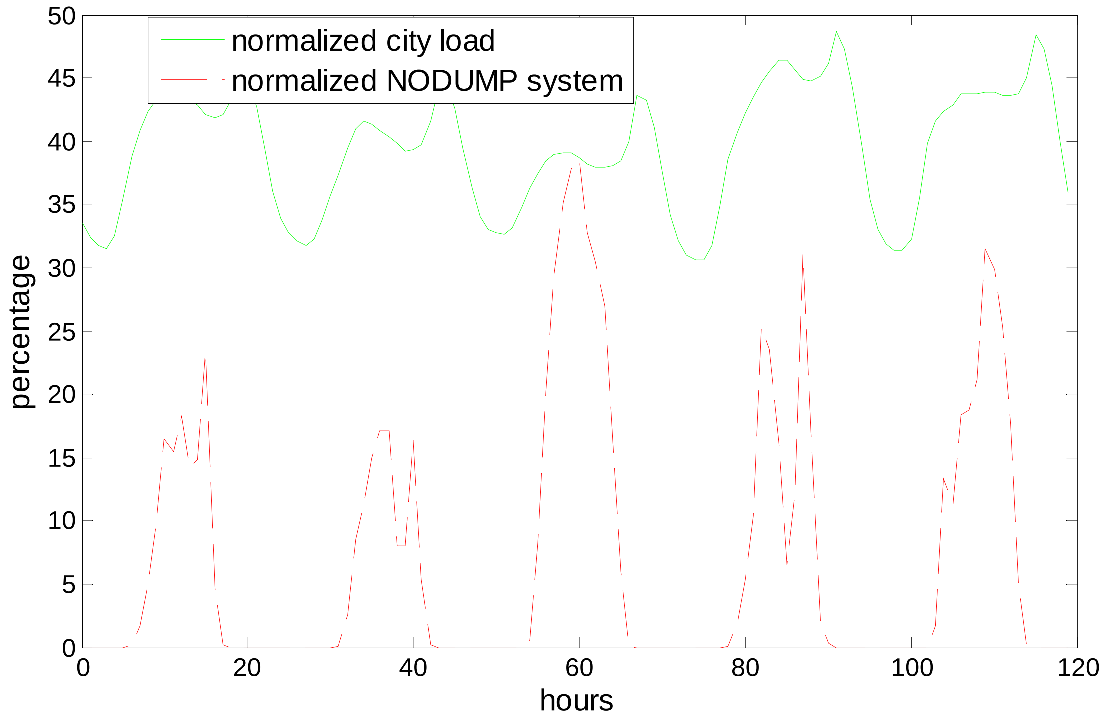
Concerning the efficient connection of VLS-PV to national grid systems

A.A. Solomon[1], **D. Faiman[1]**, and G. Meron[2]
[1]Ben-Gurion University (Blaustein Institutes)
Sede Boqer, Israel
[2]Israel Electric Corporation, Haifa, Israel

IEA PVPS Workshop:
"Towards a future of large-scale deployment of PV"
Congress Center,Hamburg, September 22, 2009

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
- Quantitatively: 1 - 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

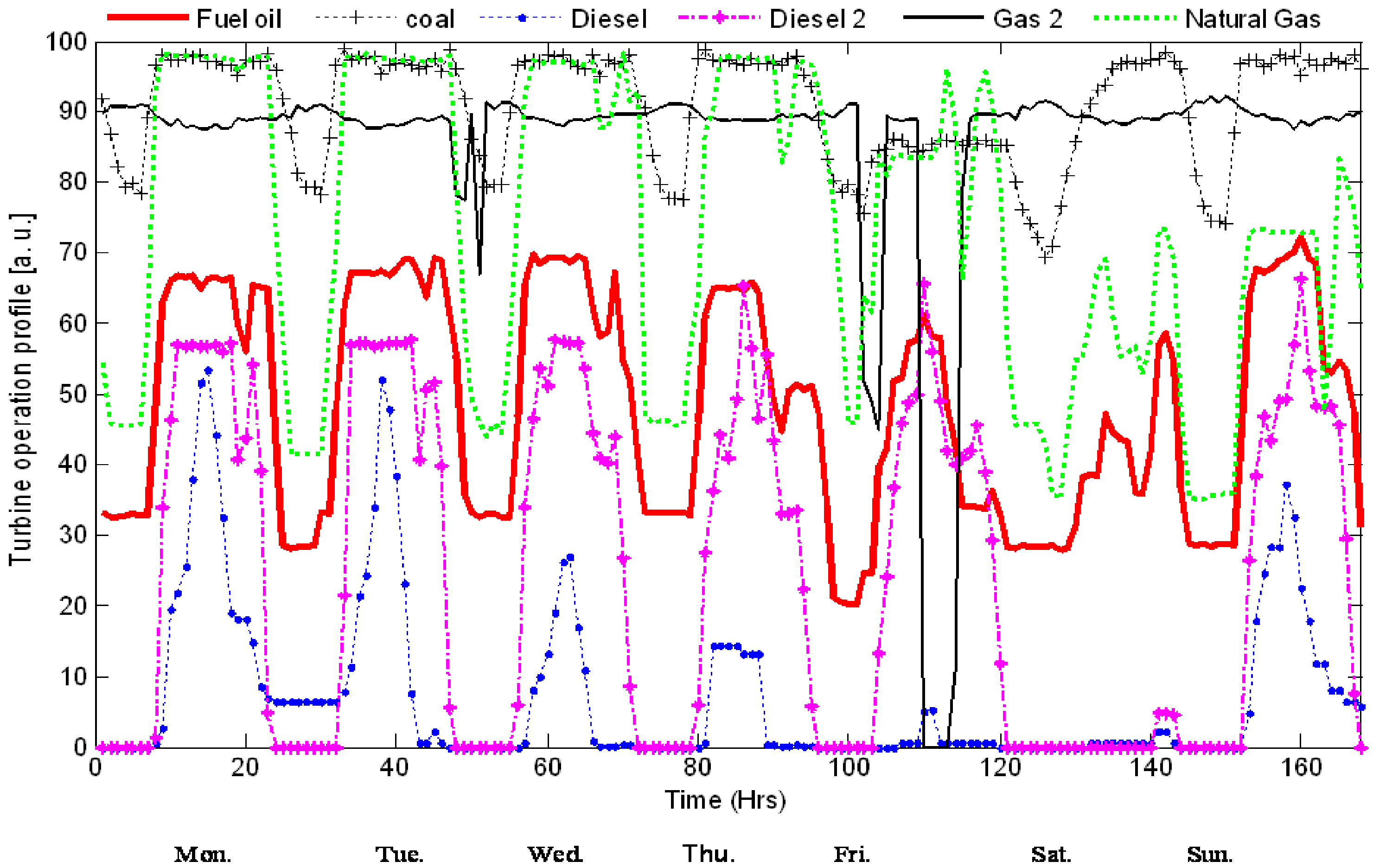
What if flexibility is < 100% ?

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**

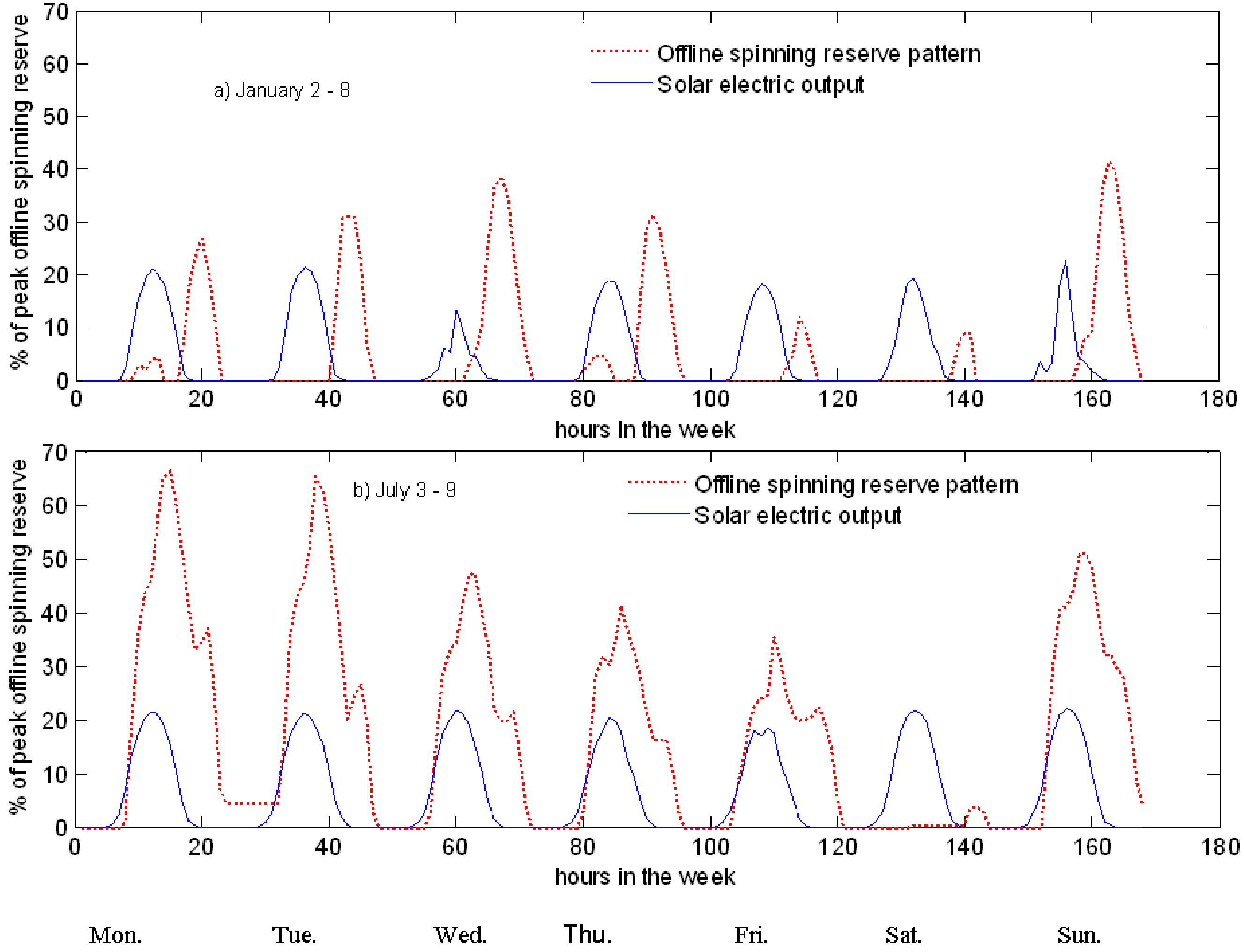
- *If* the Israeli grid is really 65% flexible:
- No-Dump PV system size is 830 MWp
- Provides 2.7% of annual requirements

The real world !



Only spinning reserve is readily "solarizable"

Spinning reserve vs. solar



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

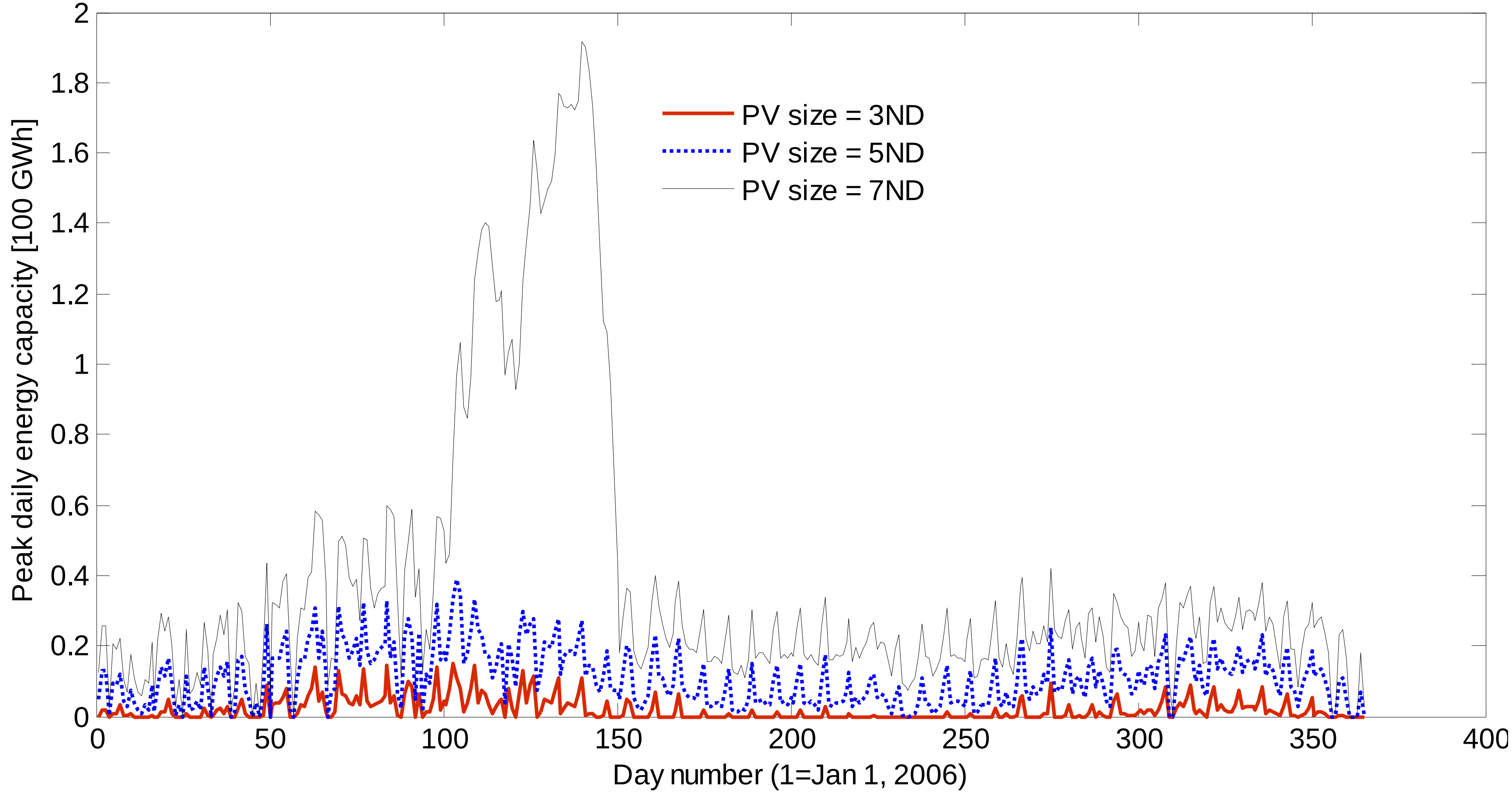
Assume: 75% round-trip storage efficiency
and grid flexibility *ff* = 0.70

Strategy 1: Fix storage size at *nominal* value
100 GWh and dump any excess generation

Result: 25% of annual needs provide by solar, only
10.4% of PV generation lost (storage inefficiency)

Bonus: 42% provide by solar if we allow *total* PV loss
of 20% (dumping plus storage inefficiency)

Alternative Strategy



Ramp down *baseload* plants for 50 days in spring

Results of spring ramp-down

1. Increases solarizable part of load
2. Enables *direct* grid-injection of more PV

Baseload reduction from 30% to 25% enables PV to supply 44.4% of annual load.

Grid operation at ff = 0.80 raises annual PV penetration to 59%

Additional 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 baseload 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
- Need to keep grids as flexible as possible

Acknowledgments

- Israel Ministry for National Infrastructures
- The Israel Electric Corporation
- Tom Hansen (Tucson Electric Power Co.)
- Colleagues in IEA Task 8 PV Specialists
- The Bona Terra Foundation, Albert Katz Graduate School of Desert Studies, Kreitman School of Doctoral Studies