Future Energy Scenarios Worldwide
(Example: Armenia)

Presented by ASA and NREL Staff

Introduction  By Ken Touryan

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Humanity’s Top Ten Problems for next 50 years

1. ENERGY
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION

2003  6.3  Billion People
2050  8-10  Billion People
**OPEC ascendant.** BP projects non-OPEC oil output (pink wedge and below) to plateau as OPEC’s market share (dotted line) rises.
Solar Radiation Processes and Conversion Paths


Incident Sunlight → Production of Heat → Thermoconversion → Etc.

Primary Processes

Conversion Mechanisms/Technologies (including storage)

Useful End Products
### Detailed Morphology for Solar Thermoconversion Paths

<table>
<thead>
<tr>
<th>Production of Heat</th>
<th>Thermocconversion</th>
<th>Primary Process</th>
<th>Primary Products</th>
<th>Conversion Mechanism/Technology</th>
<th>Useful End Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean currents</td>
<td>Turbines</td>
<td>Electricity</td>
<td>Shaft Horsepower</td>
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<tr>
<td>Ocean Thermal</td>
<td>Closed and Open Cycle Heat Engines</td>
<td>Electricity</td>
<td>Shaft Horsepower</td>
<td></td>
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<tr>
<td>Gradients</td>
<td></td>
<td>Thermomechanical Effect</td>
<td>Shaft HP</td>
<td></td>
<td></td>
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<tr>
<td>Hot Fluids, Solids (May require Solar Concentrators)</td>
<td>Various Heat Engines</td>
<td>Electricity</td>
<td>Shaft HP</td>
<td>Process &amp; Space Heat</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Winds</td>
<td>Wave Conversion Devices</td>
<td>Electricity</td>
<td>Shaft HP</td>
<td>Electricity, Shaft HP</td>
<td></td>
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<tr>
<td></td>
<td>Wind Turbines</td>
<td>Electricity</td>
<td>Shaft HP</td>
<td></td>
<td></td>
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<tr>
<td>Evaporation/</td>
<td>Salinity Gradients</td>
<td>Electricity</td>
<td>Shaft HP</td>
<td>Electricity, Shaft HP</td>
<td></td>
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<tr>
<td>Precipitation</td>
<td>Hydroelectric</td>
<td>Electricity</td>
<td></td>
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</tbody>
</table>
Energy Substitution Model

- Wood
- Coal
- Oil
- Natural Gas
- Nuclear
- Sol-Fus

Thick lines after Marchetti 1977
Thin lines from BP Statistical 2007
Converging Trends Will Shape Our Future for Renewable Energy

These trends are:

• Increasing environmental awareness
• Availability of new technology options
• World energy demand growth
• Energy security risk and uncertainties
• Increasing business interest
Desired Future Scenario Worldwide

- Promotion of Use of Energy from Renewable Sources
- All 27 EU countries have responded: 10-30 yr. plans
- Russia has created its own plan: 10% by 2020
- Armenia followed Switzerland: 20-30 yr. plan
- DEM organized a team. Results presented to the ROA government (see March 2012 Issue of PSCF)
Preparation of the Renewable Energy Development Roadmap of Armenia (REDRA)

2011
The goal: Vision, Targets, Strategy

Time horizons:

• Short term – to 2013
• Mid term – to 2015
• Long term – 2020 and beyond
### Vision. Variables/factors (RA Goals, Technologies, Flexibility, Legislation)

#### RoA TARGETS

<table>
<thead>
<tr>
<th>Energy Demand, GWh</th>
<th>Electrical</th>
<th>Thermal</th>
<th>Transport</th>
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</thead>
<tbody>
<tr>
<td>2010: 4 500</td>
<td>2010: 11 400</td>
<td>2010: 7 900</td>
<td></td>
</tr>
<tr>
<td>2015: 5 700</td>
<td>2015: 11 900</td>
<td>2015: 10 350</td>
<td></td>
</tr>
<tr>
<td>2020: 6 600</td>
<td>2020: 12 600</td>
<td>2020: 13 600</td>
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</tbody>
</table>

- Energy Independence: reducing dependency on imports
- Potential of lowering the energy costs
- Creation of high tech industries, infrastructure, service, education, jobs
- Environmental benefits

#### LEGISLATION

<table>
<thead>
<tr>
<th>Tariffs</th>
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<tbody>
<tr>
<td>Mandatory</td>
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<tr>
<td>Tax holidays</td>
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<tr>
<td>Duty exemption</td>
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<td>Favorable financing</td>
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<td>Net Metering</td>
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<td>Certification</td>
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<td>Standards</td>
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<td>...</td>
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#### TECHNOLOGIES

- Renewable Energy Technologies
  - SWH
  - Wind
  - PV
  - SHPP
  - Biofuel
  - Biomass
  - Solar Architecture
- Heat Pumps
- Electric Cars
- System Integration, Load Leveling
  - Pumped Hydro Storage
  - Hydrogen: electrolysis, fuelcells
  - DSM
- Energy Efficiency
  - Insulation, management, etc.
  - Distribution system control
## Wind Power Plants: Technical potential

- Measured Wind Power Potential at Top-Ranked Sites

<table>
<thead>
<tr>
<th>Confirmed by monitoring</th>
<th>Not confirmed by per Feb. 2008</th>
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<tbody>
<tr>
<td><strong>Poushkin Pass:</strong></td>
<td>Karakhach Pass (West):</td>
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<tr>
<td>19.5 MW, 48.9 GWh</td>
<td>125 MW, 300-320 GWh</td>
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<tr>
<td><strong>Karakhach Pass (East):</strong></td>
<td>Sisian (Bichanag) Pass:</td>
</tr>
<tr>
<td>125 MW, 320 GWh</td>
<td>155 MW, 420-430 GWh</td>
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<tr>
<td><strong>Zod Pass:</strong></td>
<td>Charentsavan reg.:</td>
</tr>
<tr>
<td>50 MW, 120 GWh</td>
<td>20 MW, 45 GWh</td>
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<tr>
<td><strong>Subtotal:</strong></td>
<td><strong>Subtotal:</strong></td>
</tr>
<tr>
<td>195 MW, 490 GWh</td>
<td>300 MW, 765 GWh</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
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<tr>
<td>495 MW, 1250 GWh</td>
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</table>
Base Case RE Output

Annual Production, GWh

RE production up to 2020

Hydro
Wind
Geothermal
Biofuel
Heat Pumps
Solar Thermal
PV