Potential for Distributed Photovoltaic Electricity Production in Israel

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Motivation

- Solar electricity production systems can be either
  - Large utility-scale solar power stations
  - Distributed PV on rooftops

- Distributed PV on rooftops is better!
  - Eliminates the need for vast tracts of land
  - Reduces transmission costs & efficiency losses
  - Reduces building's solar heating

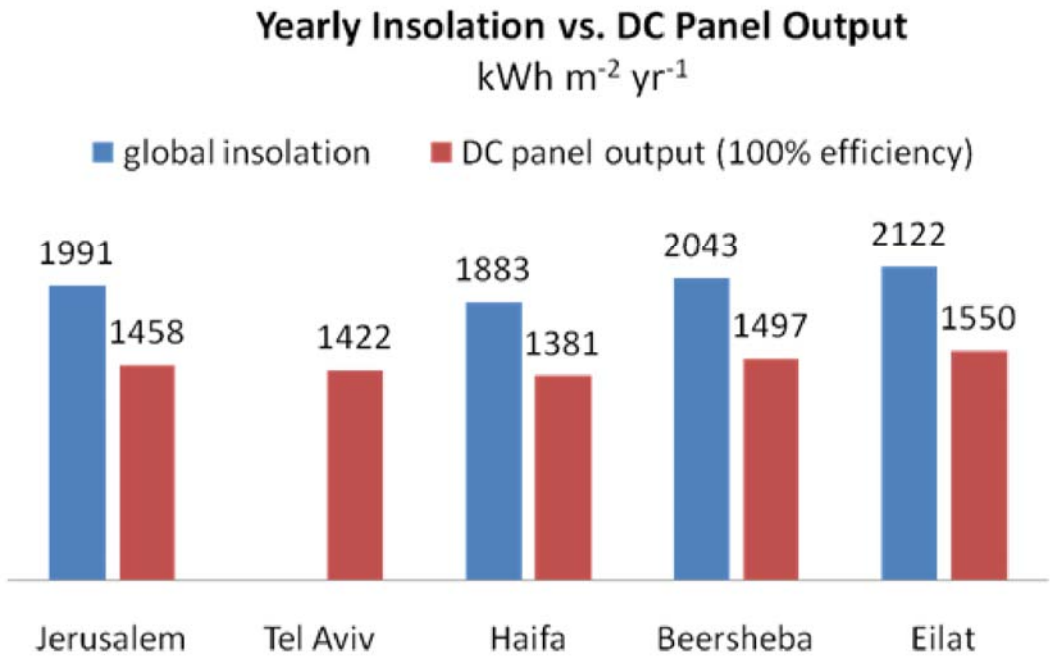
However, does enough usable rooftop area exist?

(to produce a significant portion of Israel's electricity demand)

PV Output

Global Insolation
Total incoming radiation over a year's period measured on a horizontal surface [1].

DC Panel Output (100% efficiency)
Calculated DC Output horizontal solar panel with 100% efficiency [2]. Taking into account actual radiation and panel temperature.



[1] Measured by the Israeli Meteorological Service over a three year period between 2004-2006.
[2] D. Faiman, D. Feuermann, P. Ibbetson, B. Medwed, A. Zemel, A. Ianetz, V. Liubansky, I. Seter, S. Souraqui, PV Systems for Israel's Cities: How Large Should They Be? State of Israel Ministry of National Infrastructures, report RD-24-99, October 2000.

PV Output

Utilizing a Nationwide Average of Panel Output
Using an average is justified since measured insolation values in 10 locations around Israel vary only slightly between locations (-/+ 8%).

Mean DC output - 1460 kWh m^{-2} yr^{-1}
For a panel with 100% efficiency under local conditions.

Panel Efficiency - 16%
Represents a relatively high-efficiency commercially available silicon panel.

DC – AC Conversion Efficiency - 90%
Represents the mean inverter and wiring losses.

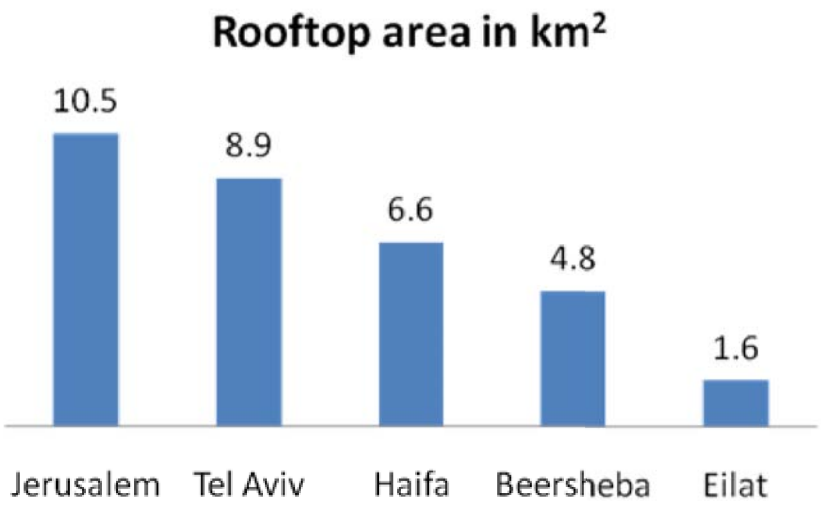
Average AC panel output is 210 kWh m^{-2} yr^{-1}

Rooftop Area Calculations

GIS (Geographic Information System) calculations covering all towns in the country were performed by the Israeli CBS*:

- All buildings were strictly bounded by polygons
- Polygon areas were summed by town and nationwide
- Total rooftop area in Israel: **234 km²**

* Central Bureau of Statistics



Available Rooftop Area

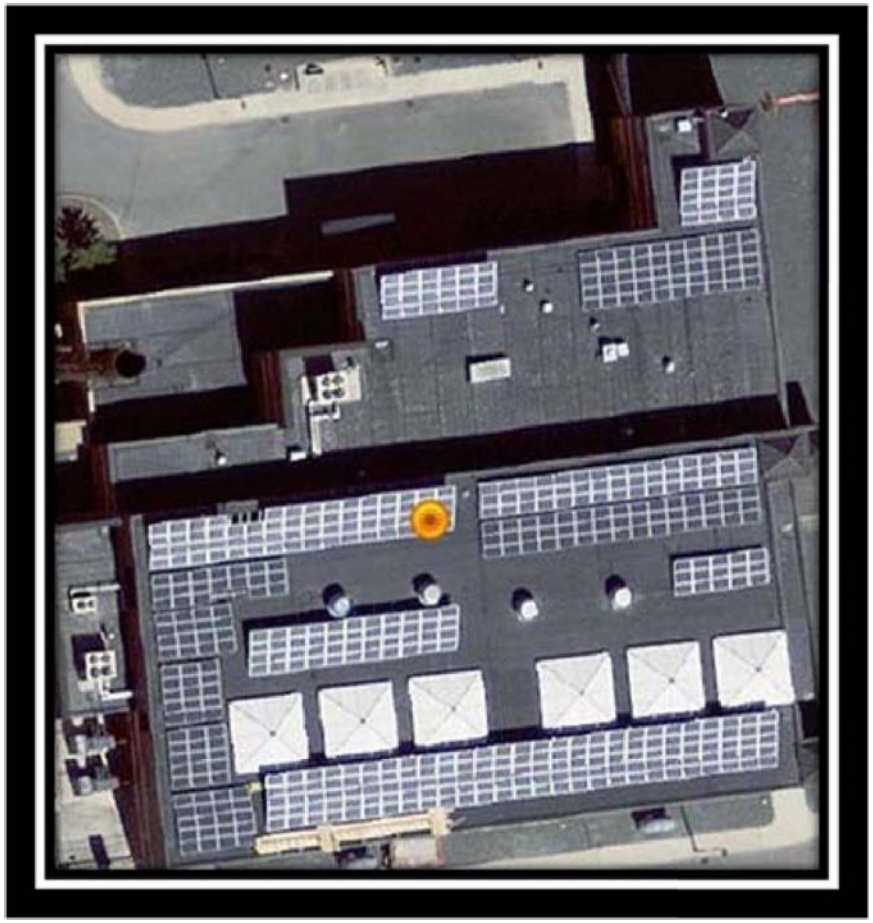
Most of the rooftop area can't be used.

Available space can be limited by:

- Structures
- HVAC (Heating, Ventilation, and A.C.)
- Solar water-heaters (especially in Israel)
- Shading
- Pitched roofs

Estimating the percentage of available rooftop area is hard

However, some rules of thumb exist …



Picture from http://gis.cityofboston.gov/solarboston/

Available Rooftop Area

Usable area for PV panels
total rooftop area

Roof Type	Israel (1)	U.S. (3)
Pitched Roof	**20%**	**18%**
Flat Roof	Residential - **50-70%** Commercial/Industrial - **up to 90%**	**65%**
Mean	**30%** (estimate (2))	**32%** (4)

(1) Rules of thumb for rooftop availability used by Israeli PV installers [1].

(2) A conservative estimate was made for the mean value in Israel to ensure that errors are made on the side of caution.

(3) A study in the U.S. [2] shows similar availability estimates.

(4) U.S. Mean was calculated knowing the pitched/flat roof ratio.

[1] Solar Power Israel ltd.
[2] M. Chaudhari, L. Frantzis, T. E. Hoff, PV Grid Connected market Potential in 2010 under a Cost Breakthrough Scenario, 2004. Via www.ef.org/documents/EF-Final-Final2.pdf.

Rooftop area can be used efficiently…

Total PV Potential

The available rooftop for placing PV systems can now be calculated:

Rooftop area	**234** km^2
Available rooftop area	**70** km^2

Using the calculated average AC panel output of 210 $kWh\ m^{-2}\ yr^{-1}$ we can calculate the solar production potential and compare it to the national electricity demand:

Solar production potential	**14.8** $TWh\ yr^{-1}$
National electricity demand[1]	**50.1** $TWh\ yr^{-1}$
Ratio of potential-demand	**30%**

[1] Israel Electric Company, 2008.

Conclusions

30% of Israel's electricity demand can be met **using rooftops only**.

With no means of energy storage, solar electricity production is **economically limited to 10-15%** of total national production [1].

Hence, the **available rooftop area is sufficient** for producing all the electricity that is economically-feasible.

There is no shortage of rooftop area

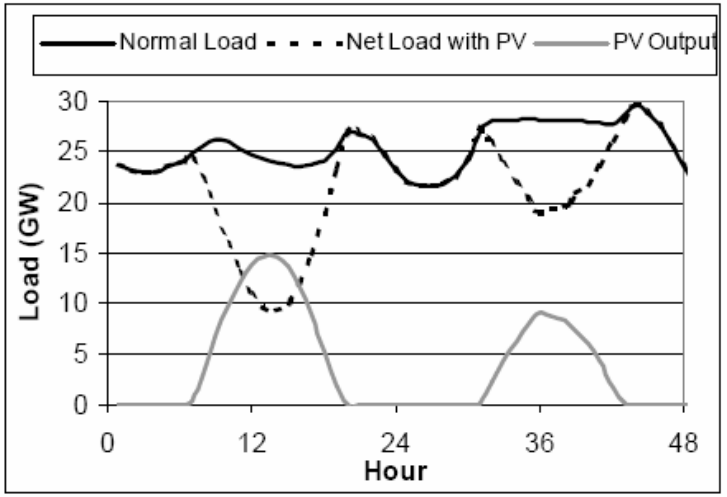


Fig. 2: System Load With and Without a Large (16 GW) PV System on Two Spring Days

[1] P. Denholm, R. Margolis, Very Large-Scale Deployment of Grid-Connected Solar Photovoltaics in the United States: Challenges and Opportunities, NREL Report No. CP-620-39683. 2006.

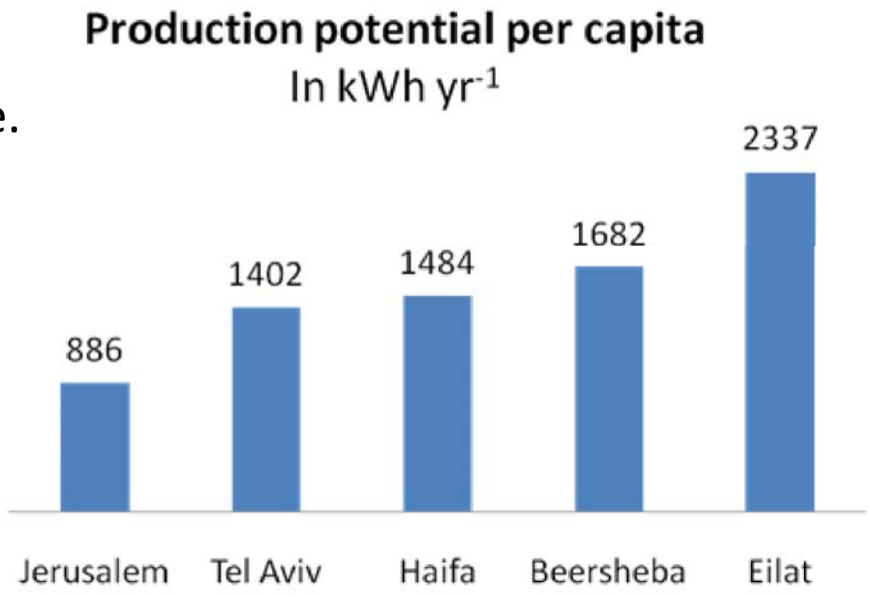
What's Next?

Where to start?

Where is makes most economical sense.

Eilat has:

- highest insolation values
- highest rooftop area per capita
- no nearby power plant



Eilat seems as an obvious place to begin a city-wide rooftop PV program.

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