Solar PV Uptake and Solar Thermal Programme -MK Case Study-

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Overview

- The current state
- Solar energy in the INDC
- Boosting PV systems
The current state
Installed capacity

► Solar thermal
► Year 2009: 18 MWth; 25 744 m2 [1]
► Year 2014: 6.15% of the total number of surveyed households with solar collectors, 3809 m2 (3136 surveyed; 560 000 total number of households) [2]

► Solar PV
► Year 2015: 102 plants, 16.71 MW, 21 411 MWh [3]

Support schemes

- **Solar thermal**
  - Program for partial subsidizing of purchased and installed solar thermal collectors in households (2007, 2009 - 2015) - subsidies of 30% from the total investment, up to 300 EUR per household.
    - Subsidized households: 3611; Total budget: 800 000 EUR
  - Reduced VAT for solar collectors (5%)

- **Solar PV**
  - Feed-in tariff:
    - Maximum Plant Size: 1MW
    - Less than 0.05 MW: 16 €/kWh
    - More than 0.05 MW: 12 €/kWh
    - Fixed tariff period: 15 years
    - Cap: 18 MW
Regulation and procedures: PV plants guidelines (2015)

3. STEP-BY-STEP DIAGRAM OF THE DEVELOPMENT PROCEDURES AND DOCUMENTS

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Competent institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Establishing a company</td>
<td>6.9</td>
</tr>
<tr>
<td>4.2 Use of the land</td>
<td>6.7, 6.8 or municipality</td>
</tr>
<tr>
<td>4.3 Environmental Impact Elaborate Study</td>
<td>6.6 or municipality</td>
</tr>
<tr>
<td>4.4 Approval for connection to the distribution system</td>
<td>6.5</td>
</tr>
<tr>
<td>4.5 Construction permit</td>
<td>6.7 or municipality</td>
</tr>
<tr>
<td>4.6 Award of temporary status of preferential producer</td>
<td>6.3</td>
</tr>
<tr>
<td>4.7 Design and construction of the connection</td>
<td>6.5 or authorised company</td>
</tr>
<tr>
<td>4.8 Use permit</td>
<td>6.7 or municipality</td>
</tr>
<tr>
<td>4.9 Energy generation license</td>
<td>6.3</td>
</tr>
<tr>
<td>4.10 Registration of the facility in the Register of electricity generation facilities from renewable energy sources</td>
<td>6.2</td>
</tr>
<tr>
<td>4.11 Award of status of preferential producer</td>
<td>6.3</td>
</tr>
<tr>
<td>4.12 Power purchase agreement with the electricity market operator</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Legend:
- Duration of the procedure
- Construction works
- Risk: inability to obtain right of use of State-owned land; delays and uncertainty of outcome and costs
- Delay: unforeseen factors leading to changes in the course of the procedure
Solar energy in the INDC
Assumptions under the baseline and mitigation scenarios

- **Solar thermal**
  - 60% of hot water needs in urban areas and 50% of those in rural areas by 2035 will be covered by solar collectors

- **Solar PV**
  - Is it assumed that 180 MW will be constructed by 2035
Economic evaluation

- Solar thermal collectors
- Gasification of res. and com. sectors
- Geothermal Power Plants
- Increased use of railway
- Renewal of vehicle fleet
- Campaigns and EE info centers
- Phasing out of incandescent lights
- Phasing out of resistive heating
- Distribution losses reduction
- Labeling of appliances
- Small hydro power plants
- Big hydro power plants
- New buildings
- More gas power plants
- Biofuels 5% in 2020
- Biofuels 10% in 2020
- Wind power plants
- Buildings retrofit
- Biomass CHP
- Passive house
- Railway extension to Bulgaria
- Biogas power plants
- Topification of Bitola

€/t CO₂
Marginal abatement cost curve (2030)

- **Specific costs (€/t)**
  - Renewal of vehicle fleet
  - Increased use of railway
  - Geothermal Power Plants
  - Gasification of res. and com. sectors
  - Solar thermal collectors
  - Bicycles, walking

- **Reduction Mt CO₂**
  - Solar PV
  - Big hydro power plants
  - New buildings
  - Wind power plants
  - Biogas power plants
  - Toplification of Bitola
  - Railway extension to Bulgaria
  - Buildings retrofit
  - Biofuels in 2020
  - More gas power plants

- **Other Actions**
  - Campaigns and EE info centers
  - Phasing out of incandescent lights
  - Phasing out of resistive heating
  - Distribution losses reduction
  - Labeling of appliances
  - Distribution losses reduction
  - Distribution losses reduction
  - Biofuels 5% in 2020
  - Buildings retrofit
  - Biofuels 10% in 2020
  - More gas power plants
  - Wind power plants
  - Biogas power plants
  - Toplification of Bitola
  - Railway extension to Bulgaria
Boosting PV systems
International Context: PV Revolution

Exhibit 2
Welcome to the Terrordome... $/MMBTU by Energy Type

- Henry Hub
- US Bituminous Coal
- Brent
- LNG
- Solar

Source: EIA, CIA, World Bank, Bernstein analysis
International context: PV Revolution

Growth of Wind and Photovoltaics

[Graph showing the growth of wind and photovoltaics from 1996 to 2030]
International context: Grid parity in 102 countries

Unsubsidized PV system price 1400 Euro/kWp+VAT, LCOE with 20 years lifetime, 5% p.a.
### Average employment over life of facility (Jobs per megawatt of average capacity)

<table>
<thead>
<tr>
<th>Source of Energy</th>
<th>Manufacturing, construction, installation</th>
<th>Operating &amp; maintenance/fuel processing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>5.76-6.21</td>
<td>1.20-4.80</td>
<td>6.96-11.01</td>
</tr>
<tr>
<td>Wind power</td>
<td>0.43-2.51</td>
<td>0.27</td>
<td>0.70-2.78</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.40</td>
<td>0.38-2.44</td>
<td>0.78-2.84</td>
</tr>
<tr>
<td>Coal-fired</td>
<td>0.27</td>
<td>0.74</td>
<td>1.01</td>
</tr>
<tr>
<td>Natural gas-fired</td>
<td>0.25</td>
<td>0.70</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Note: Based on findings from a range of studies published in 2001-04. Assumed capacity factor is 21% for solar PV, 35% for wind, 80% for coal, and 85% for biomass and natural gas.

Table 8: Average employment over life of facility (Jobs per megawatt of average capacity)

Source: UNEP, ILO, IOE and ITUC (2008)
International context: The hottest scientific topics

- Better integration of solar and wind
- Integration of power, heating, cooling, water and transport systems
- Market arbitrage (time delay, power-heat, power-water, demand management, power-fuels)
- Solution for road freight, shipping, aviation and high temperature processes - biomass + synthetic fuels?
- Quantification of socioeconomic impacts of mitigation measures and policies

(N. Markovska, Climate Change Mitigation: Will we make it?, Plenary lecture, SDEWES2015, 2 Oct 2015)
National context:
Resource potential

- Individual houses: 320,000
- Available PV area: 12.8 mil m² (80 m² roof area, 50% usable for PV modules)
- Installed PV capacity: 1.28 GW (0.1 KW/m²)
- Electricity produced: 1.64 TWh (1280 hours load factor)
- 23% of total consumption (around 7 TWh)
- Roofs of public, administrative, commercial and industrial buildings to be added on top...

(Own rough estimations)
Conclusions from a recent study*:

- PV systems, particularly small ones installed at households, can be financially viable even without feed-in tariff.
- Pay-back period 7-9 years (at current electricity prices and technology costs).
- The electricity distribution company will benefit from:
  - Local electricity produced in on-pick period
  - Lower distribution losses
  - New possibilities for grid regulation

(*G. Cogelja and D.Dimitrov, Feasibility of PV systems without feed-in tariffs, Forum of renewable energy stakeholders (4th meeting, 04.11.2014), USAID project for clean energy investments)
Key areas for action

Legal and regulatory framework

- The Electricity Supplier is a balance responsible entity:
  - Obligation for the Electricity Supplier to take the electricity excess which occurs when the PV system produces more electricity than is needed by the household
  - Obligation for the Electricity Supplier to supply electricity to cover the gap when the PV system does not produce electricity (during the night) or produces less electricity than is needed by the household.

- The trading ratio is 1:1 - annually, the PV system produces less or equal amount of electricity than the amount of electricity taken by the household.
Key areas for action

Finance

- Establishing technology-specific consumer credit facilities, (particularly useful for technologies that require higher up-front investments).

Market development

- Indirect and/or “soft” interventions such as education, campaigns and performance rankings.

- Introduction of strict product standards and product labeling.

- Introduction of strict installation and O&M standards and certification of companies for planning, installation, and balance of system, and operation and maintenance (O&M) of PV system.
Key areas for action

Entrepreneurship and business acceleration (opportunities)

- In the latter segments of the PV system value chain: planning, installation, and balance of systems, and O&M,
- Tailor-made programs for technical assistance for the local companies.

Technology development

- R&D tax credits,
- Research grants,
- Publicly funded competitive research collaborations, competitions,
- Public investment in R&D,
- Public or private agreements on technology cooperation,
- Demonstration projects and applied research networks.