

Matching large solar PV power plants to the Israeli grid

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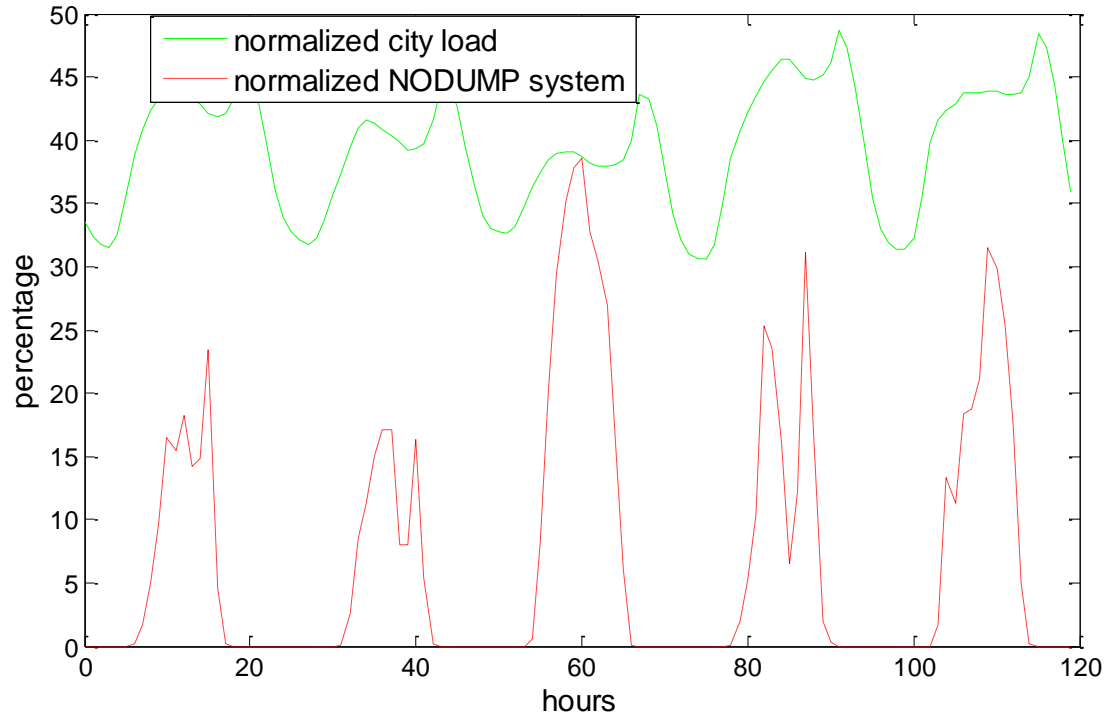
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The Problem



A large PV system may instantaneously provide more energy than the grid can absorb

Address problem in 4 stages

- 100% "Flexible: Grid (all solar acceptable)
- More realistic flexibility (some acceptable)
- The real world (ehh!)
- Storage to the rescue

Caution: We only have hourly data

Flexibility

- **Qualitatively:** The ability of the grid to turn down its generators in order to accommodate large PV input
- **Semi-quantitatively:** Ratio of minimum to maximum levels of generation
- **Obscuring factor:** Economic issues (ignored in this study)

IEC Statistics for 2006

- Total generating capacity = 10.5 GW
- Total electricity production = 50.3 TWh
- Min hourly prod/Max hourly prod = 0.64

For 100% Flexibility

Q: What is maximum size of no-dump PV?

A: 5.4 GWp \Rightarrow 8.75 TWh
= 17.4% of total requirements

What if we allow some dumping?

System size	% annual needs provided by PV	% of PV dumped
ND	17.4	0
2xND	31.6	9.0
3xND	37.2	28.7
4xND	39.9	42.6
5xND	41.7	52.0

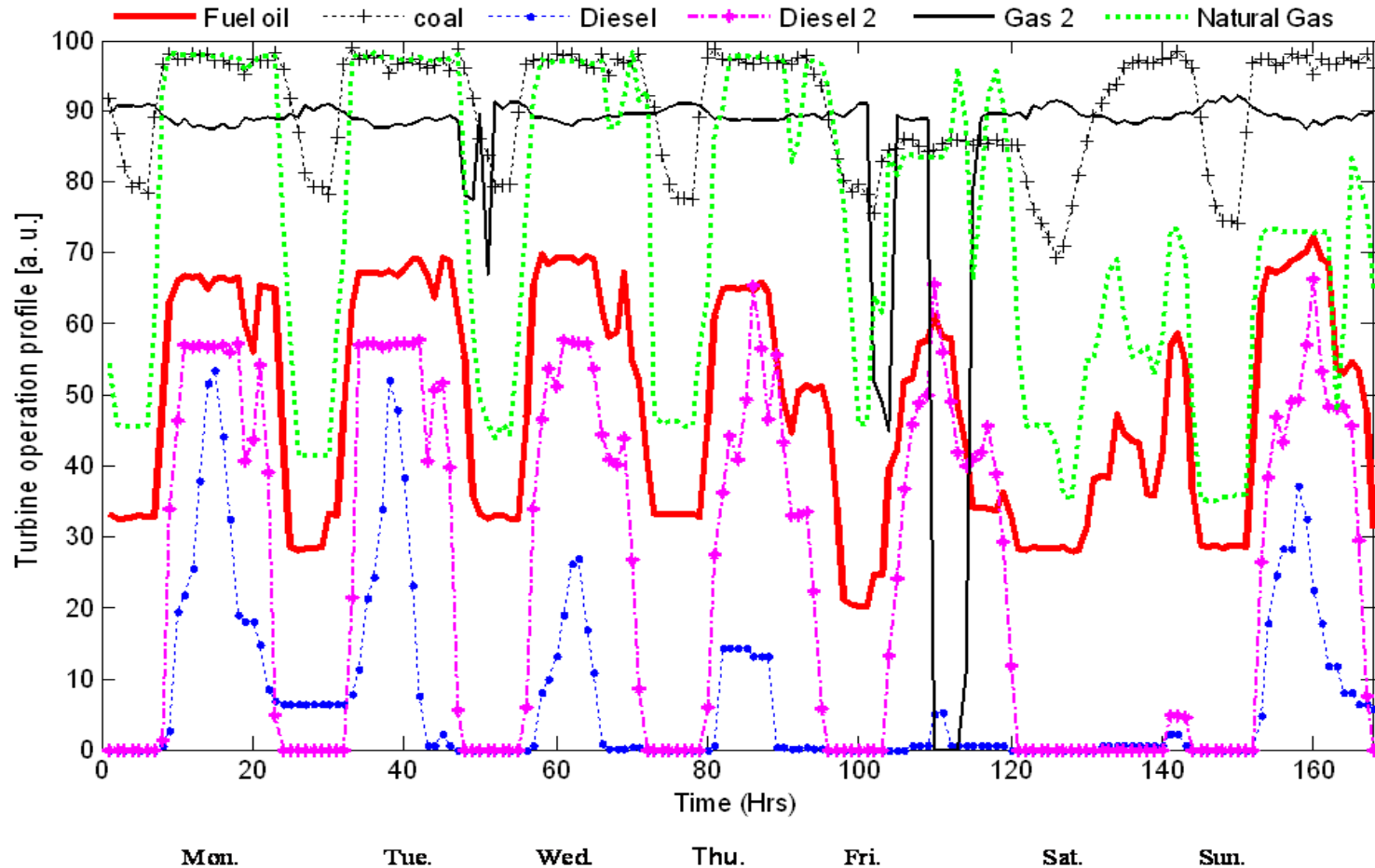
What if flexibility is < 100% ?

Flexibility	ND size [GWp]	% annual needs provided by PV
100%	5.4	17.4
90%	4.2	13.7
80%	3.1	9.8
70%	1.7	5.5
65%	0.83	2.7
60%	0.68	0.2
50%	0.05	0.02

Provisional "good" news

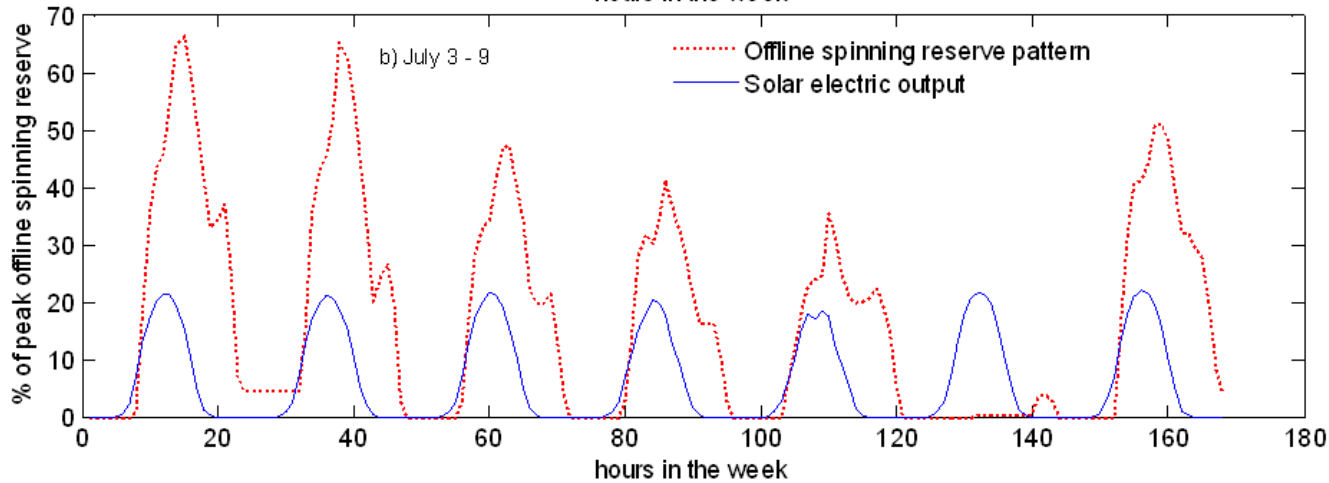
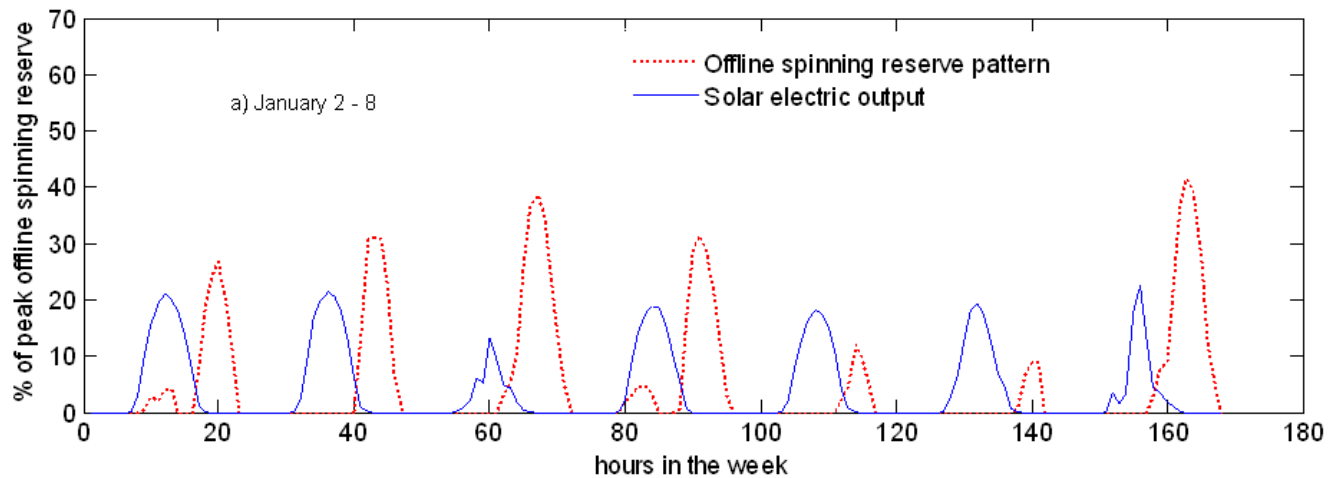
- If the Israeli grid is really 65% flexible:
- No-Dump PV system size is 830 MWp
- Provides 2.7% of annual requirements

The real world !



Only spinning reserve is readily "solarizable"

Spinning reserve vs. solar



Mon. Tue. Wed. Thu. Fri. Sat. Sun.

No such thing as a no-dump system !!!

A 830 MWp PV system in reality

- Not "No-dump"
- Dumps 43% of its annual production
- Replaces only 28% of spinning reserve
- Provides only 1.5% of annual needs

Storage to the rescue

Q: How much (100% efficient) storage is needed to restore 830 MWp PV system to no-dump status?

A: 33 GWh.

Results: 2.7% of annual needs supplied
50% of spinning reserve fuel saved

Bonus: Can use storage to solarize base load

Recent results

Spreading PV systems around the Negev does *not* improve grid penetration substantially

Sun-tracking slightly improves situation

Seasonal re-scheduling of base-load plants via storage *massively improves grid penetration*

IEC should prefer gas to coal (or nuclear) in future - to keep system flexibility high

Conclusions

- Storage plus base-load re-scheduling can allow massive solar penetration
- Need more actual plant data
- Hourly data are probably too coarse
- Need to quantify storage efficiency
- Need to include economic constraints

Acknowledgments

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