

Developing Renewable Energy Technologies in Israel

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Agenda

- Renewable Energies - breaking the oil addiction
- The Israeli advantage
Academia as a source for innovation
- Research directions looking forward
- Examples

Climate Change Predictions Are Confirmed

- ❑ 78% of British Columbia pine will die by 2013
- ❑ British Columbia, Ministry of Forests and Range (2006):
40% of the pine is now gone
- ❑ Sea level rise has accelerated in the past two decades:
- ❑ Surface area of September Arctic sea ice
 - IPCC Prediction for 2008 reduction from 7.5 to 9.5 Million square miles to 6.5 to 9.0
 - Actual reduced to 4.5 M square miles

Tipping Point?

In order to avoid the chance that we avoid “tipping points” such as the thawing of the tundra, climate scientists are calling for more aggressive action, therefore the target was reduced from 500 to 450 ppm.

Renewable Energies - breaking the oil addiction

- 80% of world power comes from fossil fuels, which are limited and polluting resources
- Oil reserves are expected to last for <100 years of 1998 consumption. Gas and coal will last longer
- Prices of Oil are high and may increase
Value of one barrel of oil \$50-\$80
Value of one barrel of hot water ¢20 (\$0.2)
- There is little diversity in Oil Sources
- Oil reserves are geographically concentrated in hostile countries

Technology Pathways

- Efficiency (building & cities, vehicles & transportation systems, supply chains, industrial processes, smart infrastructure)
- Carbon "free" electricity (renewable/solar, nuclear, coal/NG+CCS)
- Alternative Transportation Fuels (bio/syn-fuels, electricity, H₂)
- Energy Delivery Systems (storage, high quality power, distributed generation, ??? grid)
- Unconventional Hydrocarbons (EOR, ultradeep, NG)
- "Managing" global change (adaptation, atmospheric "re-engineering")?

“The Low Hanging Fruits”: Energy Savings

“Little Creeks Make a Great River”

Regulation stimulates technology example: US domestic refrigerators and freezers efficiency standards

- US domestic refrigerators and freezers size doubled.
- Energy consumption divided by 4
- Price (in real \$) divided by 2
- Result: Energy savings is greater than all of US renewable energy.

In Israel:

- Replacing of incandescent lamps would save one 500 MW power plant
- Air-conditioning represent about 50% of peak power
- Enforce insulation standards
- Promote retrofit

Fields of Interest

Innovations

- Solid conversion: coal, biomass,...
- Ultradeep/robotics: oil/NG E&P
- CO2 capture and sequestration
- Nuclear fuel cycles
- Electricity networks
- Subsurface imaging, EOR, ...

Transformations

- Solar power: advanced PV, photosynthesis/catalysis, thermal/storage
- Biofuels
- Wind/ deep water
- Geothermal/sub-surface science & engineering

Breaking the Oil Addiction an Opportunity for Israel

Key Success Factors

- “The model for RE development is the Silicon Valley not the Manhattan Project”. (US Secretary of Energy Steven Chu)
Competition is not US, Europe, Japan, China etc but start-ups in these countries
- The future of RE hinges on long term scientific research in physics, bio-chemistry, synthetic biology etc.
Breakthrough will come from multi-disciplinary effort.
- R&D requires: Long term large investments
 - Top quality researchers
 - Input from, and symbiosis with industry
- Commercialization requires:
 - Existence of industry capable of taking in R&D results
 - Trained workforce
 - Capital

Historic Center of Excellence

- Israel was a leader in RE long before “green” became fashionable (50’s – 90’s), and remains a leader in some areas:
 - *Solar*: water heaters, solar ponds, and parabolic troughs, including regulatory innovation
 - *Geothermal*: geothermal and recovered heat
 - *Water*: *Waste-water recycling, drip irrigation, Desalination*

Reviving Renewable Energy in Israel?

“ The model for RE development is the Silicon Valley not the Manhattan Project” (US Secretary of Energy Steven Chu)



Water Heater



Solar Pond Power Plant



Solar Trough Power Plant



Geothermal Power Plant

- Infrastructure created by High-Tech
- Israel was already a RE hub from the 50's to the 90's
- Supportive governmental policy
- Recent success stories

Following the Footsteps of High Tech

Can Israel replicate its high tech success in the RE field?

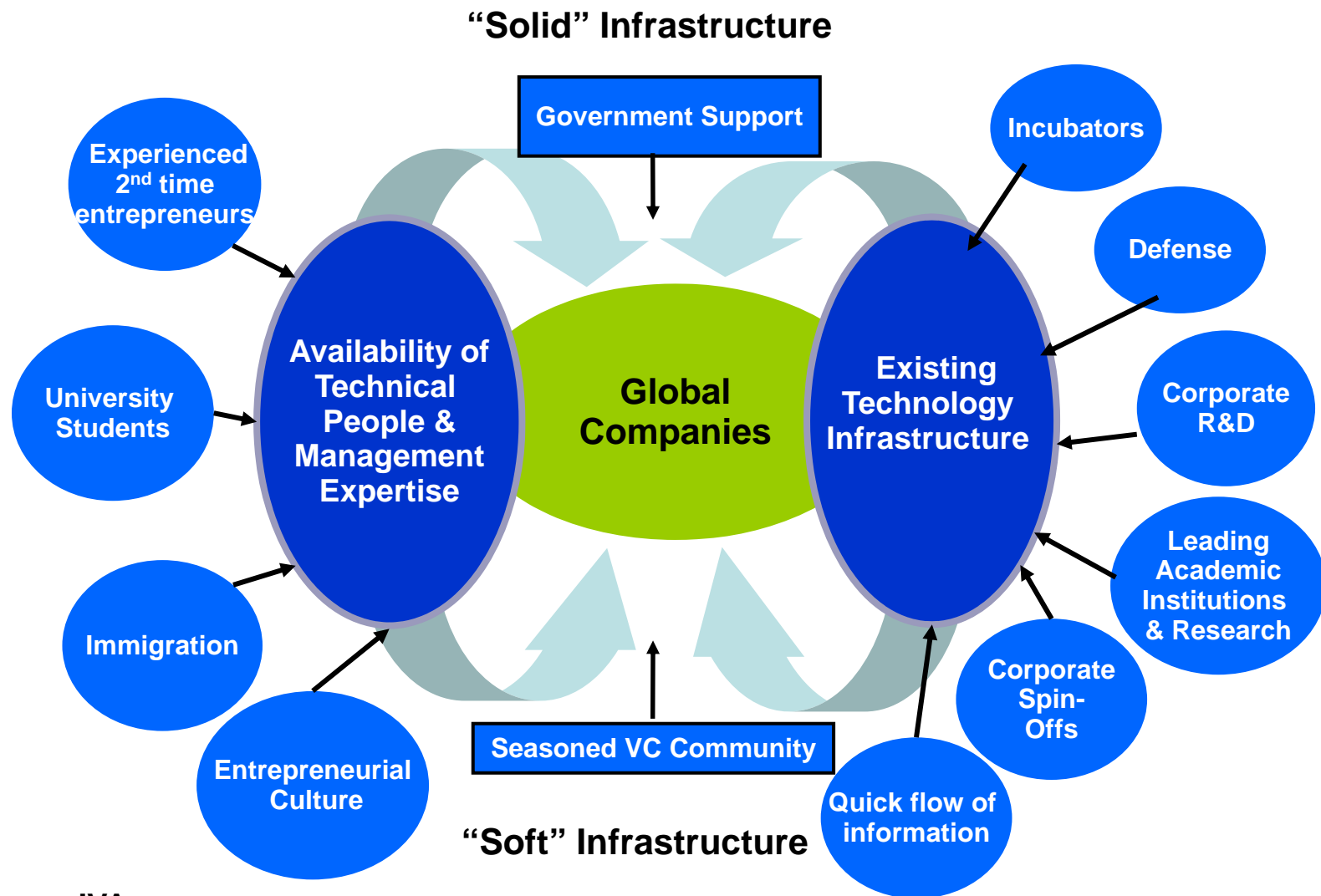
High Tech in Israel succeeded because:

- Military Industry promoted R&D and developed engineers and project managers
- Vocational schools flourished
- Russian immigration with ability to switch careers and willingness to take any job
- Government policy encouraging VC

Infrastructure created by High-Tech

- **Management:** Pool of experienced managers and marketing professionals
- **Services:** Legal, patents, financials
- Active **VC firms**
- Subcontractors
- Logistics
- **Role Models**
 - ✓ **Teva** (generic drugs)
 - ✓ **Netafim** (drip irrigation)
 - ✓ **Ormat** (geothermal energy)

Israel's Unique Infrastructure



Source: IVA

Conclusion Key Factors of Success (KFS)

1. Relevance / Marketing

Real Solutions for Real Problems

2. Comprehensive / Inclusive Team

3. Critical Mass/Niche Markets

4. Dilemma: Focus or Alternatives

5. Financing: The Advantages of Starting Frugal

Research Directions Looking Forward

- Next generation PV cells - higher efficiency at lower costs
New materials, improved optics, quantum dots
- Artificial photosynthesis
- Crop trait improvement for stress tolerance (drought, salinity, cold stress, nitrogen levels) and adaptation to a changing environment (Evogene)
- Developing energy-crops optimized for biomass and biofuel production
- Genetically engineering microbes to generate complex hydrocarbons for the fuel and other industries (Synthetic Genomics, LS9, Amyris)
- Bio-electronics - using biological molecules for nanotechnology applications (Dr. Iris Visoly-Fisher, Dr. Nurit Ashkenasy BGU)
- Electrochemistry for improved batteries (EV, utility storage)

Ormat – as an example

- 1300 MW of Ormat Power Plants Worldwide (in over 20 countries)
- 10% of global power production today is produced by Ormat
- 1% of the total global potential
- Annual savings of up to 2.6 million tons of CO₂



Providing Communities with Clean Energy from Sustainable Resources

- The Steamboat Geothermal complex, within the city limits of Reno, Nevada
- Supplies 64 MW in 2007 rising to 84 MW in 2008
- Enough green, base load power for the needs of every residence in the City of Reno

MALI, Africa 1966 Village Power



Reno, Nevada 2006 City Power



Experimental Solar Pond Power Plant.
Dead Sea

Geothermal Power Plant in Hawaii



Innovative Green Power Technology

Geothermal Power Plants



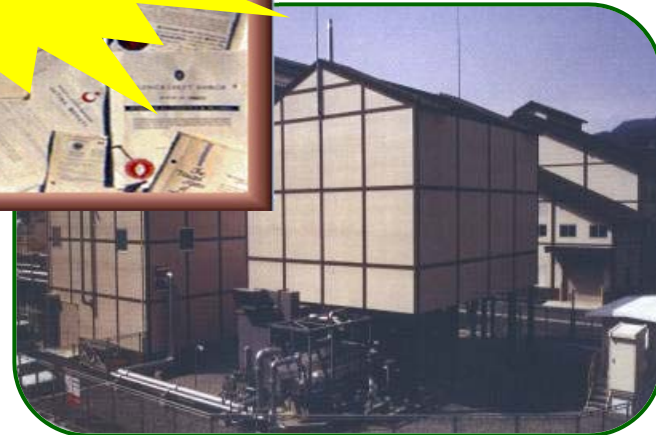
Solar thermal



Industrial Waste Heat Recovery

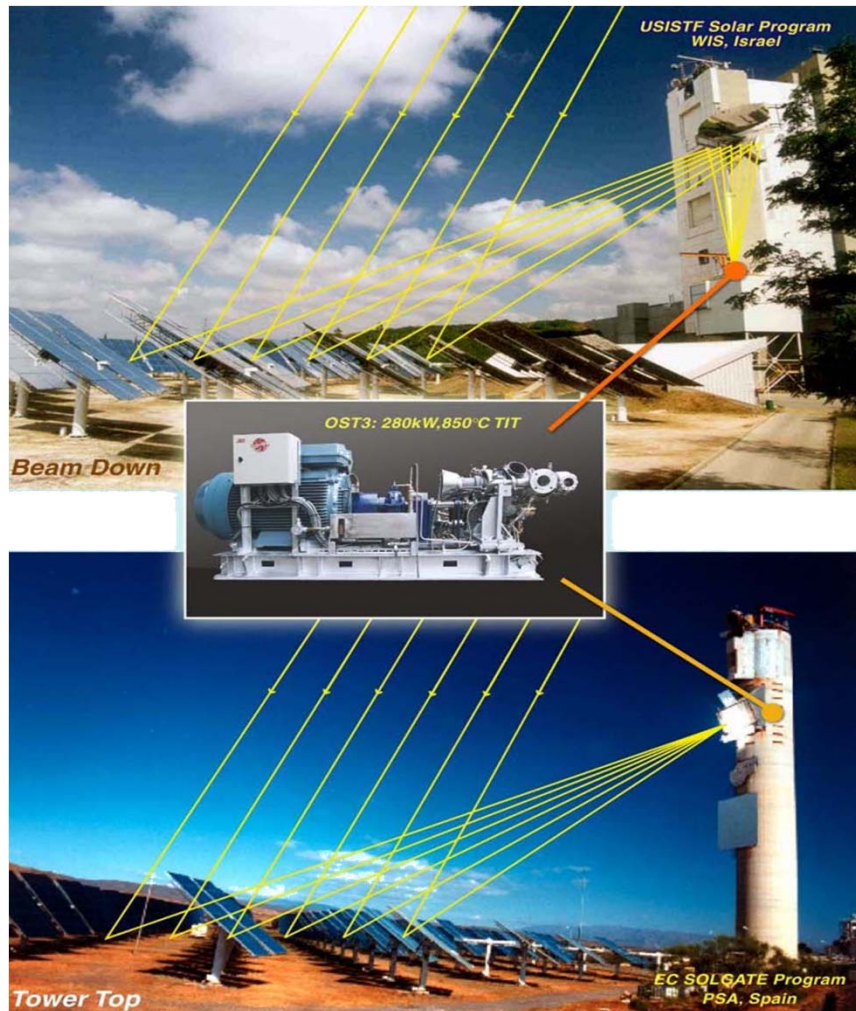


Resource Recovery:
Biomass



PATENT PROTECTION
as of 2007
75 US Patents

Ormat Brayton Cycle Units



For Simple or
Combined Cycle
Solar Power Plants

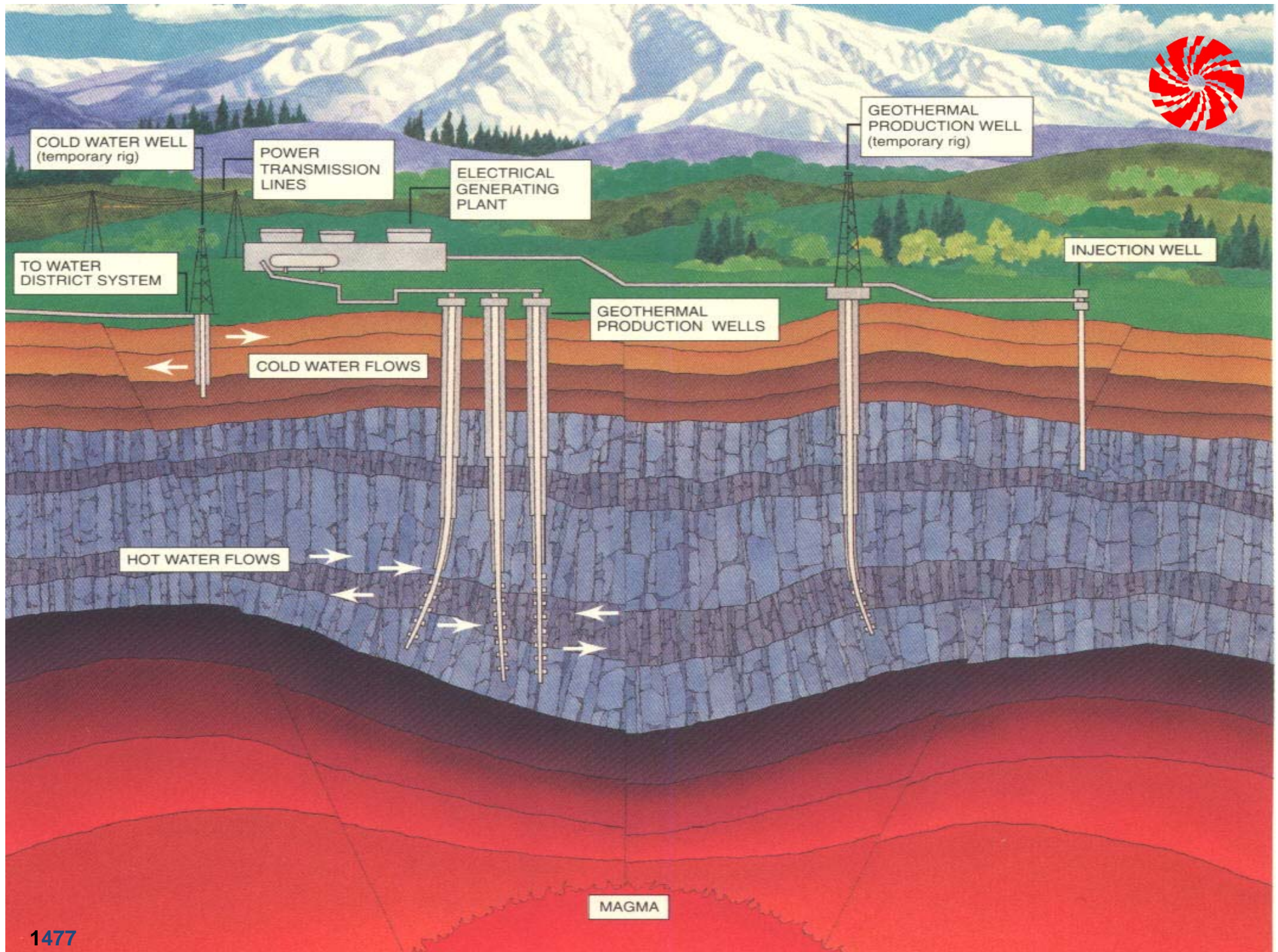
Geothermal Energy :

Example of RE development

- Huge untapped potential
- Low footprint
- The most economically viable of all Renewable Energies
- Stable, reliable and predictable generation regardless of time of use or weather

The Problem

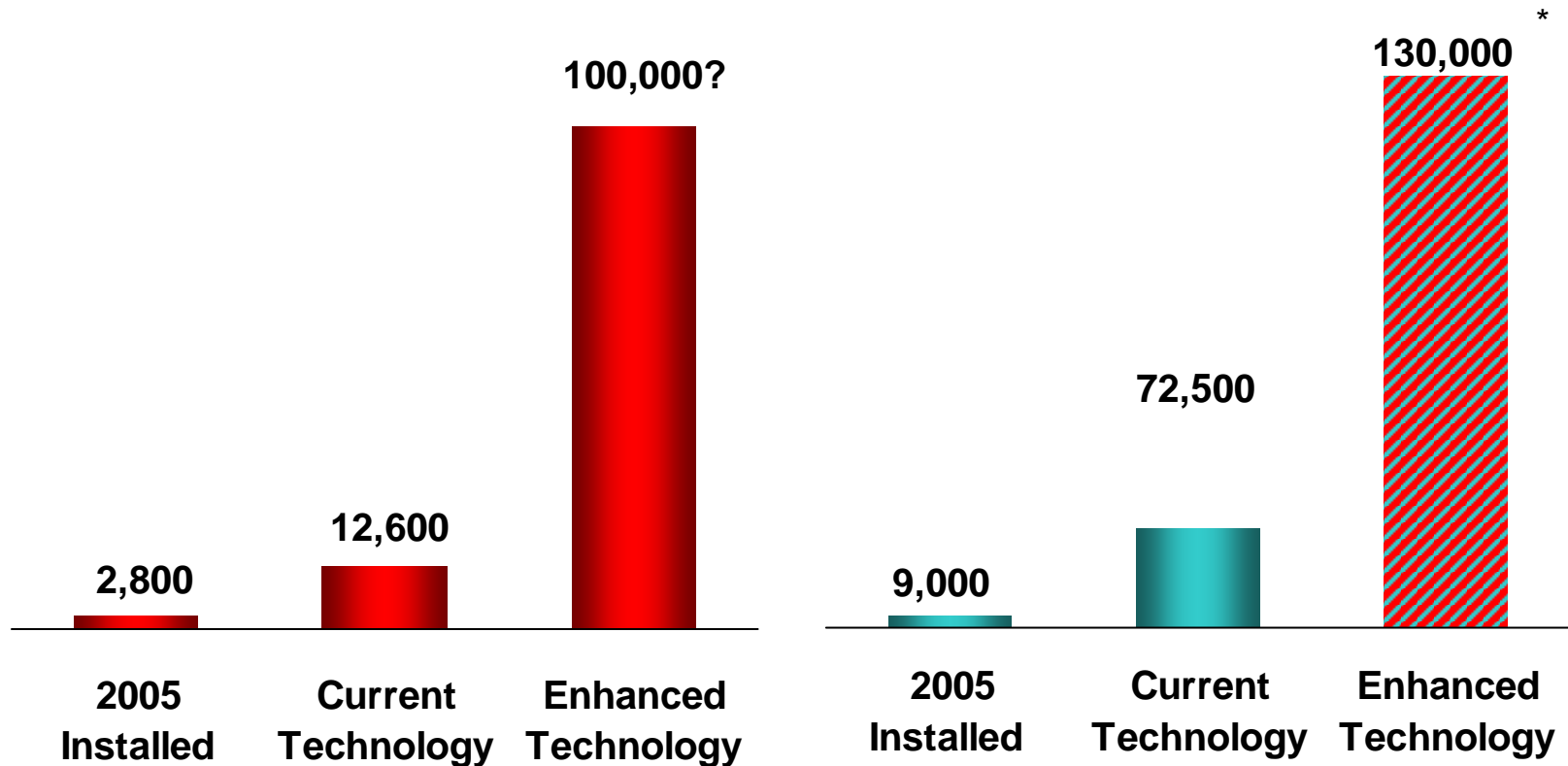
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Geothermal Energy Potential

U.S. Geothermal Potential (MW)

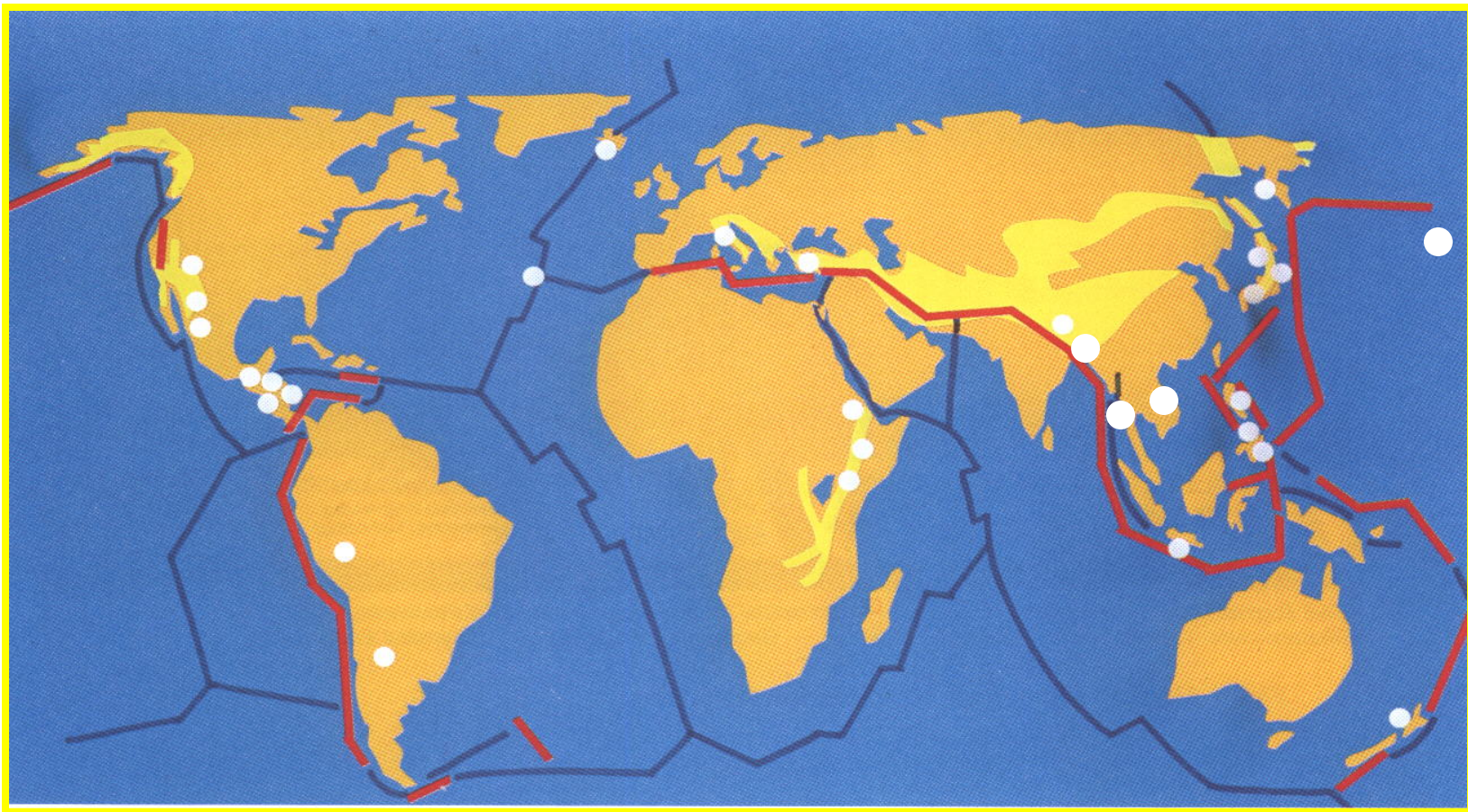
World Geothermal Potential (MW)



*** U.S. and Australia only**

Sources: Geothermal Energy Association (GEA), A Guide to Geothermal Energy & the Environment (2005);
WGA Geothermal Task Force Report (January 2006)
Western Governments' Association, Clean Energy, a Strong Economy and a Healthy Environment (June 2006);
The future of geothermal energy, MIT(2006)

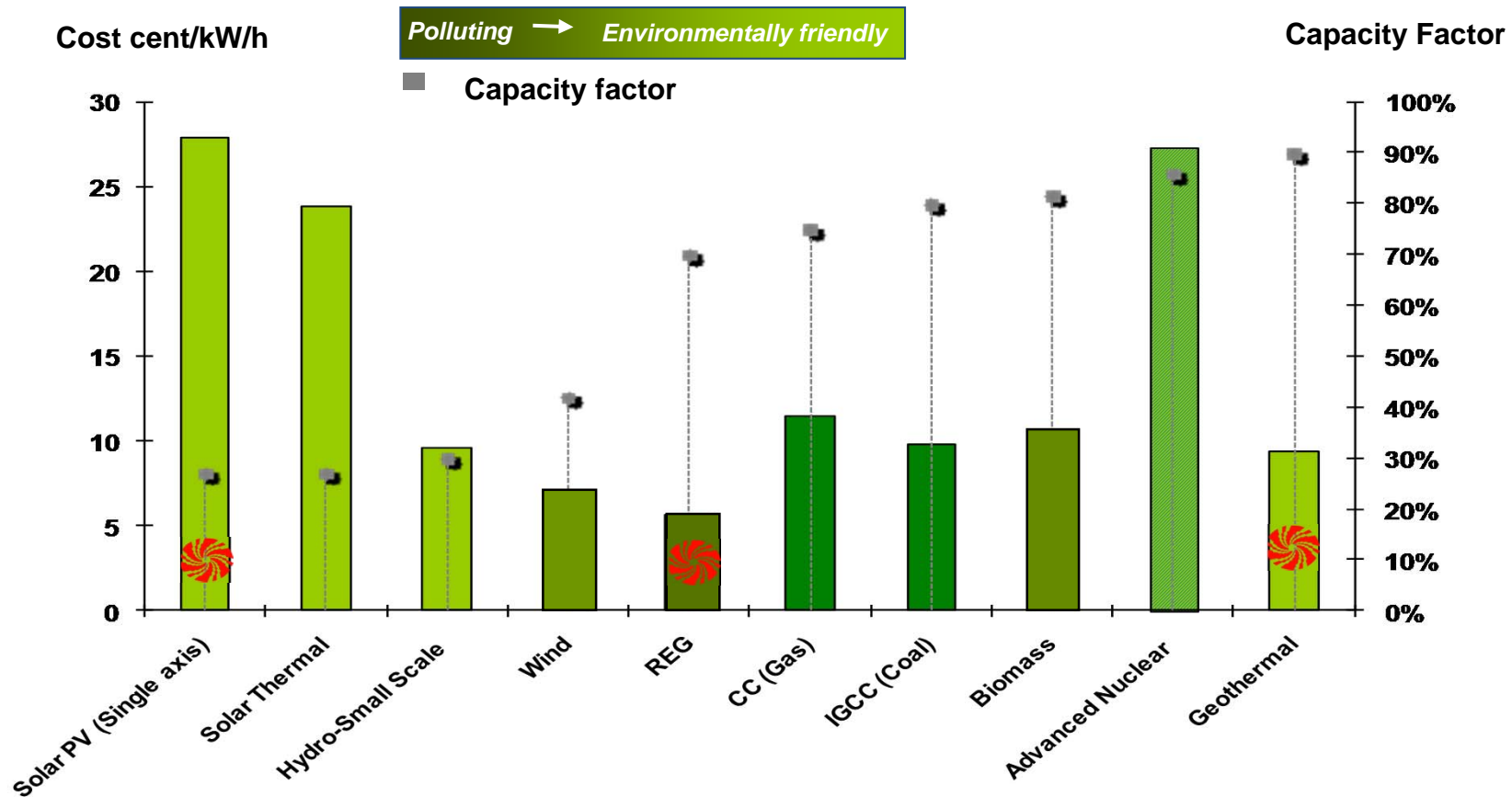
World Map of Lithospheric Plate Boundaries



Areas where Geothermal Projects are in Operation or Planned

Environmental Impact

Geothermal Generation is Dependable and Cost Effective



Source: Competitive costs of California central station electricity generation technologies, California Energy Commission January 2010, and Ormat.

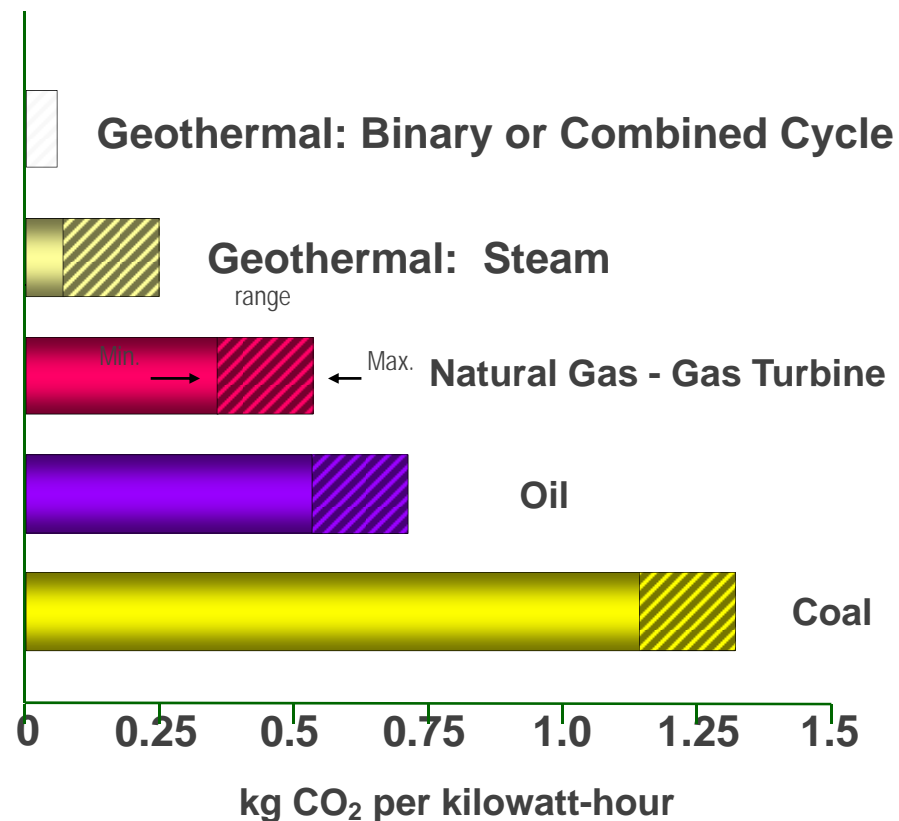
Advanced Nuclear -in service 2018

Environmental Features of Geothermal Energy

Land Area Occupied

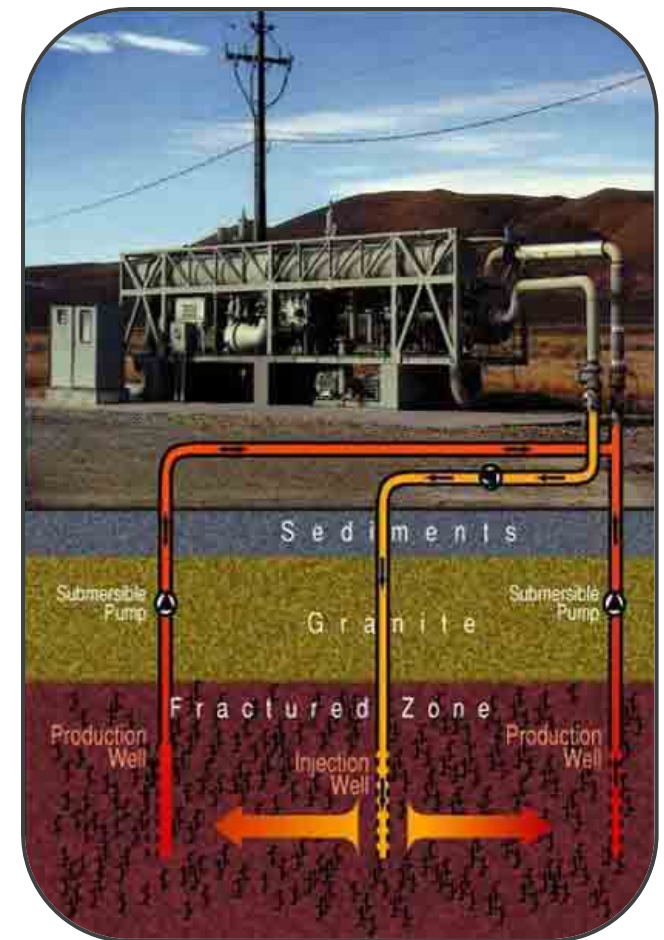
CO2 Emissions

Technology	Land area (m ² /GWhr/year for 30 years)
Geothermal	404
Wind (land with turbines and roads)	1,335
Photovoltaics	3,237
Solar Thermal	3,561
Coal (including open pit mining)	3,642



DEEP Enhanced Geothermal System (EGS)

- DEEP expected be the first EGS project to generate commercial power in the USA
- DEEP utilizes existing deep wells which have EGS potential characteristics are not producing geothermal fluids at commercial levels



Strategy

- Based on **Innovative Technology**
- Growth :Finding a **niche** with large potential, Securing the company's DNA
- **Vertically integrated** - operates in all stages of the geothermal power generation supply chain (drilling (resource exploration), equipment manufacturing, project development, engineering, construction, as well as owning and operating renewable energy power plants)
- **Constant re-evaluation of the market** to secure the company's position in the “food chain”

Involvement in the Community

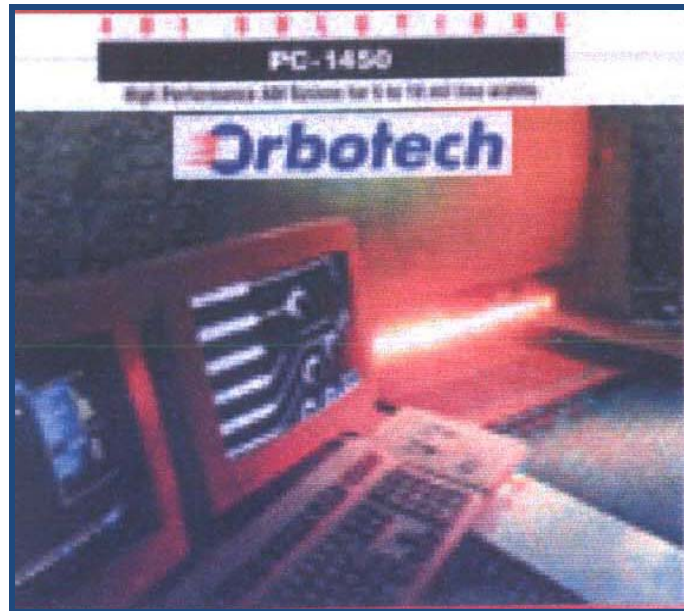
Example: Ort-Ormat Vocational School, since 1971



Importance of Coaching:

Ormat's in-house Technological Incubator

PCB and FPD

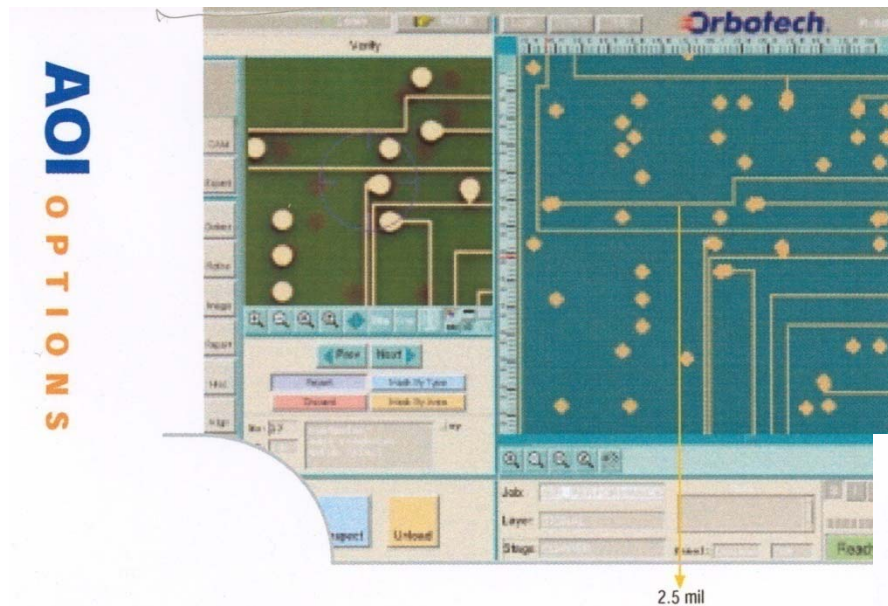


Biotechnology



Mechanical Engineering as Enabler for a New Field

Automatic Optical Inspection Equipment



Enables scanning of 2.5 mil lines
For the InSpire 9060



Orbotech®

Breaking the oil addiction - Action Items

- Mobilize and Support Universities, for this Task
- Revive Tech Schools.
- Commit multi-year budget to long term basic research
- Foster Multi-Disciplinary R&D involving Universities and Industry (MAGNET)
- Short term: Israel as a Beta-Site. Incentivize investments in Industry, take initiatives which aren't trendy by focusing on energy efficiency (building retrofits, smart grid, etc.)
- “Exit” culture cannot be a guideline for RE industry.

Supportive Governmental Policy

- Government objective - **10%** of consumed electricity to be generated from renewable sources **by 2020**
- **Feed-in-Tariff** policy; Attractive FITs published for PV and small wind
- **Governmental tenders** for large RE projects: a desalination plant in Ashkelon (fully operating), two 80-125 MW solar thermal power plants and one 15 MW PV power plant in the south of Israel (tender issued in 2008)
- **Governmental Support for R&D:**
 - An Incentive package of 400 m. NIS over 5 years was approved (Aug 2008).
 - 75 m. NIS over 5 years dedicated to the establishment of a RE incubator for early stage technologies in the Arava (Eilat-Eilat)
 - ISG – Israeli smart grid cluster established in these days
- Encouragement and support of international cooperation:
 - IEA (SolarPACES, PVPS, HTS)
 - EU (FP7)
 - DOE
 - Bilateral
- Inter-ministerial commission for green taxation

Recent Success Stories

Solar

- **Siemens** acquires Israeli **Solel**, a global leader in Solar Thermal Technologies , for \$418 m. (Oct 2009)
- **Siemens** acquires 40% of **Arava Power Company**, a leading developer of PV power plants (Aug 09)
- **Alstom** invests in **BrightSource Energy**, a global leader in tower based solar thermal power plants (May 10)
- **GE** invests in **SolarEdge** (Oct 09)
- **Solon** to enter Israel's PV market as a developer. Forms a strategic collaboration with Israeli Electric Company (IEC) (Nov 10)

Water

- **Veolia Water** partners with two Israeli companies to build the world's largest Reverse Osmosis **Desalination Plant in Ashkelon**. The plant works at full capacity (108 m3/year) as of Dec 2005
- **GE** partners with **Kinrot Ventures**, an Israeli Incubator for water technologies (Nov 10)

Interesting Sectors for the Israeli Hi-Tech

- The sectors in which Israel can add value:
 - Communications
 - Semiconductors
 - Combining Software with basic science and hardware
 - Optics
 - Medical Equipment
- Sectors that Provide Solutions for Under Developed Countries:
 - Energy, Energy Savings
 - Water
 - Biotechnology
 - Security
 - Organic Agriculture
 - Robotics

Strategy

- Base on Innovative Technology
- Growth :
 - Finding a niche with large potential
 - Securing the company's DNA
- Securing the company's position in the “food chain” by constant market re-evaluation