



The Future Israeli Energy Mix and the Role of Renewable Energy

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Scope of Work

- ***The Target*** – Locating possible future gaps in energy resources till the year 2060 (Only a limited part of the work is presented)
- ***The Method*** – Analysis of the electricity market on the basis of **ENERGY** constraints (and not on power)
 - Demand side - Estimation of the **Minimal** amount required
 - Supply – Estimation of the **Maximal** amount of available energy from the known resources
- ***Identify possible gaps and propose possible solutions***

Demand estimation till Y2060

- The present 2012 demand is about: **59 TWh/year**
- Estimation of the rate of increase: **2.5%**
 - The annual increase rate till 2010 was – **3.25%**
 - Reduction of demand due to energy efficiency – Since 2010 the national energy efficiency program of the Ministry of Energy and Water Resources (res. 3954) has got into force. The target is **20% reduction till 2020** compared to the “business as usual” scenario.
 - Increase in demand is expected due to:
 - Increase in the standards of life
 - Increased usage of electricity for transportation (trains, vehicles...)
 - Technological limits on efficiency
 - Climate changes
 - Therefore – the estimated rate of electricity was reduced to 2.5% instead of the 3.25% before applying efficiency measures



The limits on the supply

- The following energy resources are analyzed:
 - Renewables:
 - Solar
 - Wind
 - Biogas and Biomass
 - Geothermal energy
 - Hydro
 - Natural gas
 - Coal
 - Oil shale

Solar Energy (PV & CST)

- The upper limit of energy that can be supplied by solar energy will be estimated by:
 - The area available for solar energy production
 - The maximum energy that can be produced per unit area using future technologies.
- Estimation of available area:
 - Today **350 km²** considered as available for solar installations
 - In the long term we estimate additional 50% increase → **525km²**
- Installed power per 1km²:
 - Today, using *BAT*, ~ **40MW/km²**
 - We estimate efficiency increase by 75% → ~ **70MW/km²**

Solar Energy (PV & CST) *continue...*

■ Amount of energy per installed unit of power:

- Capacity Factor: ~ **20%**

- Capacity Credit: ~ **78%**

- **Capacity Factor** – The ratio of actual energy produced vs. the amount that could have been produced if the sun would have been available for 8,760 hours/year

- **Capacity Credit** – reliability factor that estimates how much of the energy produced can be reliably used by the grid manager

→ **Actual/maximal production = (Capacity Factor)X (Capacity Credit) = 15.5%**

→ **1,358 hours**

- **WE estimated 50% increase → 2,025 hour/year**

Therefore, The maximum capacity is:

70 MW/km² X 525km² X 2,025hours/year ≈ 75 TWh/year

Wind Energy

- The upper limit of wind energy is estimated by:
 - The potential of installed wind power
 - The number of hours per year when the wind delivers energy based on the expected future technologies
- Wind power potential:
 - The current estimate is **800 MW**
 - Assuming allocation of 100% → **1600 MW**
- Estimation of number of hours:
 - Currently –
(Capacity Factor-26%) X (Capacity Credit-25%) = 6.5% → $8760 \times 6.5\% =$
570 hours/year
 - We estimate 200% increase → **1,710 hours/year**

The upper limit for wind energy is:

$$1600 \text{ MW/km}^2 \times 1,710 \text{ hours/year} \approx 2.75 \text{ TWh/year}$$

Biogas & Biomass

- The upper limit for energy production from biogas & biomass is defined by:
 - The total volume of organic wastes existing in Israel
 - Energy content per 1 Mton of waste (expressed in Mtoe)
 - The efficiency of installation converting organic waste to energy
- The volume of organic wastes in Israel:
 - Currently - **~ 1.5 Mton/year**
 - Estimates increase rate: **3% /year**
- Energetic value - **~ 0.25 Mtoe** per 1Mton of wastes
- Efficiency of waste to energy conversion: in 2060 we expect **50%** increase over the present combined-cycle power stations - **~ 85%**

The upper limit for electricity from wastes to energy:

$$1.5 \text{ Mt/year} \times 1.03^{50} \times 0.25 \text{ Mtoe/Mt} \times 85\% \times 11.63 \text{ TWh/Mtoe} \approx \mathbf{16 \text{ TWh/year}}$$



Other RE technologies

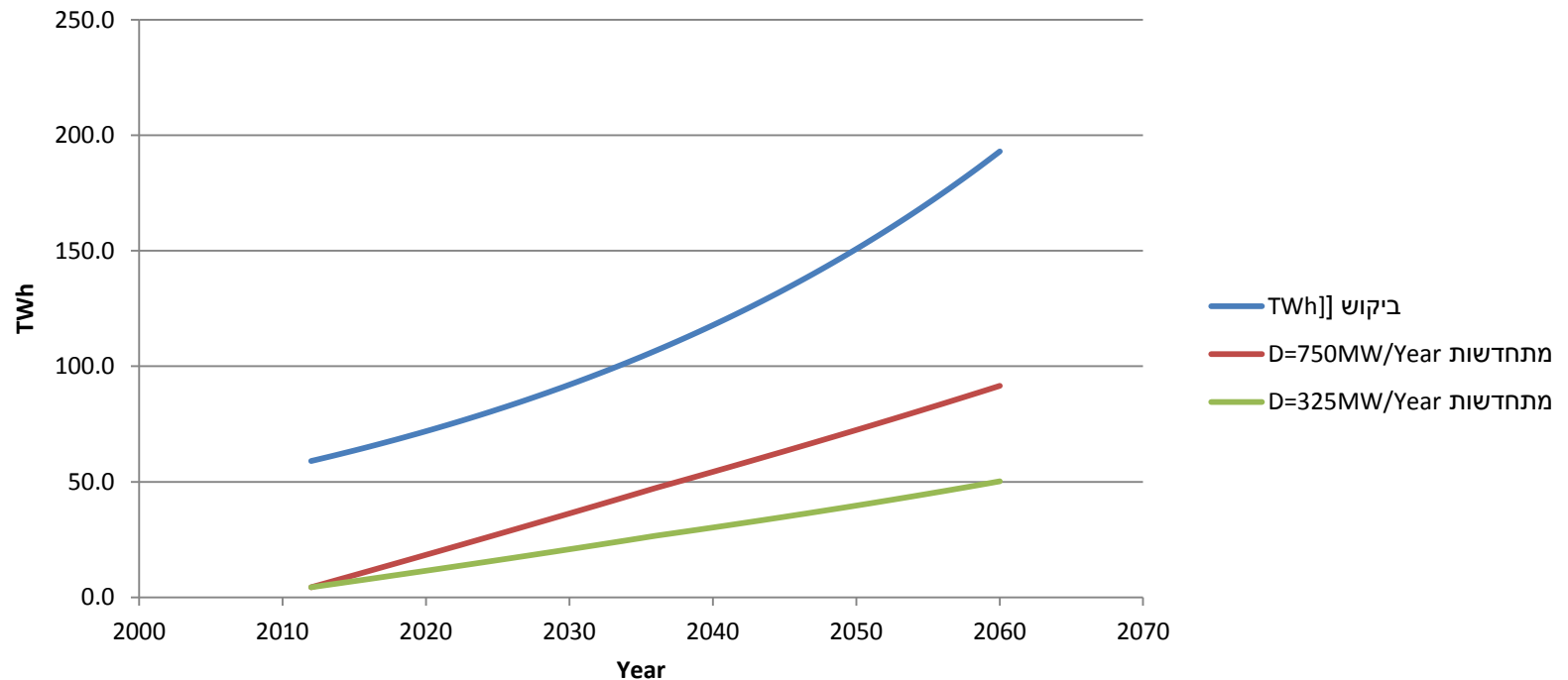
- **Geothermal energy** - Unfortunately, no major sources exist in reasonable depth
- **Hydroelectric power** - Negligible

Estimation of RE penetration rate

- **Solar** – 375 MW/year -- 750 MW/year (up to 37GW)
- **Wind** – 160 MW/year (up to ~ 2 GW)
- **Biomass & Biogas** – 3.7 TWh/5years, and 3% increase during the following years

Aggregated maximal RE production compared to minimal electricity demand

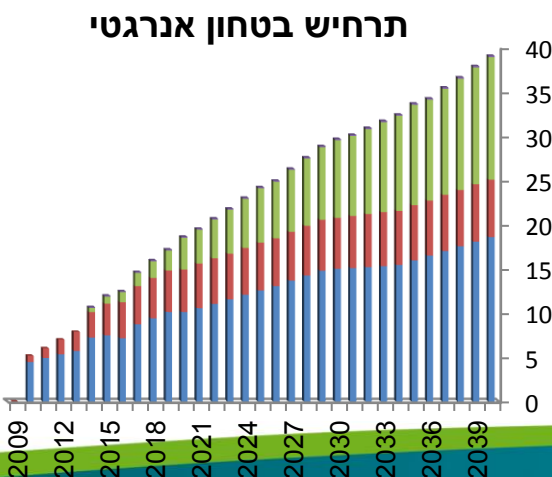
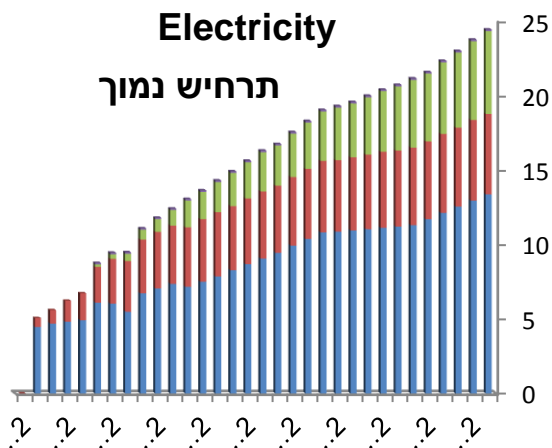
Renewables compared to Demand



* ההתפתחות מתוארת כקו ישר עקב השימוש בשיעור גידול ממוצע לאורך שנות התחזית. בפועל, לאור הקשיים בשנים הראשונות בהתגברות על עיכובים בירוקרטיים וסטוטוריים, העמידה ביעד האנרגיות המתחדשות סביר שיתואר כפונקציה מעריכית

Estimation of NG potential and local demand till 2040

- NG for Power, 20% savings till 2020
- Industry & Distribution
- Transport

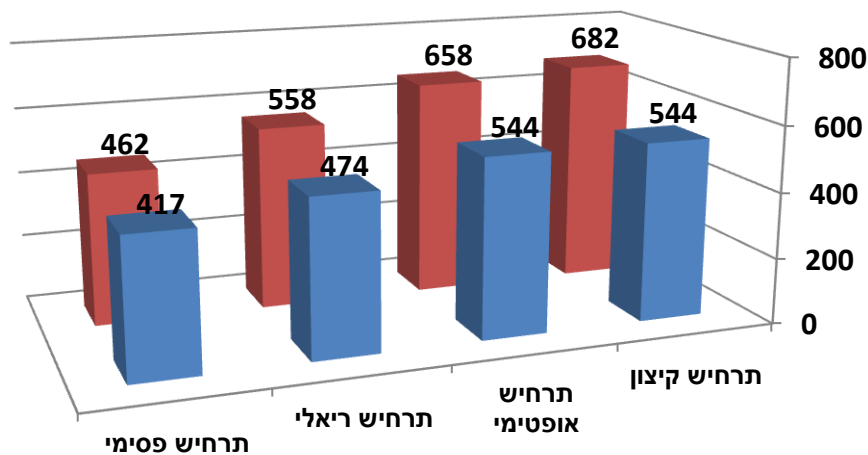


■ The estimated NG potential in the Israeli EEZ:

- Discovery 250 BCM (Tamar)
- Finding 450 BCM (Leviathan)
- Wishful thinking 500 BCM

■ **Total USGS estimate: 1200 BCM**

Total BCM 2009-2040



Natural Gas (continue...)

- The Zemach Committee predicts:
 - NG accumulative local demand till 2040 ~500 BCM
 - Strategic reserve till 2040 ~400 BCM
 - ➔ Total amount of 900 BCM for the local market
- If NG will **NOT** be exported if we assume a modest demand for **transportation** the NG will be available to the local market **till 2050-2060 only!**
- NG power system can crash due to a **single fault!** ➔
The **installed power** based on NG should **NOT** exceed **30%** of the **total installed power capacity!**
- The Ministry target currently is 50%



Coal

- The existing coal fired power plants will finish their expected lifetime on 2035-2040
- If Plant D will not be built the 50% limit on NG installed capacity will soon be exhausted!
- Coal is not a curse! Best available coal technologies are accepted worldwide by environmentalists. However, they are strongly rejected by the Israeli public.

Oil Shale

- A huge potential! **250 billion barrels** are estimated
- Just few countries make use of oil shale in large scale
- New technologies have to be developed in order to make oil shale viable option
- The Israeli public opinion even rejects the testing and developing such new technologies



Conclusions - The future energy mix in Israel

- Security and reliability → reduce the installed NG power to 30%-50% out of the total installed capacity
- If no changes in the public attitude toward coal, its share will be decreased to 5-10%
- **RENEWABLE ENERGY –**
 - If all resources will be exhausted by 2060 RE will reach **45%**! But later it will be reduced
 - More reasonably, RE share **will be up to 30%**

⇒ In about 15 years additional energy source must be introduced (Modern coal utilities?)

⇒ Starting 2050 new technologies will have to be implemented (Nuclear?)



Thank you

תודה רבה