inclination angle
- Solar Field Sizing
- Integration of Solar Field and Chemical Plant

About BrightSource Energy

The Company

- US, UK, Israel, China
- Design, develop & deploy concentrated solar thermal plants
- Sophisticated control
- Internationally renowned technical experience with world-class finance and project development capabilities

The Projects

- ***Ivanpah*** – 392 MW (3 units)
  - Operating since 2013
  - CA, USA
- ***Ashalim*** – 121 MW
  - Operating since – 2019
  - Negev, Israel
- ***Noor 1*** – 100 MW
  - In construction (advanced)
  - Dubai
- ***Redstone*** – 100 MW
  - In design (financially closed)
  - South Africa

Receiver Configuration – Height and Angle

For the receivers of 2.5 and 5 MWth:

- Checked 3 tower heights: 40m, 60m, 80m,
- Checked 3 receiver inclination angles: 30°, 45°, 60°
- For each configuration:
  - Generate optimal layout
  - Calculate performance of the layout

Receiver Configuration – Height and Angle

For Receiver of 2.5MWth:

- Solar field efficiency at design point (day 81, hour 11.5)

Inclination Angle / Tower Height	30°	45°	60°
40m	0.43	0.39	0.251
60m	0.47	0.44	0.278
80m	0.46	0.43	0.281

- 40m ➔ 60m: Gain ~10%
- 60m ➔ 80m: Loose ~2%
- 30° ➔ 45°: Loose ~8%
- 45° ➔ 60°: Loose ~36%

Receiver Configuration – Height and Angle

For Receiver of 5MWth:

- Solar field efficiency at design point (day 81, hour 11.5)

Inclination Angle / Tower Height	30°	45°	60°
40m	0.46	0.42	0.25
60m	0.53	0.50	0.30
80m	0.55	0.52	0.31

- 40m ➔ 60m: Gain ~16% more
- 60m ➔ 80m: Gain only ~5% more
- 30° ➔ 45°: Loose ~7%
- 45° ➔ 60°: Loose 40%

Solar field Sizing

What is the optimal number of heliostats?

More heliostats in the solar field:

- Increases production

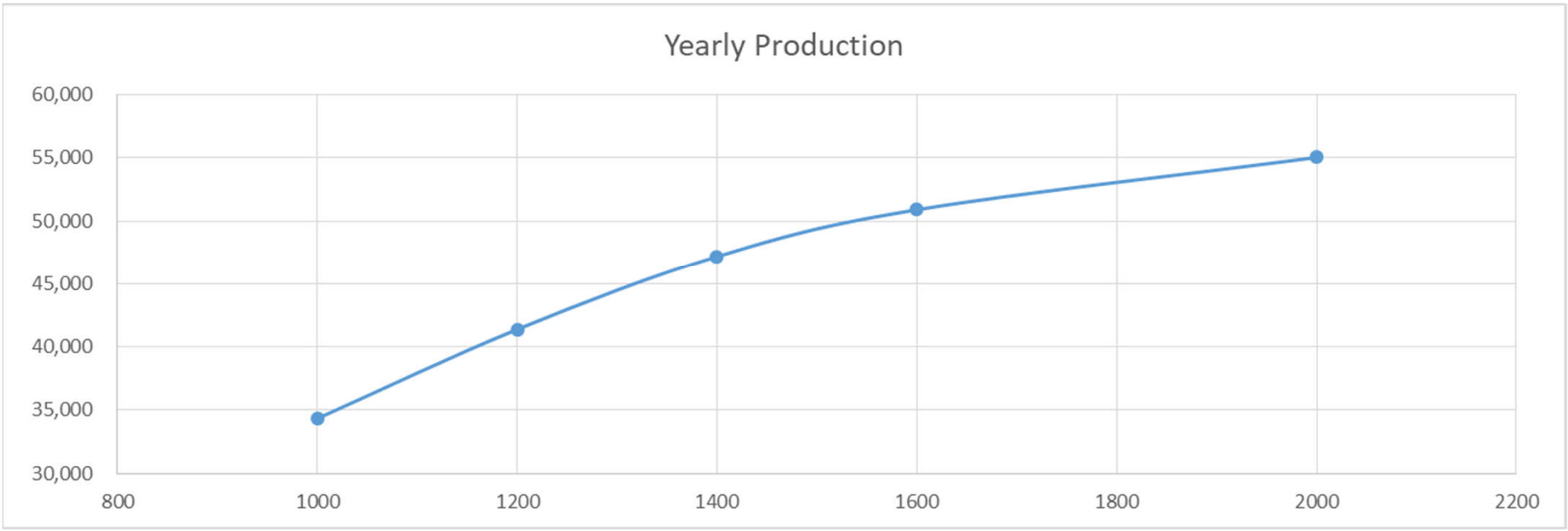
However -

- Higher cost
- The average efficiency of the heliostats decreases
  - Marginal efficiency (of the added heliostats) is small

$$\eta_{rec} = \frac{Power\ transferred\ to\ particles}{Power\ incident\ on\ receiver\ aperture}$$

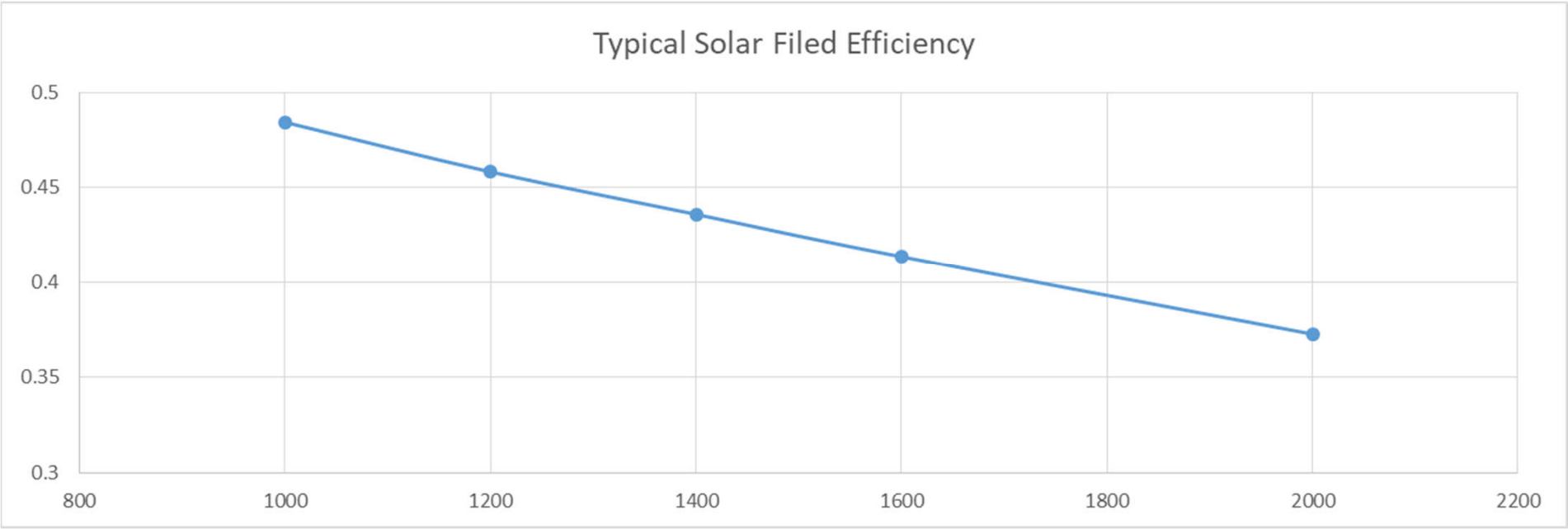
Solar field Sizing

- Yearly production vs number of heliostats
  - Receiver of 20 MWth



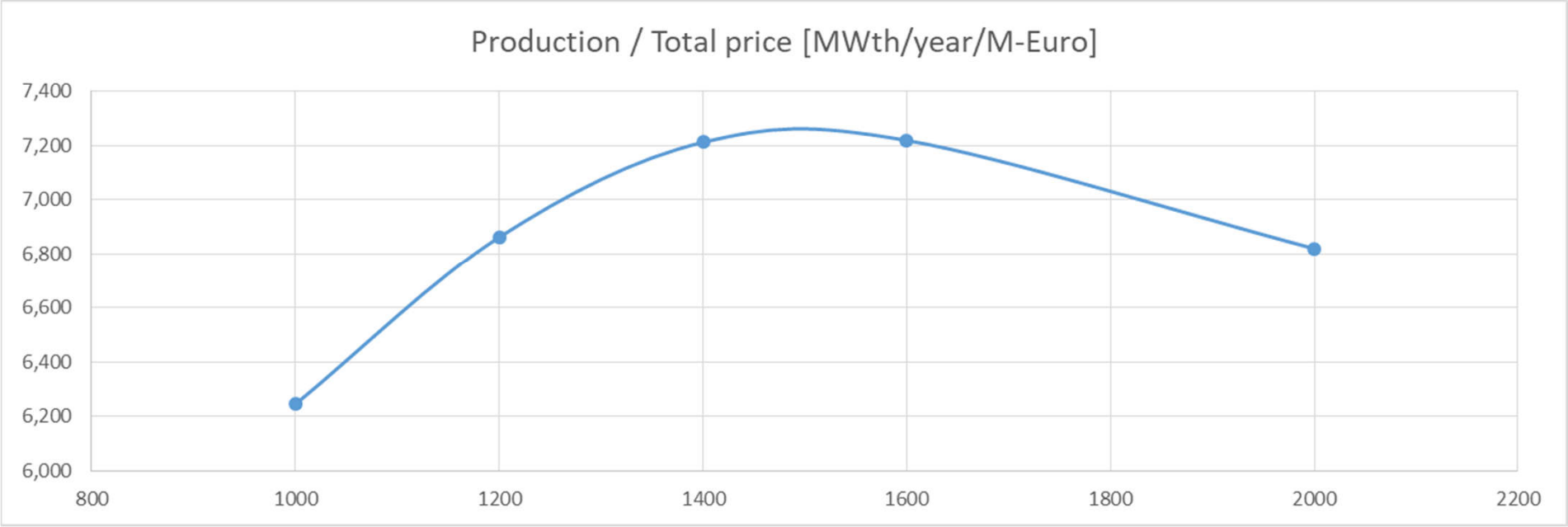
Solar field Sizing

- Average solar field efficiency vs number of heliostats
  - Receiver of 20 MWth

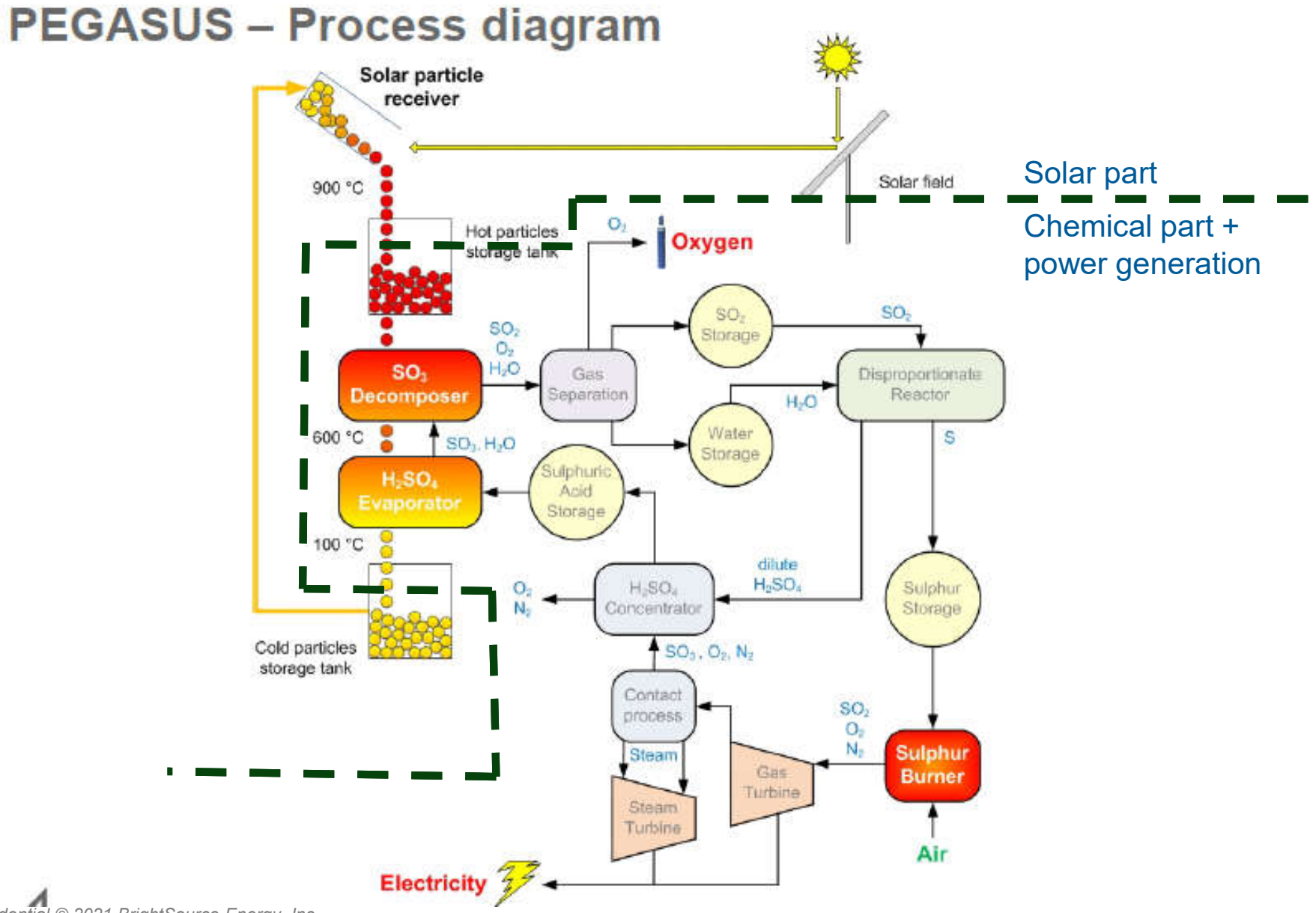


Solar field Sizing

- Production / Total Price
  - Receiver of 20 MWth
- Optimum: ~1500 heliostats (DLR results are similar: 1387)



Solar part vs. Chemical part



Solar part vs. Chemical part

- Solar part (Solar Field, Particle Receiver, Cold and Hot particle storage tanks): **Discontinuous operation (Daily startup)**

- Chemical part **(**sulphuric acid evaporation, SO_3 decomposition, sulphur production via disproportionation, sulphur combustion and combined cycle power generation): **continuous operation**

Challenge: Design the Solar part to be able to provide continuous thermal input to the Chemical part

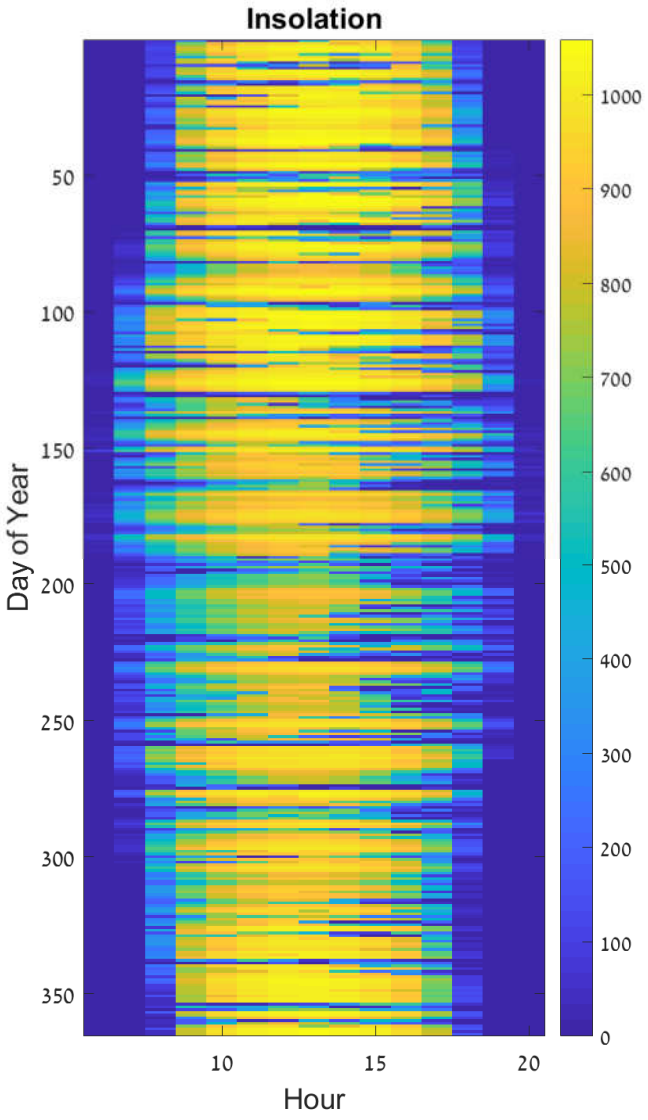
Solar part vs. Chemical part

Avoid restart of chemical part:

- Day/Night
- Several days without operation

Strategy:

- Design stage:
  - Sizing of the storage and the solar field
- Operation strategy:
  - Reduce load of the chemical plant



Thank you!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