Strategies to reduce transmission costs for solar plants in the National Electricity Market

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In the news

An aerial impression of the Kogan Creek Solar Boost Project. Source: CS Energy

Outline

- Brief overview of plant technologies
- Transmission investment goals
- Transmission in the NEM
- Solar plant output simulations
- Analysis of results
- Conclusions

Ground mounted PV plants

34MW PV plant in Arnedo, La Rioja, Spain. Source: Renewable Energy magazine

Two-axis tracking PV plants

1MW PV plant in Madera, California. Source: PROINSO

Concentrating Solar Power (CSP)

SEGS plant in Kramer Junction, California. Source: TREC-UK

Concentrating Solar Power (CSP)

Andasol-1 plant, Granada, Spain (7.5 hours TES). Source: German Aerospace Center

Transmission investment goals

- From *Review of Energy Market Frameworks:*
  - Timely processing of connection applications
  - Cost-reflective pricing
  - Efficient level of investment
- Main issues for renewable energy
  - Build in high quality locations (further from grid), or lower quality locations (closer to grid)?
  - Plants built faster than transmission 2-3 years vs 8-12 years (Mills et al., Cavallo)

Transmission in the NEM

NEM regions (interconnectors in red)

Transmission in the NEM

- Open access to transmission network
- Costs are recovered from loads, not generators
  - "Under-signalling of network costs for new generators" (Frontier Economics)
- Shallow connection charging
- Augmentation subject to RIT-T
  - Net benefit (there may be cheaper measures)
  - Evidence of intraregional mis-pricing
  - May be slow: EIS, land title, build-out (8-12 yrs)

Rule change: Scale Efficient Network Extensions (June 2011)

- Proposed by MCE
- Encourage efficient network development
  - Identify regions with high renewable potential
  - Forecast future generation
- A chicken and egg problem
  - One generator ready now, but more expected
    - Risks for generators, TNSPs
  - Risks building transmission to right scale
    - Stranded assets
    - Inefficient duplication

Rule change: Scale Efficient Network Extensions

- Generators are given option to connect
- Once first generator connects, build
- Shallow connection from generators to new network nodes

Under current arrangements, generators ..

- may cluster around existing transmission
- will minimise cost of grid connection
- may form agreements with nearby loads
- may encounter **constrained transmission**

Transmission sizing strategies

- High capacity factor generators (e.g. coal-fired plants meeting base load)
  - Size transmission line to rated output
  - “Get all power to market”
- Low capacity factor generators (e.g. CCGT meeting peak load)
  - Size transmission line to rated output
  - “Get high value power to market”
- Solar generators?

Prior work

- Work on sizing in the wind sector
  - Cavallo (1995) – oversizing farms
  - Boerema and MacGill (2010)
  - Pattanariyankool & Lave (2010)
- Recent work on storage in CSP systems
  - Johnston (2009): CSP in the NEM
  - Beyond Zero Emissions ZCA Plan (2010)
  - Denholm, et al (2010): role of storage
  - Wittmann, et al (2011): operation strategies

Solar plant output modelling

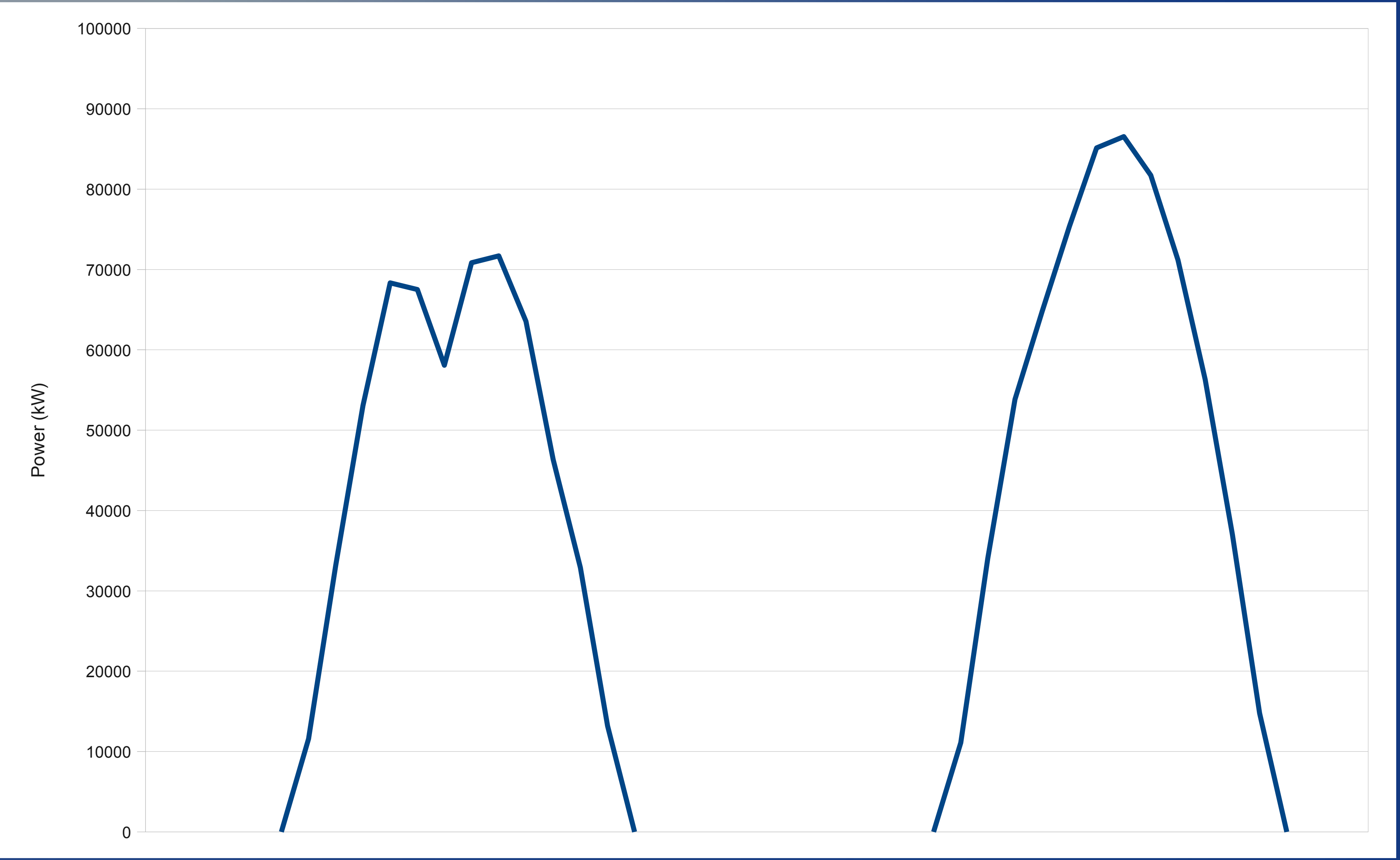
- System Advisor Model (NREL)
- Modelled 100MW plants in **Cobar, NSW**

Source: Google Maps

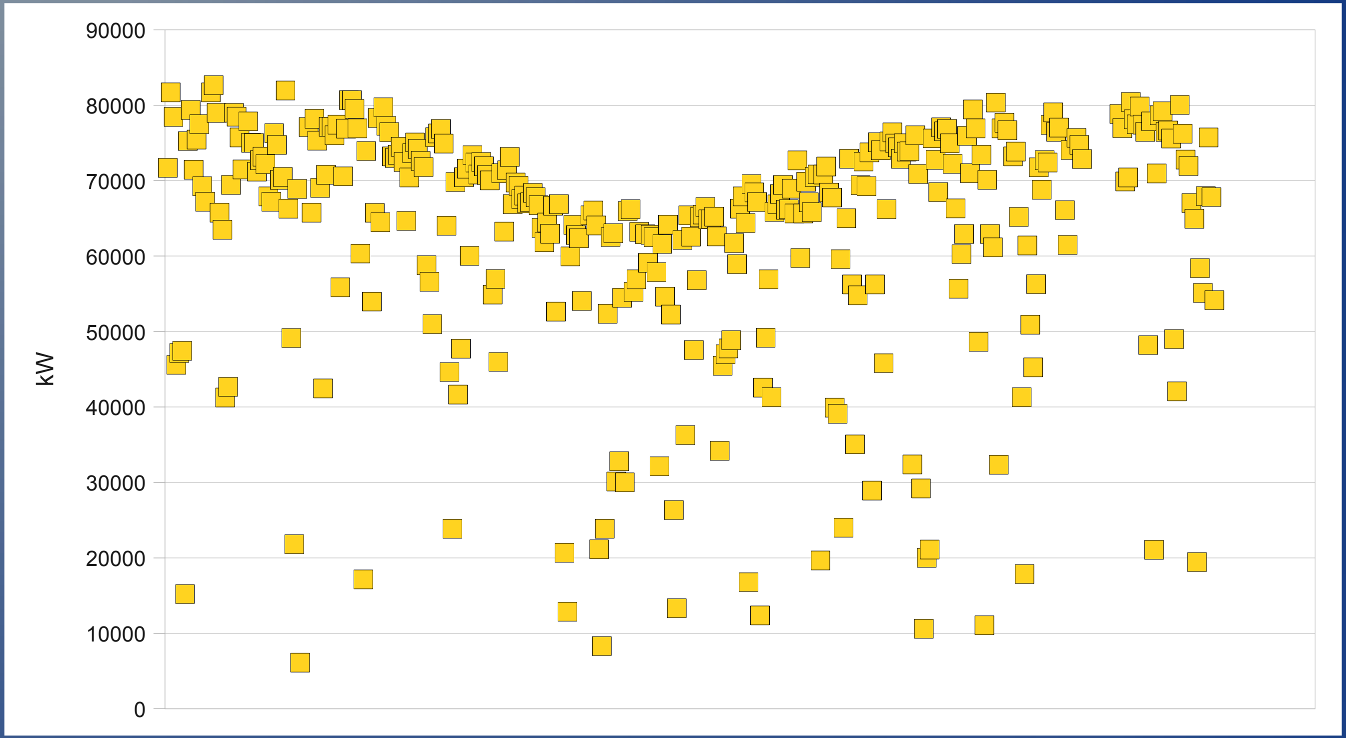
Solar plant output modelling

- System Advisor Model (NREL)
- Modelled 100MW plants in **Cobar, NSW**
- 2009 weather data
- Modelled systems
  - PV
  - 2-axis tracking PV
  - CSP (w/ thermal storage)
- NEM spot price data (NSW, 2009) from AEMO
  - Half hourly, averaged to hourly

PV output (Jan. 1 & 2, 2009)



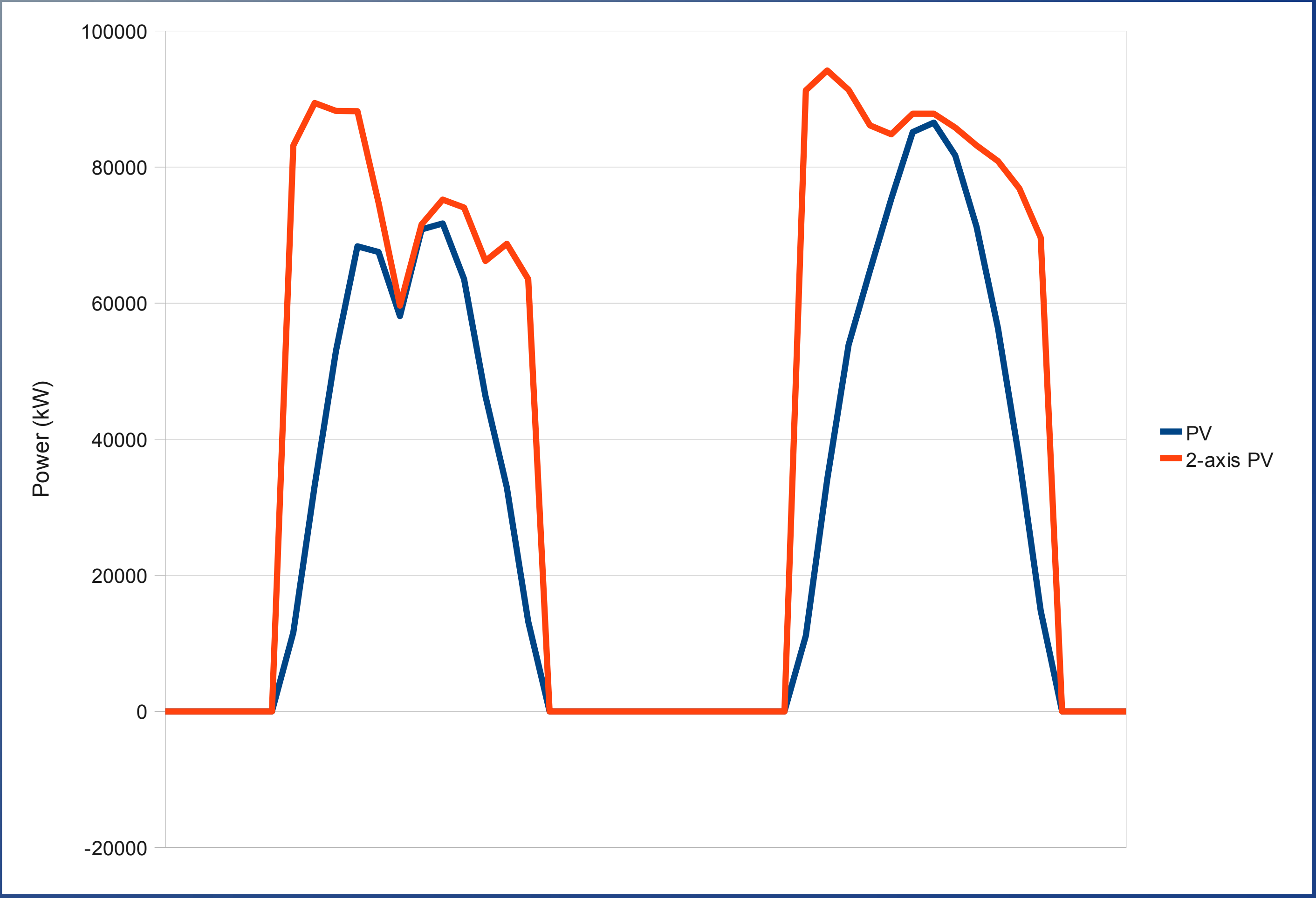
PV output (every noon, 2009)



PV results

Transmission capacity (MW)	Annual yield (GWh)	Energy fraction	Revenue ($)	Revenue fraction
90	178.31	1.000	6,601,000	1.000
80	178.17	0.999	6,596,000	0.999
70	174.74	0.980	6,443,000	0.976
60	164.99	0.925	6,029,000	0.931
50	148.93	0.835	5,418,000	0.821

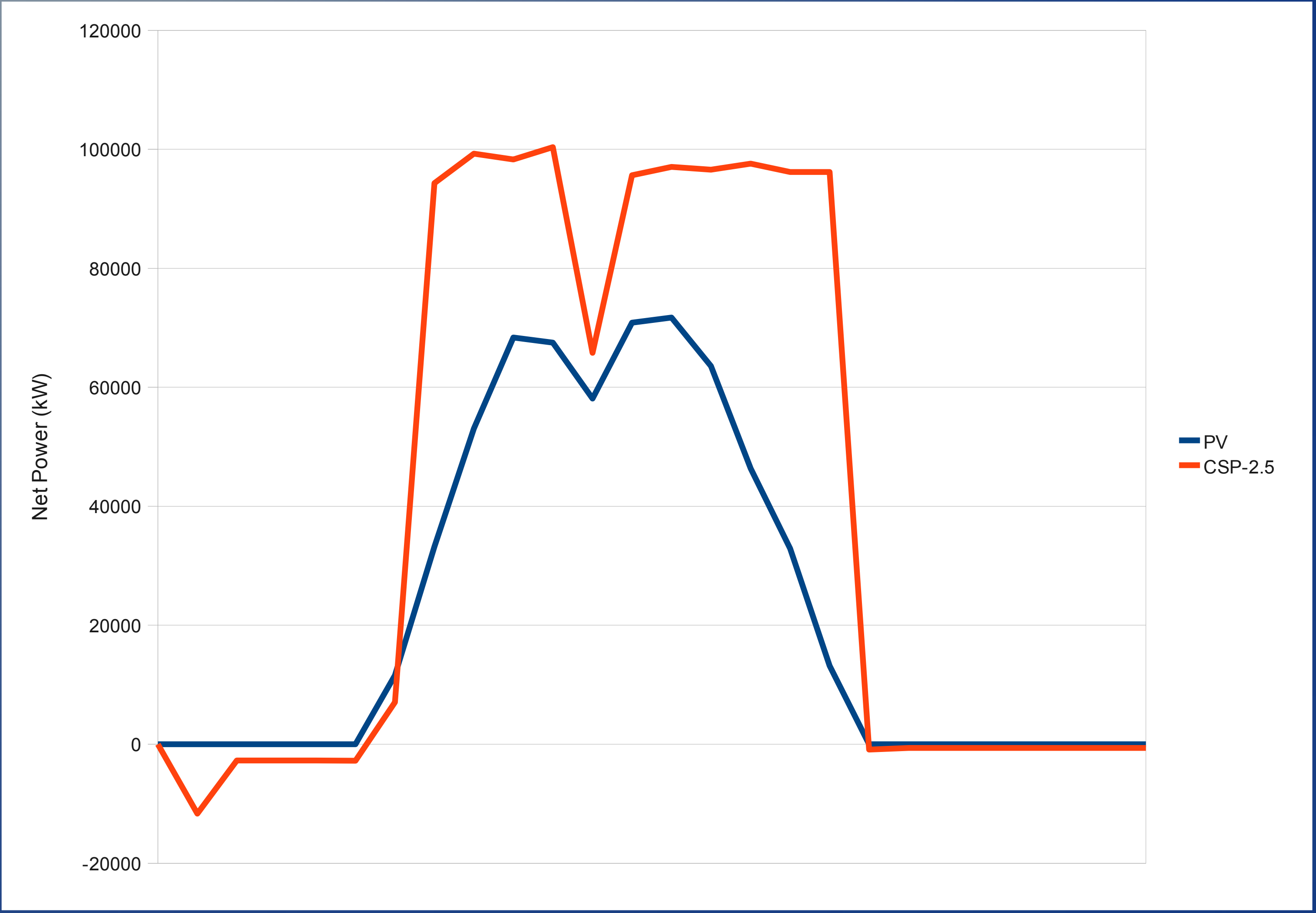
PV and 2-axis tracking PV output (Jan. 1 & 2, 2009)



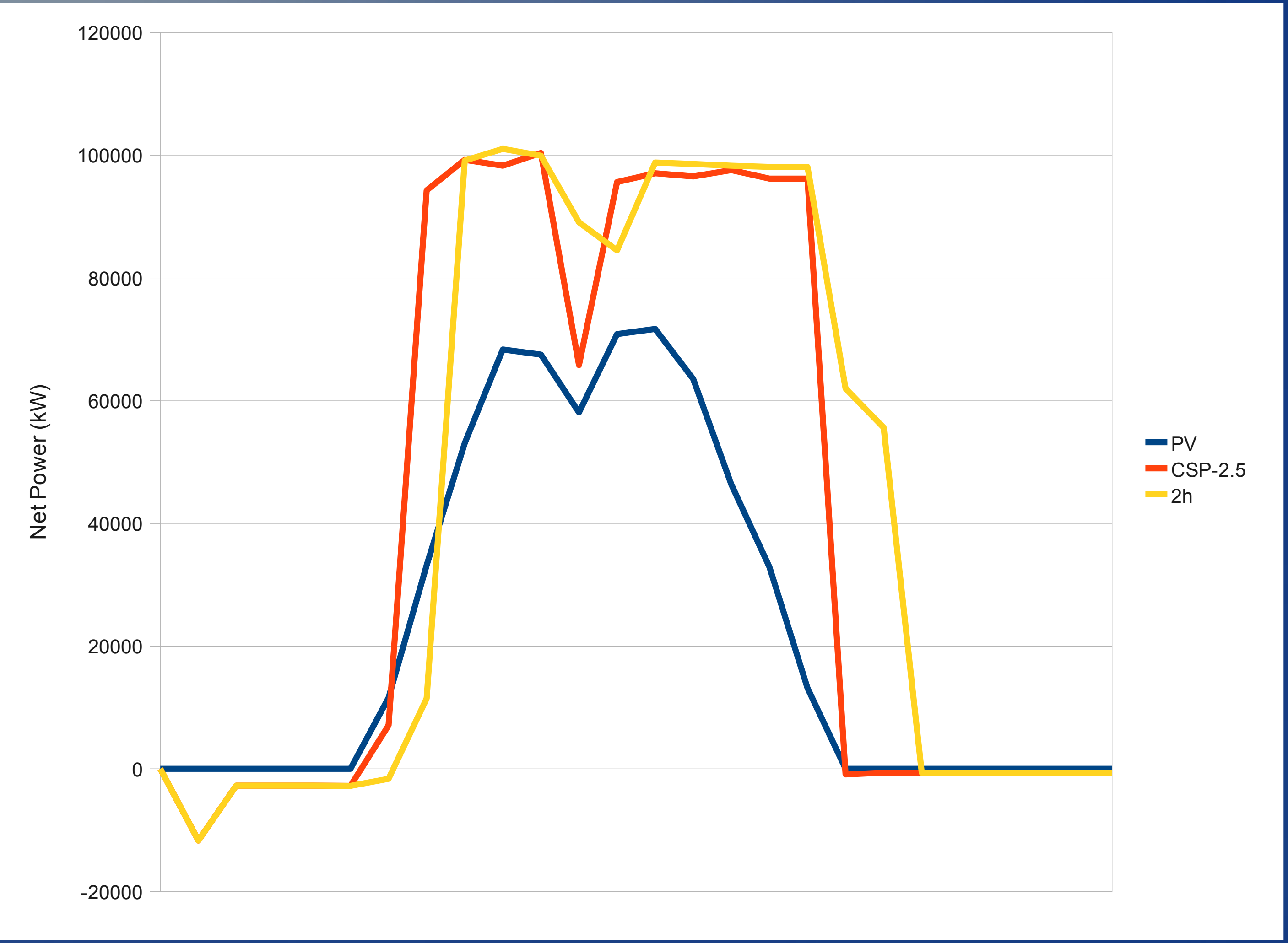
2-axis tracking PV results

Transmission capacity (MW)	Annual yield (GWh)	Energy fraction	Revenue fraction
90	251.70	1.00	1.00
80	242.71	0.96	0.97
70	223.58	0.89	0.89
60	198.07	0.79	0.79
50	168.98	0.67	0.67

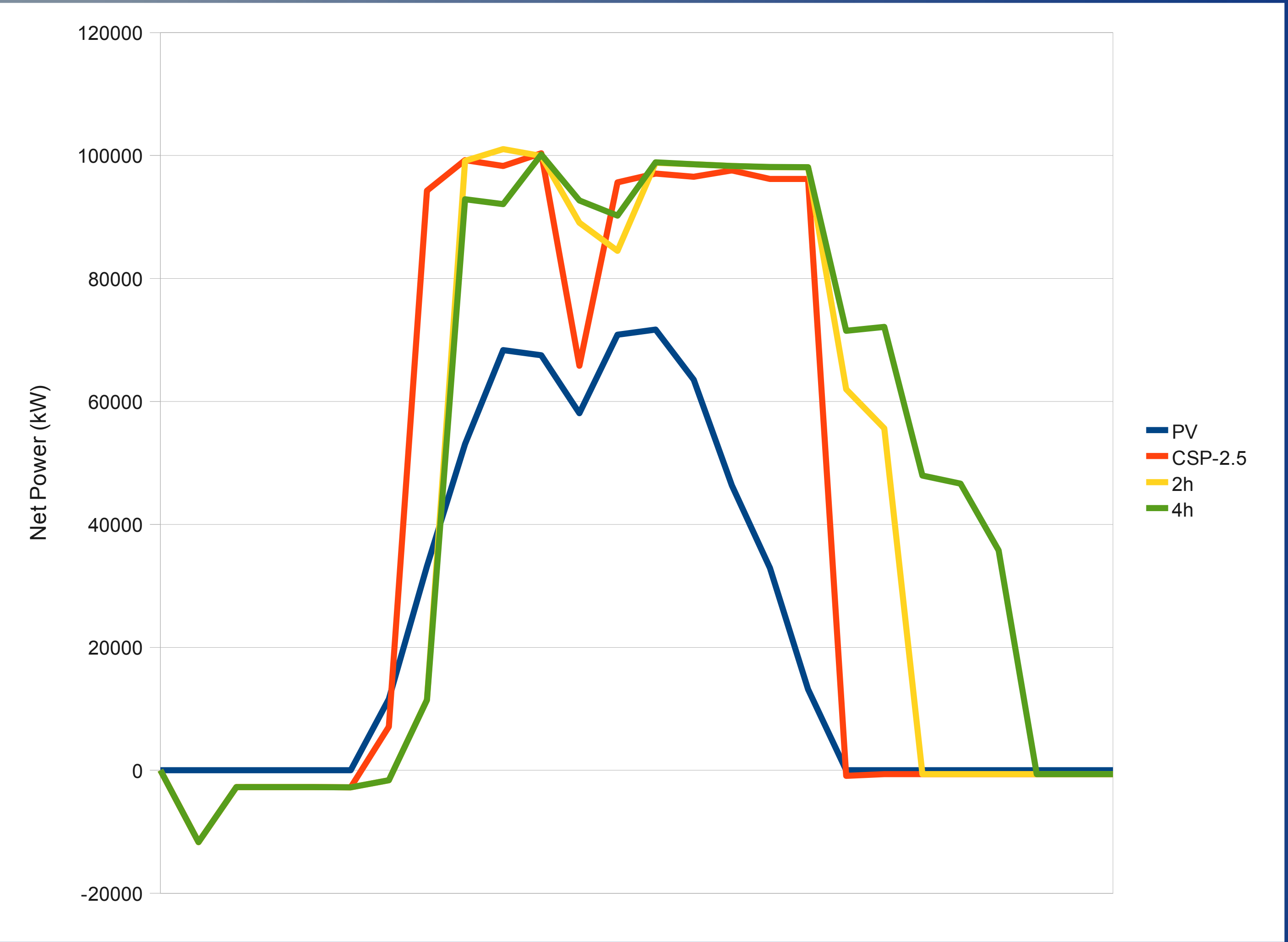
Trough net output
Jan. 1 & 2, 2009



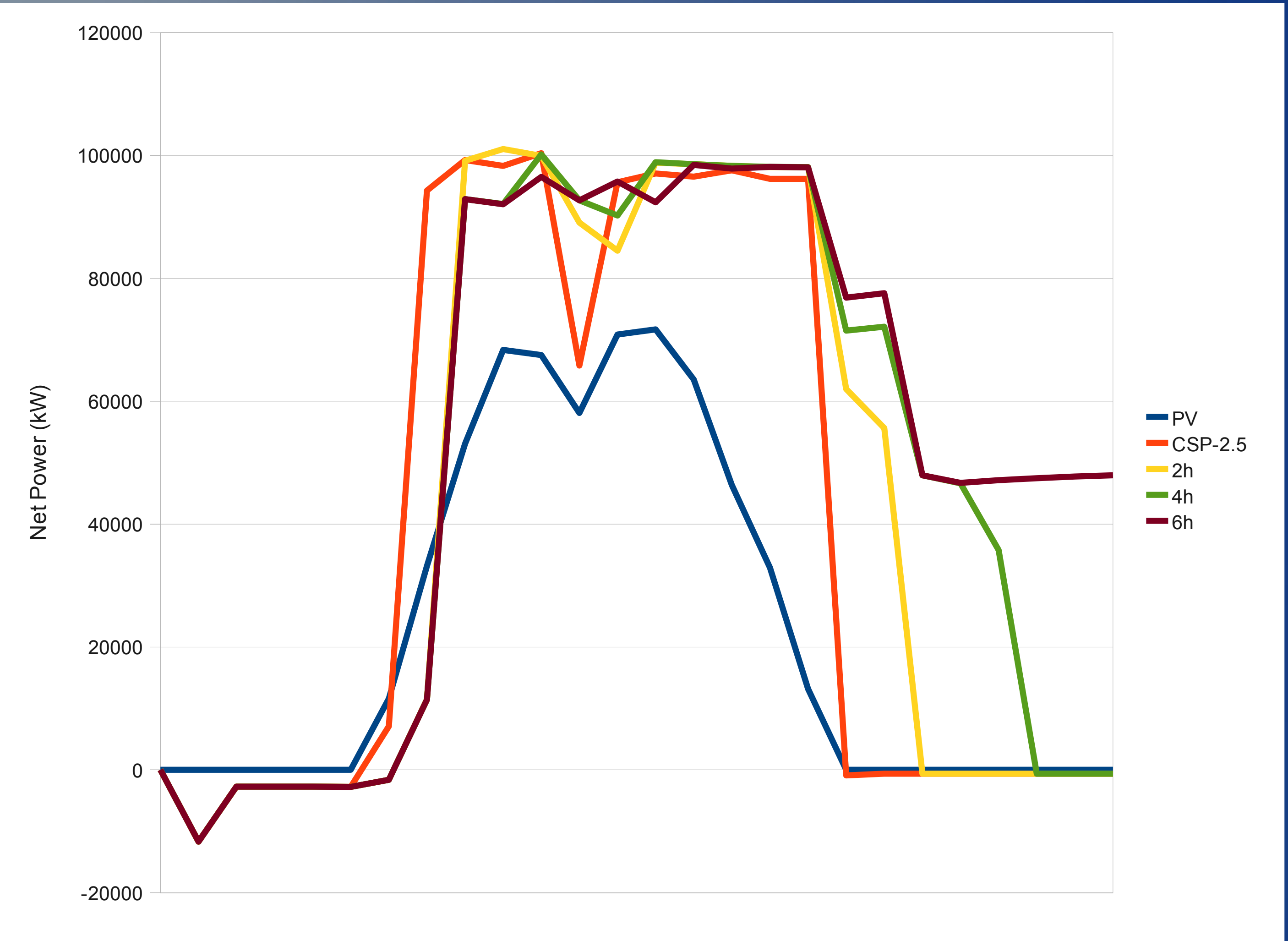
Trough net output
Jan. 1 & 2, 2009



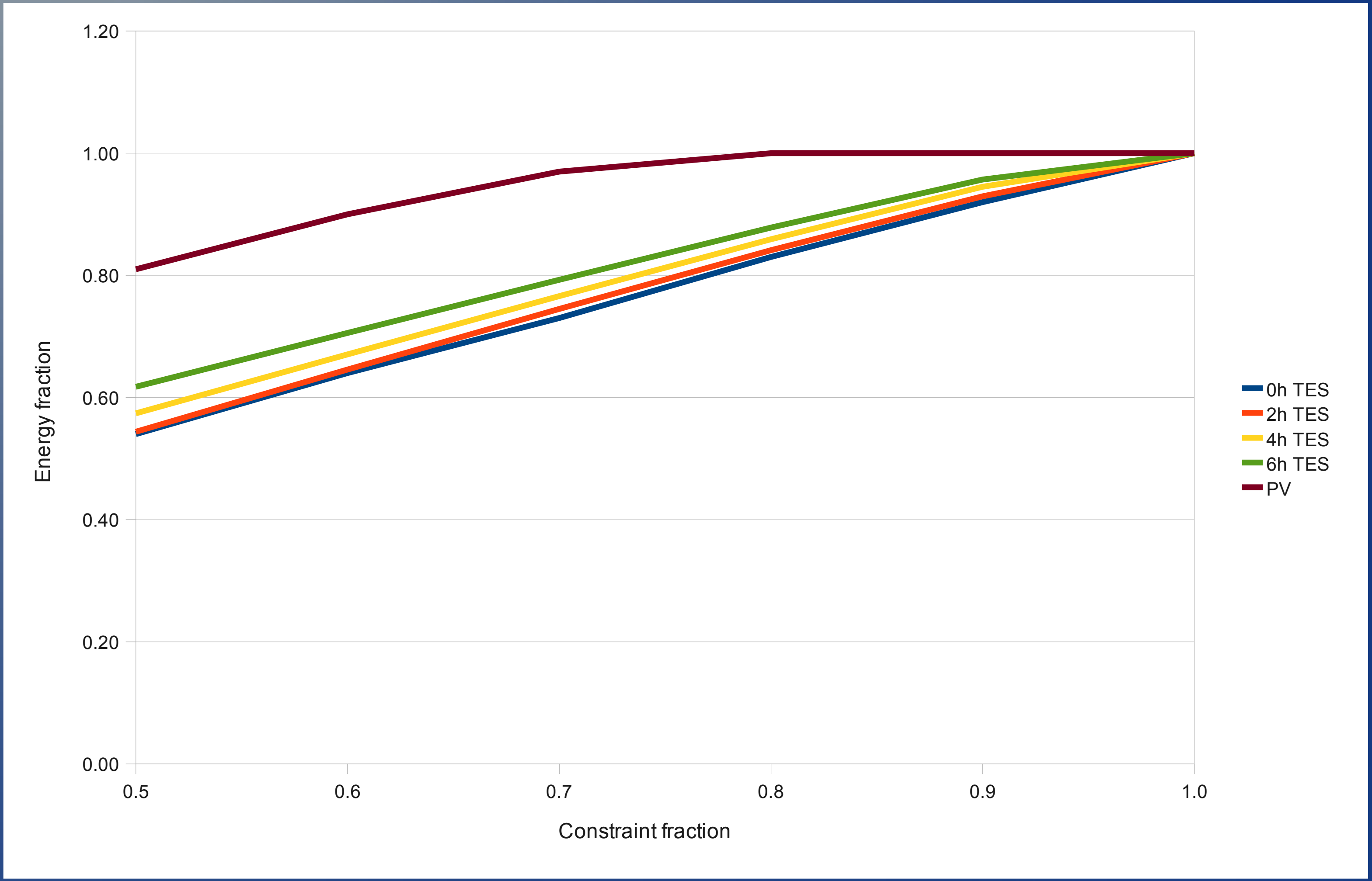
Trough net output
Jan. 1 & 2, 2009



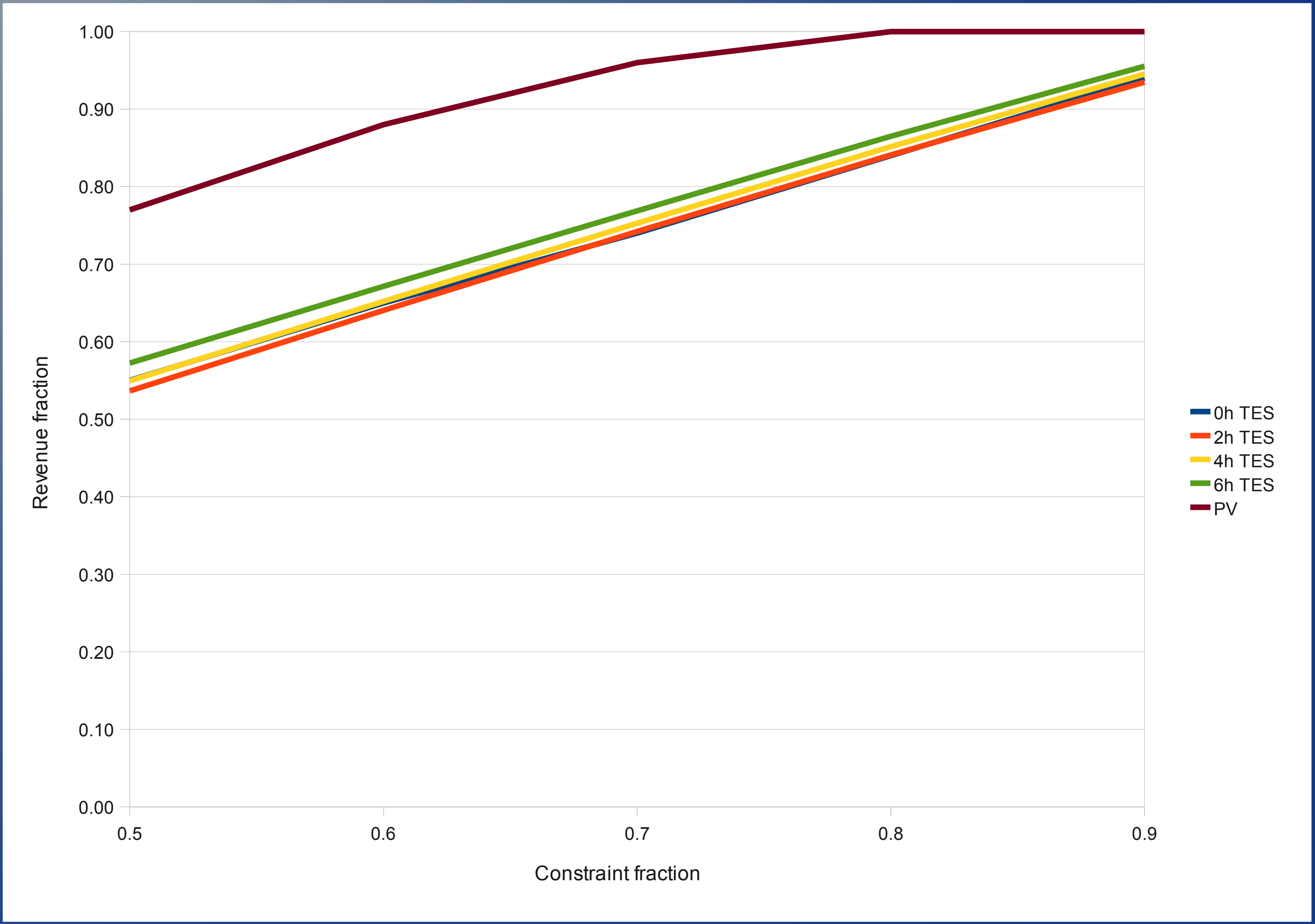
Trough net output Jan. 1 & 2, 2009



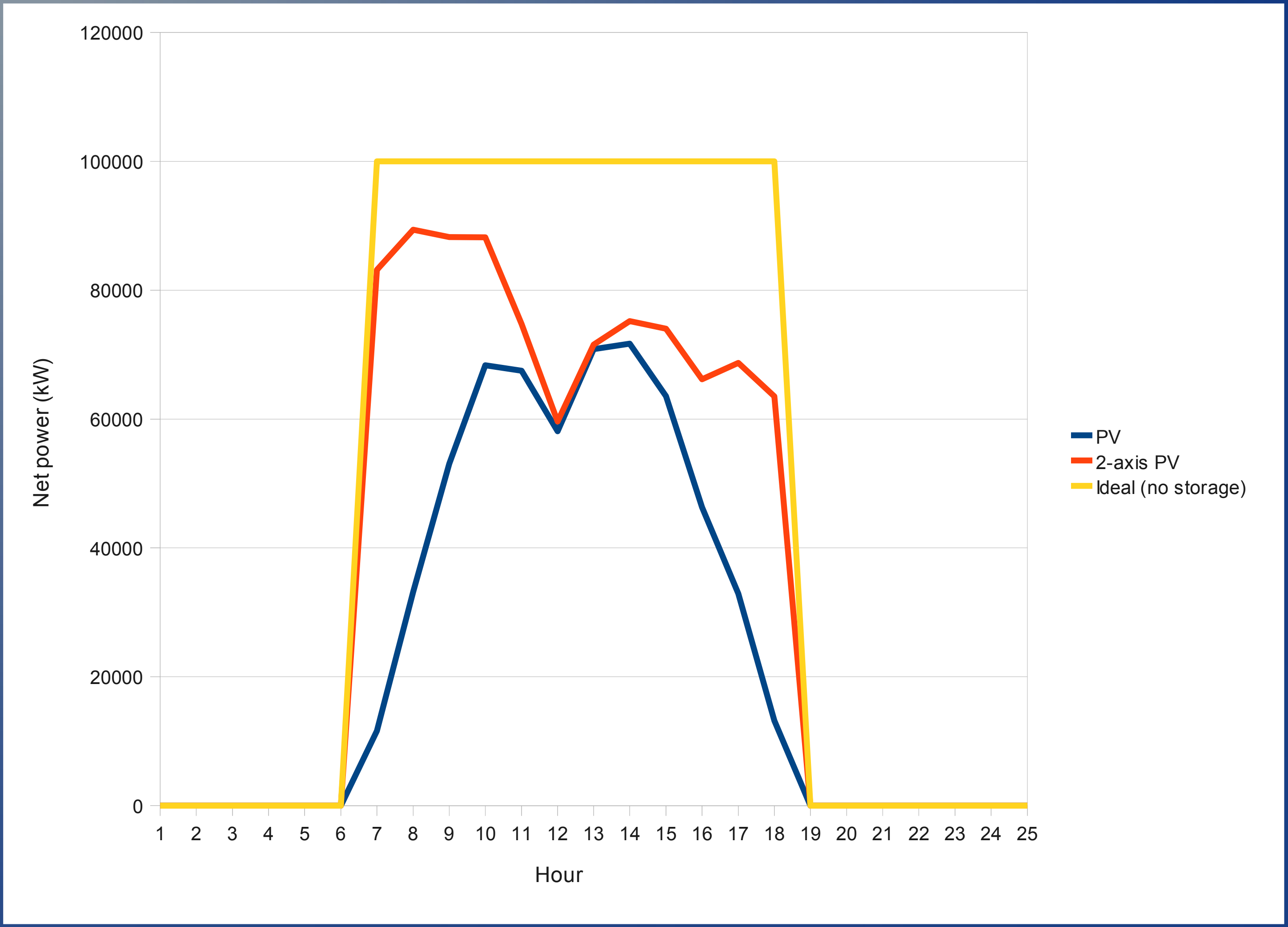
Trough plant energy yield



Trough plant revenue



“Ideal” generation curve



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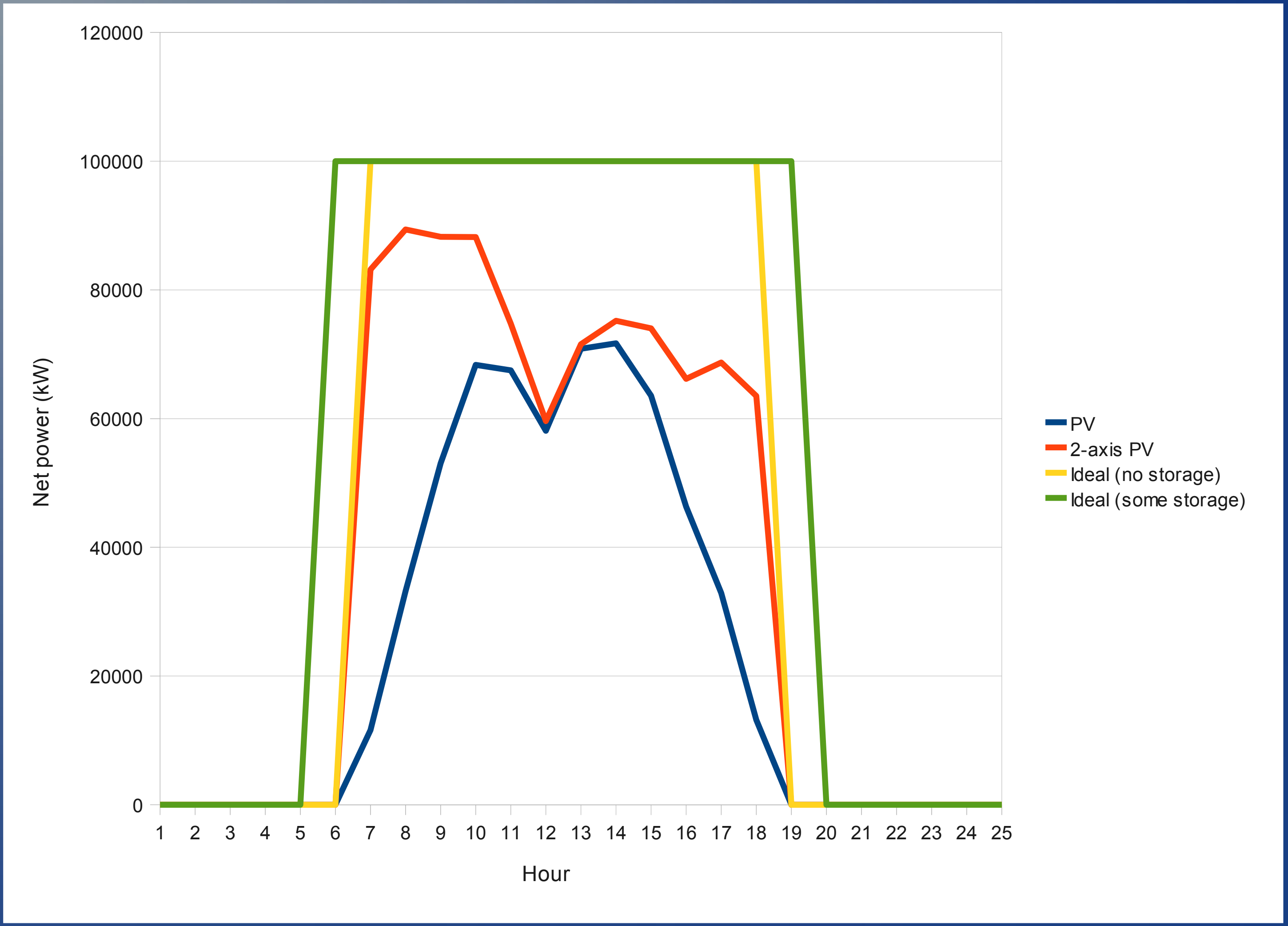

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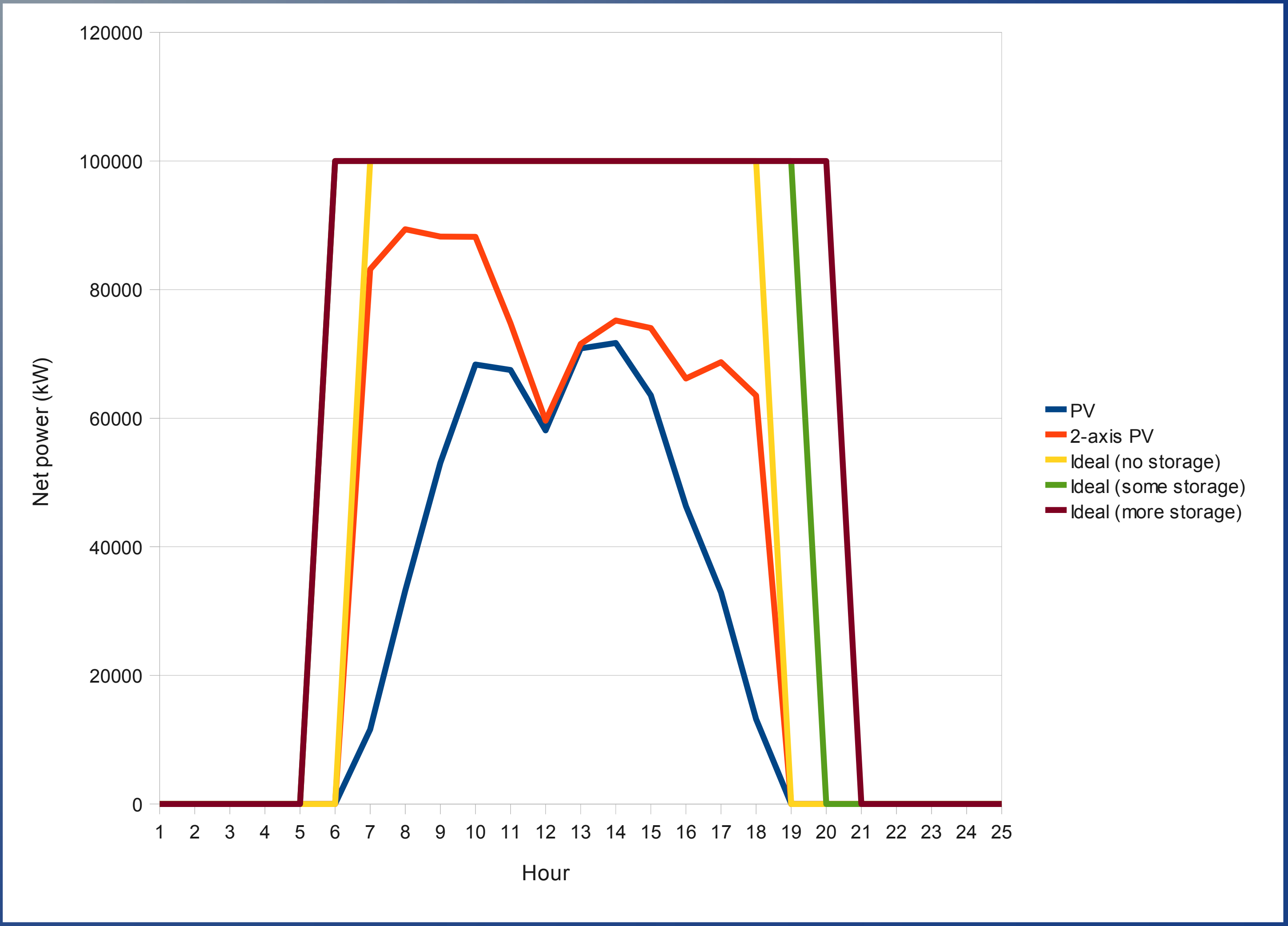

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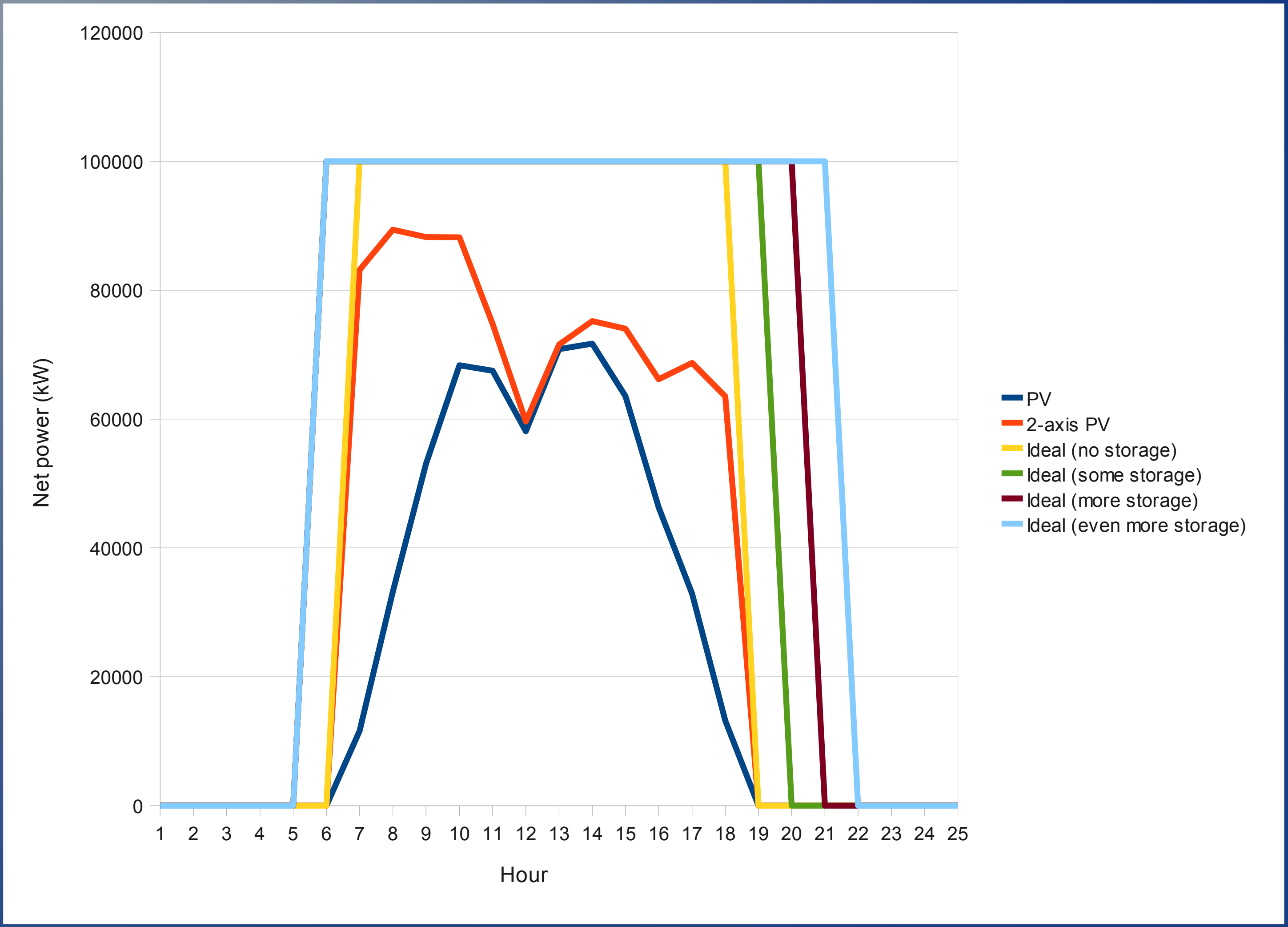

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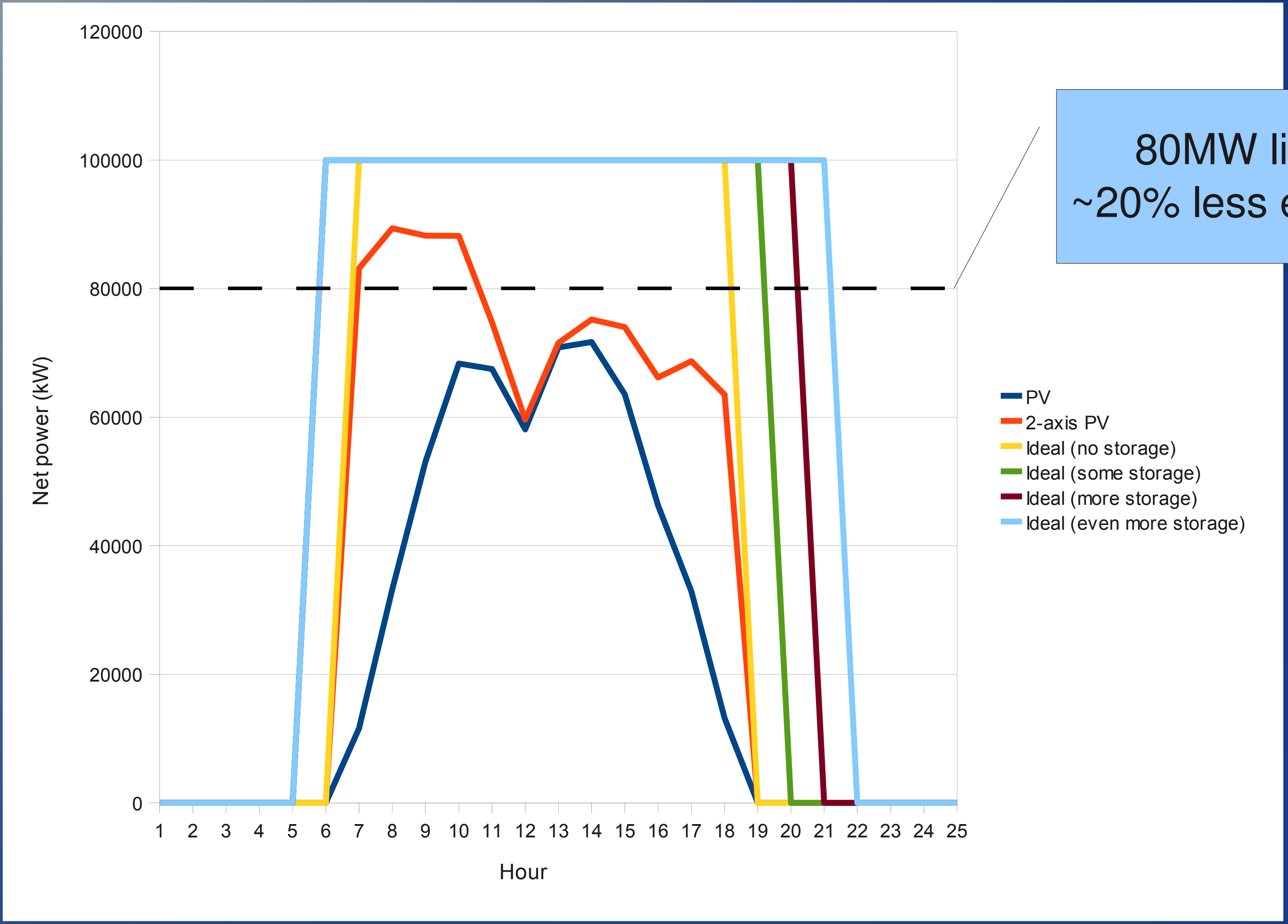

80MW limit
~20% less energy

Conclusions

- In restructured industries (NEM), transmission investment needs to be carefully directed
- Risk, not cost, the biggest problem
- Modular construction a big advantage
- Over-sizing fixed PV systems very effective
- More CSP storage → higher impact of constraint (just like fossil plants)
- Better to match power block to available transmission (less $, run at full load)

Questions?

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