Renewable Energy Overview

Gideon Friedmann
Office of the Chief Scientist
Ministry Responsibility

- Supply & management - natural resources
- Peacetime & emergency
  Today & in the future
- Balancing between suppliers & consumers
- Economic, environmental & social constraints
Chief Scientist Office

- Scientific & technological support to policy
- Develop and preserve Israeli know-how
- Maintain activities
- Decision Targeted Techno-Economincal Studies
Main Activities

- Taking part in formulation of policy
  - Technological, Scientific, Economic Advice
  - Setup of multi-disciplinary Administrations
- Funding and Monitoring of R&D and Commercial Projects
- Advancing International Collaboration
System Oriented Activities

- Fuel Alternatives
- Smart Grid
- Smart Cities
- Nuclear Power Plant
- Continental Shelf (Mediterranean)
Technology Oriented Activities

- **Renewable Energy**
  - Solar, Wind, Geothermal, Biomass…

- **Energy Conservation**
  - CHP, Engines, Smart Home

- **Basic and Applicative research in supporting areas**
  - Material science, High-Temperature Superconductivity, Batteries, Fuel Cells, Controllers, SW Simulation…
Energy

Types of Energy

- Mechanical
- Heat
- Electrical
- Chemical
- Nuclear
Energy

Energy Uses
- Transportation
- Electricity Generation
- Heating

[Diagram showing energy use percentages: Heat 47%, Transport 27%, Electric 17%, Other 9%]
Energy Sources

- **Historical**
  - Wood, Water

- **Modern**
  - Coal, Oil, Gas, Nuclear (Fission)

- **Future**
  - Renewables, Nuclear (Fusion), ???

2012

- Coal: 29.0%
- Oil: 31.4%
- Natural gas: 21.3%
- Nuclear: 4.8%
- Biofuels and waste: 10.0%
- Hydro: 2.4%
- Other**: 1.1%

IEA 13 371 Mtoe
Fundamental Sources

- The Sun
  - Fuels, Solar, Wind, Sea
- Earth
  - Geothermal
- Nuclear
  - Fission, Fusion
- Gravitation

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Why Change?

- Environment
- Energy Security
- Living Standard / Price
- Politics
Energy Crisis

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The Environment

- Pollution
- Global Warming
- Bio Diversity
CO2 Emissions 2005-2011

Figure 5. CO₂ emissions worldwide (million metric tons)²²
Energy Supply (Long Term)

Energy Use by Source

Paul Chefurka

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Energy Security (Short Term)

- Countries prefer not to rely on imports
- **No** to Concentration
  - single source
  - single location
Prices

- Energy
- Food

Key crude oil spot prices in USD/barrel

IEA

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Politics

- Oil is concentrated in a few countries
- Scarcity and price cause friction / war
- Developing vs Developed world
What Must Be Done

- Energy Conservation
- New Clean Sustainable Energy
- Overhaul of energy infrastructure
- Sustainable existence – including Rainforest
Energy Conservation

Where
- Transportation
- Homes
- Industry
- Commerce

How
- Technology
- Standards
- Procedures (Regulation)
Transportation

Energy Conservation
Industry – Energy Management

Smart Meters
Power Usage, Power Quality and Power Control

The Benefits of Smart Grid Metering for Industrial Customers
Industry – Energy Recovery

**Energy-Efficiency Comparisons**

- **Standard Power Plant**
  - 60% “Waste” heat rejected to environment
  - 40% Useful energy produced for electricity

- **District Energy/Combined Heat and Power Plant**
  - 20% “Waste” heat rejected to environment
  - 40% Useful energy produced for heating and/or cooling via district energy system
  - 40% Useful energy produced for electricity

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Energy Conservation

Standards & Regulation
Clean Sustainable Energy

- Solar
- Wind
- Hydro
- Geothermal
- Biomass
- Nuclear (?)
Is there Enough?

<table>
<thead>
<tr>
<th>Units of 150,000 TWh</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Solar</td>
<td>10,000</td>
</tr>
<tr>
<td>On Land (25%)</td>
<td>2,500</td>
</tr>
<tr>
<td>Available Land (1%)</td>
<td>25</td>
</tr>
<tr>
<td>Efficiency (10%)</td>
<td>2.5</td>
</tr>
<tr>
<td>Humanity Annual Use</td>
<td>1</td>
</tr>
</tbody>
</table>
What is Renewable?

- Sustainable - Does not deplete resources
- Does not add CO$_2$
Types of Solar Technologies

Solar

PV

Concentrating

Standard

Concentrating

Thermal
Technology Drivers

- Efficiency
- Cost
- Usability
- Fundamental Issues
  - Intermittency
  - Need for Backup
Solar PhotoVoltaic (PV)

- Monocrystalline (20%)
- Polycrystalline (15%)
- Amorphous (9%)
- Other Materials (CIGS, GaAs)
- Multi-Junction
Innovation in PV

- Bifacial
- Water Splitting Hybrid
- Multi-Junction
Thermal Solar (CSP)
CSP Block Diagram

The Solel Solar Field
Application to Power Plant
Advantages of CSP

- Stability
- Storage possible (even full dispatch)
  - Shift to peak hours
  - Ancillary services
- Easy Hybridization
  - Easy Backup
  - Heat Support
Innovation in CSP

1. Solar Field tracks the Sun to collect solar thermal energy @ 5500°C
2. Heat from collectors transformed by HTF (Heat Transfer Fluid) to reduce the change
3. Heat delivered to the Energy Center, ready for dispatch
4. Steam from storage supplied on demand, 24/7, fully stabilized

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Hybrids – Geothermal, Biomass

Advantages

- Increase Temperature
- Stability
- Shared Costs
- Compensate reservoir depletion
Solar Heat
Innovation with Solar Heat
Wind

- Higher Energy Density
- Most Dominant Renewable
- 2.3% of World Electricity
- Energy $\approx V^3$
Advantages of Wind over Solar

- Land Use
- Cost
- Fits better in Europe
Wind Innovation
Hydro Power
Geothermal Energy

Cold water pumped down

Steam and hot water

Generating Station
Geothermal Energy

Advantages
- 24/7 Dispatchability
- Low Cost
- Small Land Footprint
- Heat is not wasted

Issues
- Requires Rock Fracking
- Long Term Depletion
- Depth & Temperature
Geothermal Innovation

- Closed Loop system
Ocean Energy

TIDE COMING IN

TIDE GOING OUT

By V. Ryan

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Biomass

- Organic Materials from Plants

\[
\text{carbon dioxide} + \text{water} \xrightarrow{\text{light energy}} \text{carbohydrates} + \text{oxygen}
\]

\[
\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{light energy}} \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2
\]

\[
6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{light energy}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2
\]
CO₂ Cycle

Crops like corn are finely ground and separated into their component sugars. The sugars are distilled to make ethanol, which releases carbon dioxide that can be used as an alternative fuel. That CO₂ that is reabsorbed by the original crops.
The Process

Raw Materials
- Agriculture
- Muni Waste
- Animal Waste
- Industrial Waste

Process
- Chemical
- Biochemical
- Heat

Products
- Fuels
- Electricity
- Heat
- Chemicals
- Food
Is Biomass Renewable?

- Not Always
  - Oil, Plastic
  - Wood from the Rainforests
  - Non Carbon Neutral Cycles

- However, should be encouraged as Waste Treatment

- Innovation Drivers: Cost, CO2 Footprint
Innovation

- Enzymatic conversion of recycled oil and fat trap to biodiesel
- Conversion of biomass into biocoal
Nuclear Energy

Advantages
- 24/7 Dispatchability (Base Load)
- Low Cost
- Small Land Footprint

Issues
- Safety
- Waste Fuel
4th Generation Plants

- Much less nuclear waste (and shorter)
- More Energy yield
- Use of waste fuels as source
- Safer (Passive Shutdown)
Nuclear Fusion

- Abundant Fuel
- No Toxic / Radioactive Waste
Issues – Solar & Wind

- Intermittency
- Need for Backup
Partial Solution - Storage

- Mechanical
  - Flywheel
  - Pumped Water
  - Compressed Air

- Chemical
  - Batteries
  - Hydrogen
  - Hydrocarbons

- Physical
  - Capacitors

- Heat
Storage Innovation
Renewable Policy

- Main Drivers: Sustainability, Pollution & CO$_2$
- Support (with or w/o Quotas)
  - FIT
  - Capital Subsidy
  - Mandatory percentage
  - Self Consumption Schemes
EU Targets

Renewable Electricity in Europe

- Hydro
- Geothermal
- Solar
- Tide, Wave Ocean
- Wind
- Biomass

~ 20%

Non-hydro ~ 24%

34%
Main Benefits of Renewables

- Energy Diversity & Security
- Emissions & Pollution Reduction
- Price Stability
- Electricity at Maintenance costs after term
- Educational / Image value (Sustainability)
Main Issues with Renewables

- **Intermittency**
  - 1 year daily Germany min max production
    - 30 vs 530 GWh

- **Need for Backup**
  - There are continuous days with no production

- **Costs (Upfront)**
  - Consumer Prices in Germany rose 50%
  - Transmission grid upgrades
Current Renewable Cost

Presented Cost of Electricity from various sources

Cost of KWh (USD Cents)

- Wind
- PV
- CSP
- Geothermal
- Coal
- Gas
- Fossil w Peak

Series 2 and Series 3
Proper Comparison

Full Cost of fossil

Emissions Reduction
Backup Supply & Storage
Security of Source
Decommissioning
Net Cost (Cap & Op)

Equivalent Price RE

Price Stability
Emissions Reduction
Energy Security
Equivalent Price

5 cents
Thank You!

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