Multi-scale methods for evaluation of the potential of renewable energy sources in rural areas

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THE GORDIAN KNOT

an integrated view...

sectors

themes

scales

Water

Energy

Food

resilience

sustainability

equity

regional

local

global

social

economy

environment
FOOD AS BASIC NEED

MASLOW'S Hierarchy of Needs

- Physiological Needs
- Safety Needs
- Belongingness & Love Needs
- Esteem Needs
- Need to Know & Understand
- Aesthetic Needs
- Self-Actualization
- Transcendence
WHAT IS FOOD?

http://www.youtube.com/watch?v=ANIQNFBVOtE
http://www.youtube.com/watch?v=bSCWZBvUA14
WORLD POPULATION GROWTH

The graph illustrates the growth of world population over time. The population has increased significantly since the Industrial Revolution, reaching 1 billion around 1800 and 7 billion by 2011. Key population milestones are marked on the graph, including:

- A. Industrial Revolution: 1760-7-1
- B. 1 Billion: 1820-8-1
- C. 2 Billion: 1927-7-1
- D. 3 Billion: 1960-1-1
- E. 4 Billion: 1974-7-20
- F. 5 Billion: 1987-7-11
- G. 6 Billion: 1999-10-12
- H. 7 Billion: 2011-10-31

The graph continues to show the projected population growth up to 2100, with the population expected to reach 11 billion by that time.
WORLD POPULATION GROWTH

2013 WORLD POPULATION DATA SHEET

Population (billions)

10 9 8 7 6 5 4 3 2 1


Less Developed Countries

More Developed Countries

2013 5.9

2013 1.2
WORLD POPULATION RESPECTIVES

- **WORLD**
  - 2013: 7.1 Billion
  - 2050: 9.7 Billion

- **MORE DEVELOPED COUNTRIES**
  - 2013: 1.2 Billion
  - 2050: 1.3 Billion

- **LESS DEVELOPED COUNTRIES**
  - 2013: 5.9 Billion
  - 2050: 8.4 Billion
AND THE PROBLEMS

- Northern hemisphere average temperature
- Population
- CO₂ concentration
- Loss of tropical rainforest and woodland
- GDP
- Water use
- Motor vehicles
- Species extinction
- Paper consumption
- Fisheries exploited
- Foreign investments
- Ozone depletion
1. Pre Industrial Phase [c. 3 000 000 BC to 1765]
A - Tool making (c. 3 000 000 BC); B - Fire used (c. 1 000 000 BC); C - Neolithic agricultural revolution (c. 8 000 BC);
D - Watts steam engine of 1765 starting the Industrial Phase (1930-2025)

2. Industrial Phase [1930 to 2025, estimated]
E - Per capita energy-use 37% of peak value; F - Peak energy-use; G - Present energy-use; H - Per capita energy-use 37% of peak value

3. Post Industrial Phase [c. 2100 and beyond]
J, K, and L = Recurring future attempts at industrialization fail. 2008 Assessment

HOW WE PRODUCE ENERGY?

“More than 90% of energy extracted from the ground is wasted before it becomes useful work.”

Fuel energy input (coal): 100 units

- Power plant losses: 70 percent
- Transmission and distribution losses: 9 percent
- Motor losses: 10 percent
- Drivetrain losses: 2 percent
- Pump losses: 25 percent
- Throttle losses: 33 percent
- Pipe losses: 20 percent

Energy output: 9.5 units
Evolution of technology

A Succession of Energy Technology Discontinuities

- 1806: Direct - Wood, Wind, Water, Animals
- 1856: Steam Engine - Coal
- 1900 - 1940
- 1906: Electric Dynamo
- 1910 - 1970
- 1950: Internal Combustion Engine - Oil
- 1970 - 1990
- 2006: Nuclear
- CCGT - Gas
- 1990 - ?
- Fuel Cell - Hydrogen?
- Direct Electricity - Solar?

New technologies
(Schoonman, 2002)
Efficiency

Compared Efficiencies of Different Energy Systems

(Siemens – Westinghouse, 2001)
Energy Resources

Comparing the world’s energy resources

Where should we invest for the long-haul??

SOLAR

World energy use

©Richard Perez, et al.

*Yearly potential is shown for the renewable energies. Total reserves are shown for the fossil and nuclear “use-them, lose-them” resources. World energy use is annual.
World primary energy consumption grew by 5.6% in 2010, the strongest growth since 1973. Growth was above average for oil, natural gas, coal, nuclear, hydroelectricity, as well as for renewables in power generation. Oil remains the dominant fuel (33.6% of the global total) but has lost share for 11 consecutive years. The share of coal in total energy consumption continues to rise, and the share of natural gas was the highest on record.

“My father rode a camel. I drive a car. My son flies a jet-plane. His son shall ride a camel!”
CONSEQUENCES

Deaths from urban pollution

Deforestation Rate: 1990-2000

Business As Usual = Three Earths by 2050


Source: Nature.Org

Consequences: Premature mortality

acquired January 1, 1850 - January 1, 2000
CONSEQUENCES: EUTROPHICATION

Number of dead zones

Note that total temperature change across several ice ages was only about 12°C.
CO2 CONCENTRATION

Concentrations of Greenhouse Gases from 0 to 2005

- Red: Carbon Dioxide (CO₂)
- Blue: Methane (CH₄)
- Black: Nitrous Oxide (N₂O)

Year
CO2 EMISSIONS

Total world-wide CO2 emissions 1990 - 2011: +46%

Sources: UNFCCC; IEA; EEA; BP 2011; Ziesina 2012.
CO2 EMISSIONS BASED ON FUEL CONSUMPTIONS

- Residential: 6%
- Industry: 20%
- Transport: 22%
- Other: 10%
- Electricity and heat: 41%
2010 - 48,629 MT CO2 EQV

* Greenhouse gases can arise from two sources

**DIRECT EMISSIONS (EXAMPLES)**
- Sector: Agricultural
  - Cows and other livestock emit tons of methane (CH4) by passing gas each day.
- Sector: Land Use Change
  - Cutting down trees for logging or agriculture releases CO2 stored in the biomass.
- Sector: Waste
  - Organic matter in landfills emits tons of methane each year.

**FOSSIL FUEL RELATED EMISSIONS**
- Burning fossil fuels (coal, natural gas and oil) in industry, residential sector, commercial & public sector, transport and energy supply.
A planet's climate is determined by its mass, its distance from the sun, and the composition of its atmosphere. Earth's atmosphere is 78% nitrogen, 21% oxygen, and 1% other gases. Carbon dioxide accounts for 0.03 - 0.04%. Water vapor, carbon dioxide, and other minor gases absorb thermal radiation leaving the surface. These greenhouse gases act as a partial blanket for the thermal radiation from the surface and enable it to be substantially warmer than it would otherwise be. Without the greenhouse gases, Earth's average temperature would be roughly -20°C.
Human actions – burning fossil fuels and land clearing – are increasing the concentrations of greenhouse gases. This is known as the enhanced greenhouse effect. Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Greenhouse gases that are not naturally occurring include hydro-fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆), which are generated in a variety of industrial processes.
There are two primary anthropogenic effects on the carbon cycle.

- Global net primary production and respiration
- Changing land-use
- Fossil fuels and cement production

Storage in Gt C
Fluxes in Gt C/year
1 Gton = 10^9 tons
Recorded global temperature change can be compared with computer models that predict temperature change under different "forcing" scenarios, (with "forcings" signifying external influences on the solar radiative budget of the planet - greenhouse gases, aerosols, increased solar radiation, and other agents). The charts compare observed temperature anomalies from the historic mean (red line) with the results of computer models that attempt to predict temperature based on the interactions of other environmental influences (gray line).

The top two charts illustrate that models using natural and anthropogenic influences alone [Natural causes & Man-made causes] fail to match the observed record of temperature anomalies since 1866. But the combination of natural and anthropogenic models [Natural and man-made causes] produces a close match to the measured data. This is seen as a clear "thumbprint" of human impacts on climate change.

Based on results such as these, the Intergovernmental Panel on Climate Change (IPCC) 2001 report stated that "concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities."
CLIMATE CHANGE III
CLIMATE CHANGE IV

- High latitude increases
- Decreases over some dry regions
- Percentage changes uncertain in desert regions
- Changes less reliable in lower latitudes, e.g., monsoon regions
CLIMATE CHANGE VI

Population
+50% by 2050

Food
+70% by 2050

Energy
+100% by 2050

Climat
+2°C by 2050
CLIMATE CHANGE VII

Estimated increasing world energy-related CO₂ emissions

Currently projected path
Technology wedges
Flat path stabilization
Reduction path leading towards a post-carbon society

Source: BP statistical review and IEA (WEO, Alternative policy scenario, 2005)
World energy-related CO₂ emission savings by country in the 450 Scenario

Share of cumulative abatement between 2010-2035

- China: 32%
- United States: 18%
- European Union: 8%
- India: 7%
- Middle East: 4%
- Russia: 4%
- Rest of world: 27%
CLIMATE CHANGE IX

A four-fold increase needed

1990-2008

2008-2020

2020-2035
ATLAS OF SOILS
WIND POTENTIAL

Legend
Full-load hours [h/a]
- Not suitable for wind energy
- 500 - 1200
- 1200 - 1400
- 1400 - 1600
- 1600 - 1800
- 1800 - 2000
- 2000 - 2200
- 2200 - 2400
- 2400 - 2600
- 2600 - 3000
- > 3000
- Country not investigated
WIND EROSION

The map shows the 30-year average soil erodibility according to climatic conditions (e.g., wind velocity) and the erodibility of the soil (e.g., texture). The areas are color-coded based on the number of erosive days per year:

- Green: < 0.25
- Light Green: 0.25 - 0.50
- Yellow: 0.50 - 1.00
- Orange: 1.00 - 2.00
- Red: > 2.00

Source: European Commission, DG Joint Research Centre.
BIOFUEL MARKETS
ENERGY MARKET
Sustainable Development: to meet the needs of the present without compromising the ability of the future generations to meet their own needs

Strategy Mix:

- **efficiency** – enhanced productivity / resource
- **consistency** – enhanced economies embedded in the natural cycles
- **sufficiency** – new concept of prosperity / satisfaction / material wealth

Management rules:

- the use of renewable natural resources must not exceed their regeneration rates
- the use of non-renewable natural resources must not exceed the rate of substituting their respective functions
- the emissions of pollutants must not exceed nature’s capability to adapt
**DIMENSIONS & SCALES**

**Multidimensions:**
- Economical;
- Ecological;
- Social & Institutional.

**Multicriteria:**
- Economical: Growth competitiveness index, Economic freedom index;
- Ecological: Environmental sustainability index;
- Social & Institutional: Quality of life index, Human development index, Knowledge society index.
DIMENSIONS & SCALES

Multiscales:

- Energy system;
- Local cluster of end-users;
- Urban / Rural agglomeration;
- Sub-region;
- Country;
- Region.
PARADIGM SHIFT
“The greatest challenge today ... is the accurate and complete description of complex systems. Scientists have broken down many kinds of systems... The next task is to reassemble them, ... that capture the key properties of the entire ensembles.”

E. O. Wilson, Harvard Consilience

Complex system:

- System of Systems;
- Emergent behavior: Behavior at a higher level is the result of many behaviors at lower levels;
- Sometimes adaptive;
- Cannot predict from constitutive parts.
Innovation is “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD 2005).

Such a definition is neutral in the sense that it does not determine the content or the direction of change (Rennings 2000).
The term environmental innovation, or shortly ‘eco-innovation’, relates to innovations aiming at a decreased negative influence of innovations on the natural environment.

Eco-innovation is “the creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and provide a better quality of life for everyone with a life-cycle minimal use of natural resources (materials including energy and surface area) per unit output, and a minimal release of toxic substances”.

ECO-INNOVATION
The classical definition of engineering: The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

In the current context of the development of the mankind society complexity of the needs require to address them by emphasizing a more cross-disciplinary, whole-systems approach to engineering.

Holistic Engineering - the Art and Science of creating effective systems, using whole system, whole life principles.
INTEGRATED TOOLS
1st LAW ANALYSIS

Net Energy = $E_{out} - E_{in}$

EROI = $\frac{E_{out}}{E_{in}}$

Energy Return on Investment (EROI) = $\frac{E_{out}}{E_{in}}$
**BIOFUELS**

The case of biofuels

EROI = 1.5 ÷ 2.5  
Net Energy = 0.5 ÷ 1.5  
Net-to-Gross ratio = 0.30 ÷ 0.60

---

**Biofuel Production**

- Land
- Water
- Topsoil
- Nutrients
- Biota
- Labor

- F1 = Gross biofuel production
- F2 = Process energy demand met by biofuels
- F3 = Biofuels invested in harvesting of residues
- F4 = Biofuel demand for agricultural production
- R = Potentially available residues (mass)
- R* = Residues used in process (mass)
- H = Process energy demand met by residues
- B = Total biomass produced (mass)
Cropping corn

- Energy demand: 3.77 MJ/kg\(_{\text{corn}}\)
- Abiotic matter degraded: 1.73 kg\(_{\text{minerals}}$/kg\(_{\text{corn}}\)
- Soil erosion: 2.26 kg/kg\(_{\text{corn}}\)
- Water demand: 500 kg\(_{\text{water}}$/kg\(_{\text{corn}}\)
- Biotic matter degraded: 90 g/kg\(_{\text{corn}}\)
- Land demand: 1.32 m\(^2$/kg\(_{\text{corn}}\)
- Price: 0.20 €/kg corn
- Labor: 30 hours/hectare
- Emissions and wastes: (e.g.: 2.15 kg CO\(_2$/kg\(_{\text{corn}}\)
Converting corn to bioethanol

- Energy demand: 25.1 MJ/kg_{fuel}
- Abiotic matter degraded: 7.45 kg_{minerals}/kg_{fuel}
- Soil erosion: 8.78 kg/kg_{fuel}
- Water demand: 1700 kg_{water}/kg_{fuel}
- Land demand: 5.10 m^{2}/kg_{fuel}
- Biotic matter degraded: 350 g/kg_{fuel}
- Price: 1.07 €/kg_{fuel}
- Labor: 39.2 hours/hectare
- Emissions and wastes

BIOFUELS
WASTE-to-ENERGY POTENTIAL

EU27 2010*
grain production
273 million t

Available agricultural waste
p.a. EU27**
225 - 270 million t

Slurry and manure are not included in this contemplation and explore further opportunities.

* www.Coceral.com, ** Bloomberg study 2010
LIFE CYCLE THINKING

EXTRACTION & PROCESSING OF RAW MATERIALS

MATERIAL & EQUIPMENT DISPOSAL

PLANT MANUFACTURING

PLANT OPERATION

SCRAP RECYCLING

REPAIR & RETROFIT
LIFE CYCLE ASSESSMENT I

- extraction and processing of raw materials
- eventual recycling or disposal as waste at the end of its useful life
- use, re-use and maintenance of the product
- packaging
- manufacturing

Life-cycle Assessment of a product or function
LIFE CYCLE ASSESSMENT II

- Goal and scope definition
- Inventory of extractions and emissions
- Impact assessment

Interpretation
EXERGY ANALYSIS I

EXERGY

- quality of materials & energy
- reference to the natural environment
- internal & external losses
- uniform approach to evaluate materials & energy

BASED ON THERMODYNAMICS

- organization degree of materials & energy
- the Second Law of Thermodynamics
- non-equilibrium thermodynamics
- entropy and entropy production
REAL PROCESSES

- mass & energy are conserved
- exergy is consumed due to: fluid flow, heat & mass transfer, chemical reactions
- nothing disappears, *everything dissipate*

\[
\sum E_{IN} = \sum E_{OUT} + I
\]

*exergy of resources = exergy of products + exergy loss*
EXERGY ANALYSIS III

ENERGY EFFICIENCY

EXERGY: CHEMICAL

EXERGY: OVERALL

\[ \Psi_{LHV} = \frac{LHV_{gas}}{LHV_{biomass}} \]

\[ \Psi_{ex,chem} = \frac{\epsilon_{ch,gas}}{\epsilon_{ch,biomass}} \]

\[ \Psi_{ex,overall} = \frac{\epsilon_{ch,gas} + \epsilon_{ph,gas}}{\epsilon_{biomass}} \]
EXERGY ANALYSIS IV

CHEMICAL EXERGY

\[ \varepsilon_o = z_{org} (\beta \cdot LHV_{org}) + z_S (\varepsilon_{o,S} - C_S) + z_{water} \cdot \varepsilon_{o,water} + z_{ash} \cdot \varepsilon_{o,ash} \]

THE RATIO \( \beta \)

\[ \beta = \frac{\varepsilon_{o,org}}{LHV_{org}} \]

PHYSICAL EXERGY

\[ \varepsilon_{ph} = (h - h_0) - T_o (s - s_0) \]
solid
biofuels

liquid
vegetable oils

coal

EXERGY ANALYSIS VI

\[ \beta = \frac{1.044 + 0.0160 \frac{H}{C} - 0.3493 \frac{O}{C} \left[1 + 0.0531 \frac{H}{C}\right] + 0.0493 \frac{N}{C}}{1 - 0.4124 \frac{O}{C}} \]

\[ \beta = 1.0374 + 0.0159 \cdot \frac{H}{C} + 0.0567 \cdot \frac{O}{C} \]

\[ \beta = 1.0437 + 0.1869 \cdot \frac{z^2 H}{z C} + 0.0617 \cdot \frac{z^2 O}{z C} + 0.0428 \cdot \frac{z^2 N}{z C} \]
## EXERGY ANALYSIS VII

<table>
<thead>
<tr>
<th>Fuel</th>
<th>$LHV_{org}$ MJ/kg organic</th>
<th>$LHV_{org}$ MJ/kg fuel</th>
<th>$\beta$</th>
<th>$\varepsilon_{ch}$ MJ/kg fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>31.0</td>
<td>24.8</td>
<td>1.07</td>
<td>26.6</td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>37.6</td>
<td>37.6</td>
<td>1.07</td>
<td>40.3</td>
</tr>
<tr>
<td>Straw</td>
<td>18.1</td>
<td>14.6</td>
<td>1.13</td>
<td>16.5</td>
</tr>
<tr>
<td>Treated wood</td>
<td>18.9</td>
<td>15.3</td>
<td>1.12</td>
<td>17.1</td>
</tr>
<tr>
<td>Untreated wood</td>
<td>18.9</td>
<td>14.8</td>
<td>1.12</td>
<td>16.6</td>
</tr>
<tr>
<td>Grass/plants</td>
<td>18.6</td>
<td>13.1</td>
<td>1.13</td>
<td>14.8</td>
</tr>
<tr>
<td>Sludge</td>
<td>19.6</td>
<td>8.2</td>
<td>1.12</td>
<td>9.2</td>
</tr>
<tr>
<td>Manure</td>
<td>19.1</td>
<td>7.5</td>
<td>1.12</td>
<td>8.4</td>
</tr>
</tbody>
</table>
EXERGY ANALYSIS IX

![Bar Chart]

- **Coal**
- **Vegetable oils**
- **Straw**
- **Treated wood**
- **Untreated wood**
- **Grass/plants**
- **Sludge**
- **Manure**

Efficiency (%)

- Based on Lower Heating Value
- Based on Chemical Exergy
- Based on Chemical & Physical Exergy
EXERGY ANALYSIS VIII

Chemical Exergy of Product Gas
Physical Exergy of Product Gas
Gasification Process Irreversibility
CLOSED LOOP PRODUCTION

- Production
  - Packaging and distribution
  - Recovery
  - Use and maintenance
  - Material sources
  - Natural environment

- Processes:
  - Recycling
  - Remanufacturing
  - Waste for recovery
  - Re-use
  - Minimised raw material extraction
  - Minimised waste streams
**GREEN ECONOMY**

*Improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.*

In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive.

Practically speaking, a green economy is one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services.

UNEP, 2012
# RENEWABLE ENERGY SOURCES

<table>
<thead>
<tr>
<th></th>
<th>Power</th>
<th>Transport fuel</th>
<th>Heat</th>
<th>Primary energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydropower</td>
<td>Hydropower (small and large scale combined)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar</td>
<td>PV</td>
<td></td>
<td>Solar thermal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>Onshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Offshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>Biomass electricity from energy crops or residues</td>
<td></td>
<td></td>
<td>Energy crops, Residues: forest, waste and agricultural</td>
</tr>
<tr>
<td>Geothermal</td>
<td>Geothermal electric</td>
<td></td>
<td>Direct use</td>
<td></td>
</tr>
<tr>
<td>Ocean</td>
<td>Wave</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ocean Thermal Energy Conversion (OTEC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tidal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Osmotic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Renewable sources of energy include wind power (both onshore and offshore), solar power (thermal, photovoltaic and concentrated), hydro-electric power, tidal power, geothermal energy and biomass (including biofuels and bio liquids).

As alternatives to fossil fuels, their use aims at reducing pollution and greenhouse gas emissions.

Another role of renewable energy is the diversification of our energy supply, with the potential to reduce the dependence on oil and gas.
The Renewable Energy Directive adopted in 2009 sets binding targets for renewable energy. The new law focuses on achieving a 20% share of renewable energy in the EU overall energy mix by 2020.

Every Member State has to reach individual targets for the overall share of renewable energy in energy consumption.

In addition, in the transport sector, all Member States have to reach the same target of a 10% share of renewable energy.
To reach the 2020 targets, the Member States have to implement their national action plans and substantially increase the financing of renewable.

Annual capital investment would need to rapidly double to €70bn.

This investment should mainly come from the private sector. This could be big energy companies investing in wind or solar farms or households investing in solar systems or other forms of renewable.
A wide range of different financial instruments are used in all Member States to help reduce renewable energy costs. These instruments include capital support: grants, loans and loan guarantees, equity funds, and production aid: feed in tariffs, premiums, quota/certificate schemes, fiscal incentives and tenders.

The Commission recommends further reforms of national renewable energy support schemes. Support schemes need to ensure the costs of renewable energy production continue to fall but they also need to provide a stable investment climate, without any retroactive changes to discourage investment.
It is the economies of scale of the industry across the EU that will drive production costs down and keep the industry globally competitive.

Renewable energy industries has a great potential for creating jobs, for equipment manufacturers, installers, technicians, builders and engineers.

The industry currently employs over 1.5 million people and by 2020 could employ nearly 3 million more, according to latest studies.
Sustainable Energy Value Chains

Wind

Solar Energy

Photovoltaic Conversion

Electric Power

Water in

Water Electrolysis

Oxygen out

Hydrogen Storage & Transport

Fuel Cell

Oxygen in

Water out

Electric Power

Biomass

Biotechnologies
Distributed Production of Energy
The concept of “Smart Grids”
The concept of “Smart Grids”

A Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety. Though elements of smartness also exist in many parts of existing grids, the difference between a today’s grid and a smart grid of the future is mainly the grid’s capability to handle more complexity than today in an efficient and effective way. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

- Better facilitate the connection and operation of generators of all sizes and technologies.
- Allow consumers to play a part in optimizing the operation of the system.
- Provide consumers with greater information and options for how they use their supply.
- Significantly reduce the environmental impact of the whole electricity supply system.
- Maintain or even improve the existing high levels of system reliability, quality and security of supply.
- Maintain and improve the existing services efficiently.
- Foster market integration towards European integrated market.
România – General Information I

- Territory Surface: 238,391 km²
- Growth rate 2007: 6.0 %
- Structure of the Economy:
  - Industry: 23.5 %
  - Agriculture: 6.6 %
  - Commerce & Services: 69.9 %
Energy Dependency - Hard Coal and Derivatives, 2005

Per cent (%)
THE CHALLENGE

Energy intensity in Europe

- at the exchange rate
- at power purchasing parity
Solar energy:
- 60 PJ thermal
- 1,2 TWh electric

Wind: 23 TWh

Hydro:
- 36 TWh
- 3,6 TWh (of which under 10 MW)

Biomass & biogas: 318 PJ

Geothermal: 7 PJ
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Share of energy from renewable sources in gross final consumption of energy in 2005 (S2005) (%)</td>
<td>17.8</td>
</tr>
<tr>
<td>B. Target of energy from renewable sources in gross final consumption of energy in 2020 (S2020) (%)</td>
<td>24</td>
</tr>
<tr>
<td>C. Expected total adjusted energy consumption in 2020 (ktoe)</td>
<td>30278</td>
</tr>
<tr>
<td>D. Expected amount of energy from renewable sources corresponding to the 2020 target (calculated as B x C) (ktoe)</td>
<td>7267</td>
</tr>
</tbody>
</table>
DOBROGEA REGION

Total surface: 1,557 kha
Farming land: 931.5 kha
Forests: 128.3 kha
Inland water surface: 396.8 kha
Shore line: 245 km
Total cereals: 1,166 mt/year
PROTECTED AREAS
SOIL DEGRADATION
ASSESSMENT PHASES

1. Naturally available resource
2. Technically accessible resource
3. Physical environment constraints of high priority
4. Planning and regulatory constraints
5. Economically viable potential
6. Deployment constraints (supply chain)
7. Regional ambition – target-setting
## ASSESSMENT PHASES

<table>
<thead>
<tr>
<th>Opportunity analysis</th>
<th>Stage 1. Naturally available resource</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regions need to explore and quantify the naturally available renewable energy resource within their geographical boundary. This will be based on data and information analysis including resource maps and inventories.</td>
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<table>
<thead>
<tr>
<th>Constraints analysis</th>
<th>Stage 2. Technically accessible resource</th>
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<tbody>
<tr>
<td></td>
<td>Regions need to estimate how much of the natural resource can be harnessed using commercialised technology (currently available or expected to reach the market by 2020). This will be based on applying parameters regarding the deployment of technology. The entire area of the region needs to be taken into account.</td>
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<tr>
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<th>Stage 3. Physical environment constraints</th>
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<td></td>
<td>Regions need to explore the physical barriers to deployment such as areas where renewables schemes cannot practically be built – e.g. large scale wind turbines on roads and rivers. This layer of constraints will reduce the overall deployment opportunity. The analysis will be based on GIS maps and various relevant regional inventories.</td>
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<th>Stage 4. Planning and regulatory constraints</th>
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<tbody>
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<td></td>
<td>Regions need to apply a set of constraints relevant to each renewable technology that reflects the current planning and regulatory framework, such as excluding from the assessment areas and resources which cannot be developed due to e.g. health &amp; safety, air/water quality, environmental protection.</td>
</tr>
</tbody>
</table>
RES POTENTIAL

- **Theoretical potential**: The highest level of potential is the theoretical potential. This potential only takes into account restrictions with respect to natural and climatic parameters.
- **Geographical potential**: Most renewable energy sources have geographical restrictions, e.g. land use land cover that reduce the theoretical potential. The geographical potential is the theoretical potential limited by the resources at geographical locations that are suitable.
- **Technical potential**: The geographical potential is further reduced due to technical limitations as conversion efficiencies, resulting in the technical potential.
- **Economic potential**: The economic potential is the technical potential at cost levels considered competitive.
- **Market potential**: The market potential is the total amount of renewable energy that can be implementation in the market taking into account the demand for energy, the competing technologies, the costs and subsidies of renewable energy sources, and the barriers.
THE ECOSYSTEM APPROACH

- Economic Prosperity
  - Resource Efficiency
  - Life-cycle Management
- Social Well-being
  - Equitable Sharing
  - Sustainable Use
- Environmental Sustainability
  - Integrated Approaches
  - Liveable Places
- Environmental Justice
  - Environmental Regulation
- Innovation & Green Growth
- Job Creation
  - Skills Enhanced
  - Local Economic Gains
- Social Equality & Inclusion
  - Cultural Diversity
ECOSYSTEM SERVICES

• Provisioning services
  food (including seafood and game), crops, wild foods, and spices
  water
  minerals (including diatomite)
  pharmaceuticals, biochemicals, and industrial products
  energy (hydropower, biomass fuels)

• Regulating services
  carbon sequestration and climate regulation
  waste decomposition and detoxification
  purification of water and air
  crop pollination
  pest and disease control

• Supporting services
  nutrient dispersal and cycling
  seed dispersal
  Primary production

• Cultural services
  cultural, intellectual and spiritual inspiration
  recreational experiences (including ecotourism)
  scientific discovery
ASSESSMENT METHODOLOGY

GLOBAL

REGIONAL

LOCAL

Human well-being and poverty reduction
- Basic material for a good life
- Health
- Good social relations
- Security
- Freedom of choice and action

Indirect drivers of change
- Demographic
- Economic (e.g., globalization, trade, market, and policy framework)
- Sociopolitical (e.g., governance, institutional and legal framework)
- Science and technology
- Cultural and religious (e.g., beliefs, consumption choices)

Direct drivers of change
- Changes in local land use and cover
- Species introduction or removal
- Technology adaptation and use
- External inputs (e.g., fertilizer use, pest control, and irrigation)
- Harvest and resource consumption
- Climate change
- Natural, physical, and biological drivers (e.g., evolution, volcanoes)

Ecosystem services
- Provisioning (e.g., food, water, fiber, and fuel)
- Regulating (e.g., climate regulation, water, and disease)
- Cultural (e.g., spiritual, aesthetic, recreation, and education)
- Supporting (e.g., primary production, and soil formation)

LIFE ON EARTH - BIODIVERSITY
A POSSIBLE METHODOLOGY FOR AGROENERGY DISTRICTS

DEVELOP BIOENERGY & BIOREFINERY SOLUTIONS

IMPLEMENTATION OF
The main goal of agriculture is to assure the sustainable exploitation of land;

Energy is just one of the factors that are contributing to the sustainable exploitation of land.

Sustainability is a complex issue and should be addressed with appropriate tools;

The evaluation of Ecosystem services could offer an appropriate perspective for the decision makers;
If our small minds, for some convenience, divide .... this Universe, into parts -- physics, biology, geology, astronomy, psychology, and so on -- remember that NATURE does not know it!

Richard P. Feynman
And please, send your comments at:
emamut@univ-ovidius.ro