The transition towards renewable energies: physical limits and temporal conditions

Iñigo Capellán-Pérez
(inigo.capellan@ehu.es)

Klimagune Workshop, Bilbao 19th 2013
Motivation (I)

• Fossil fuels: around 85% of:
  • total primary energy
  • anthropogenic CO₂ emissions

• Subject to depletion:
  - Large, «Easy» fields:
    - High (E & €) profitability
    - Cheap energy
  - Small, «Difficult» fields:
    - Low (E & €) profitability
    - Expensive energy

Diminishing returns
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[Diminishing returns]

[WE02013]
Motivation (II)

- Fossil fuels: oil

![Total oil extraction profiles from different authors](chart.png)

...peak before 2020...

Updated from [Mediavilla2013]
Motivation (II)

- Fossil fuels: oil

Total oil extraction profiles from different authors

Oil production becomes less crude

World oil production by type in the New Policies Scenario

Global oil production reaches 96 mb/d in 2035 on the back of rising output of natural gas liquids & unconventional oil, as crude oil production plateaus

[ASPO 2009]

Updated from [Mediavilla2013]
Motivation (II)

- Fossil fuels: gas

Updated from [Mediavilla2013]
Motivation (II)

- Fossil fuels: coal

Updated from [Mediavilla2013]

higher uncertainties; BUT....
Opportunities (I)

• Energy transition to avoid dangerous climate change:

  The consideration of geological restrictions invalidates high IPPC SRES scenarios.

  HOWEVER, From SRES 2000, the impacts have been revised upwards (e.g. [IPCC2014], [Smith 2009]).
Opportunities (II)

• Energy transition to overcome the fossil-based model: reduction of the economic vulnerability:
  • to price shocks,
  • external dependency.

(e.g. [Hamilton 2011]: 10/11 US recessions associated with oil price spikes)
Challenges & barriers (I)

1. Renewable energies deployment paths?
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![Graph showing TPE extraction (1) with lines for Historic demand, Renewables, Coal, Gas, and Oil from 1990 to 2050.]
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Paths: dependent on demand, technology, policies, potential, etc.
Challenges & barriers (II)

2. Renewable ("low") densities & potentials:

\[
\text{Net power} = \text{Gross power} \cdot \left(1 - \frac{1}{\text{EROI}}\right)
\]

\(\text{(maximum) Net power density}\)

- 150 W/m²
- Solar irradiance
- 168

\(\begin{array}{c|c}
\text{Fossil fuels} & 25 \\
\text{Solar (theoretical)} & 3.3 \\
\text{Solar (real)} & 5 \\
\text{Solar future (real)} & 2 \\
\text{Wind} & <0.1 \\
\text{Biofuels (real)} & \end{array}\)

\[\text{e.g. 100 Mha} \approx 130 \text{ EJ/yr.}\]

**WIND.** Application of 1st law of conservation of energy \(\approx < 35 \text{ EJ/yr.}\)

[de Castro 2011, 2013a, 2013b]
Challenges & barriers (I)

1. Renewable energies deployment paths?

![Graph showing energy sources and demand](image)
Challenges & barriers (III)

3. Most critical sector: Transport (95% oil)

Oil substitution policies: biofuels, Electric & Hybrid car, efficiency improvement, CTL, GTL,

(only) technological change might not be enough

[Mediavilla2013]
Proposals

• **Urgent action:**
  - Peakoil & CO2 exponential trends,
  - Transport: critical sector,
    - Oil substitution rate < oil decline rate,
  - (only) technological solutions might not be enough.

• **Climate change mitigation & fossil fuels depletion** *anticipation synergies:*
  - “Effective” (high+sustained) carbon prices,
  - Renewables development (! potentials),
Thank you very much
References