Systems Ecological Perspectives on Sustainability
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Solar- vs. bio-economy: ecological implications

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Focus on energy

- Note: here we concentrate on energy
- Bioeconomy has crucial role in material production, but it is outside of the scope of this presentation
- Content
  1. Transition back to renewable energy economy
  2. Bioeconomy
  3. Solar economy
  4. Conclusion

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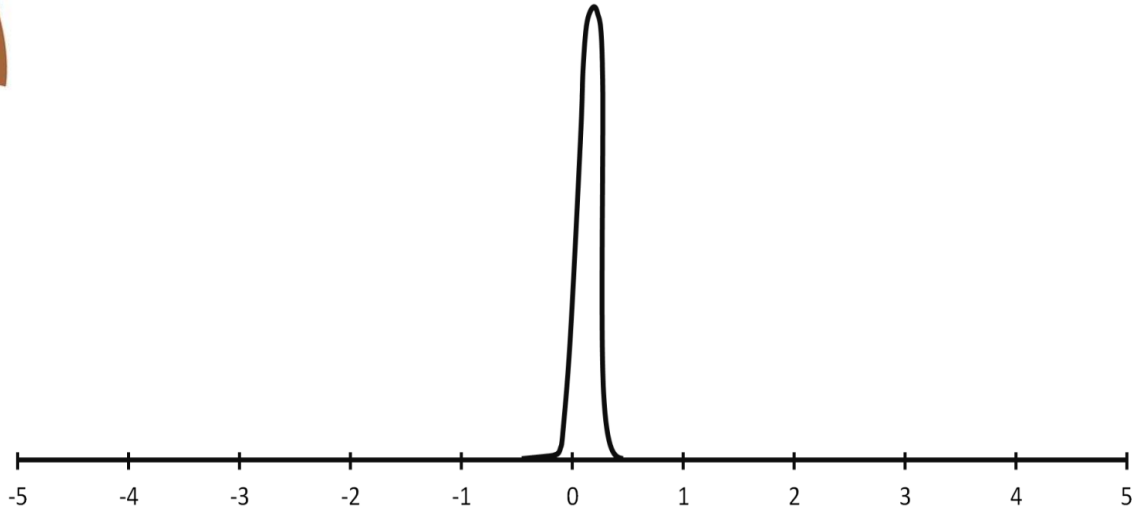
1. TRANSITION BACK TO RENEWABLE ENERGY ECONOMY

Two main options:

- Bioeconomy
- Solar economy

Hubbert peak



Use of non-renewable energy in human history [thousands of years before and after the present time] (Hubbert 1976)

M. King Hubbert, Shell oil geologist, 1950s

Sheikh Zaki Yamani on the end of the Oil Age:

"The Stone Age did not end for a lack of stones"

Ahmed Zaki Yamani, Oil minister of Saudi-Arabia, 1970s

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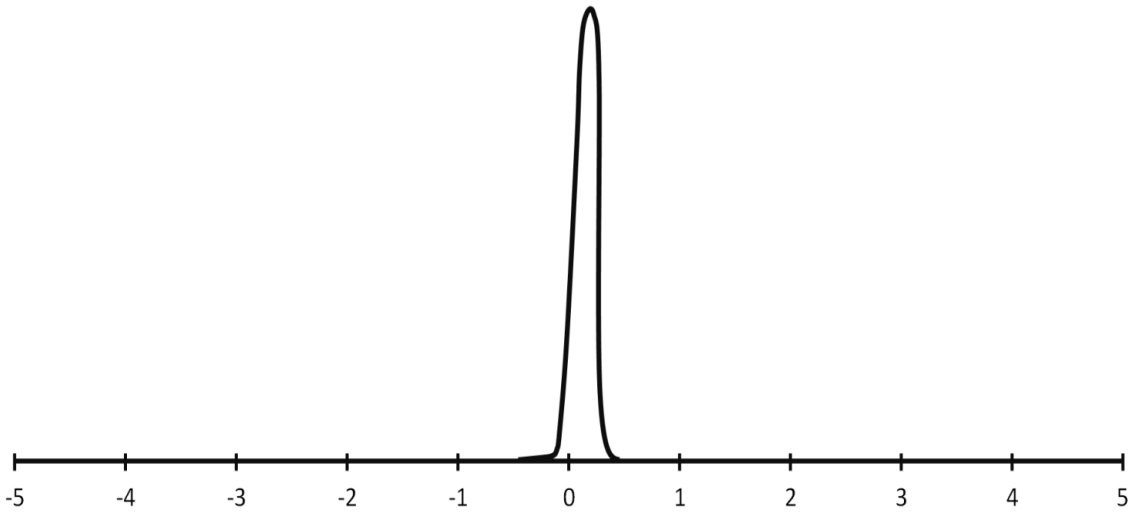
- Smooth descent => Solar economy
- Path of crises => Bioeconomy
  - Possible collapse of modern society



2. BIOECONOMY

- Bioenergy has the overall lowest environmental quality of all renewable energy forms:
  - Ecological problems
  - Emission problems
- Part of bioenergy is not even renewable
- Resource base of bioenergy is low
- But it is the dominating renewable energy form today

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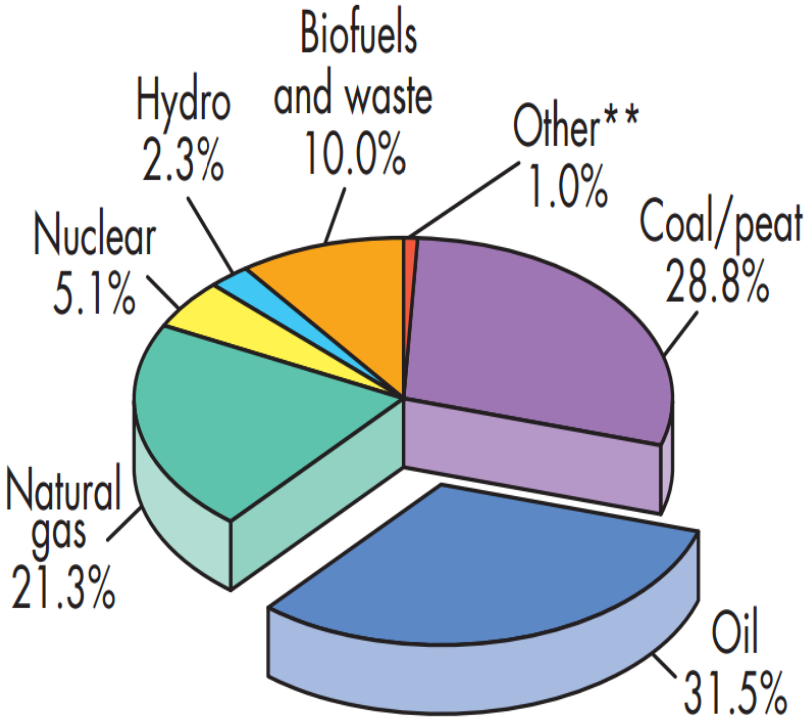
Global energy consumption 2011 (OECD/IEA 2013)



13 113 Mtoe = 559 EJ

Energy resources (UN World Energy Assessment 2000):

- Non-renewable: 1,400,000 EJ
- Renewable: 144,000,000 EJ/a
  - Bioenergy 0.002 %
  - Hydro 0.0001 %

Renewable energy 13.3 %: Strong emphasis on the renewables with the lowest environmental quality and the smallest resources

a) Energy crops

- Efficiency of primary solar energy to useful energy (power and heat) conversion: **0.5 %** (one of the lowest efficiencies of any human energy systems)
- Compare solar economy: efficiency of solar energy technologies: about **50 %**

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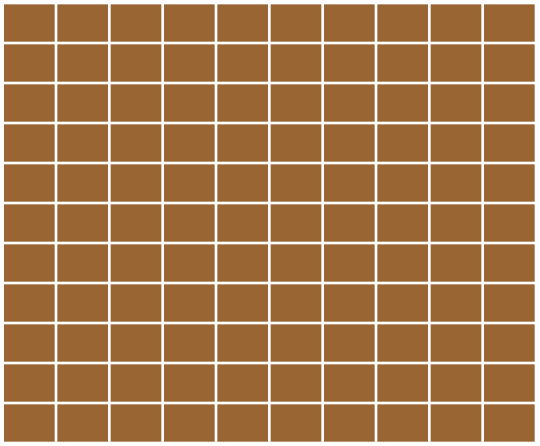
Areal efficiency: same annual energy production

Energy crops, monoculture, 100 hectares



Solar technology, 1 hectare + 99 hectares restored to natural habitat

A contribution of solar energy technology to ecological restoration

- Neither terrestial nor aquatic energy crops fit into sustainable society
- But micro algae might fit
  - Advanced technologies could be called solar energy technologies
  - Most efficient energy conversion is by biogas technology, because
    1. It operates in high humidity, i.e. no energy losses for drying
    2. It utilizes all energy sources in algae, i.e. not only oils (biodiesel tecnology) or some carbohydrates (bioethanol technology)

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b) Wastes

- Wastes are produced anyway and should be utilized as efficiently as possible
  1. As material
  2. As energy

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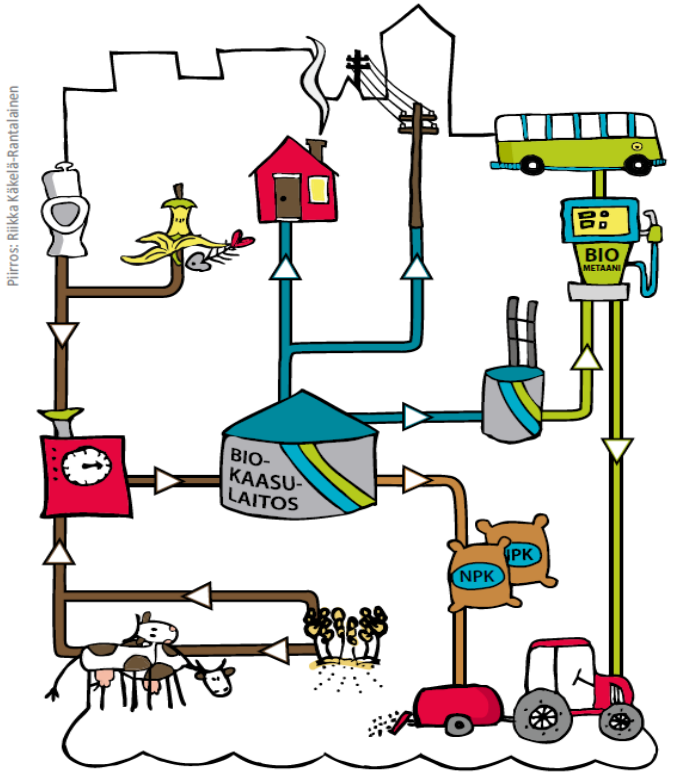
- Biowastes
  - Fertilizers are the only material use
  - Biogas technology (BG) is the only technology enabling full recovery of both fertilizers and energy

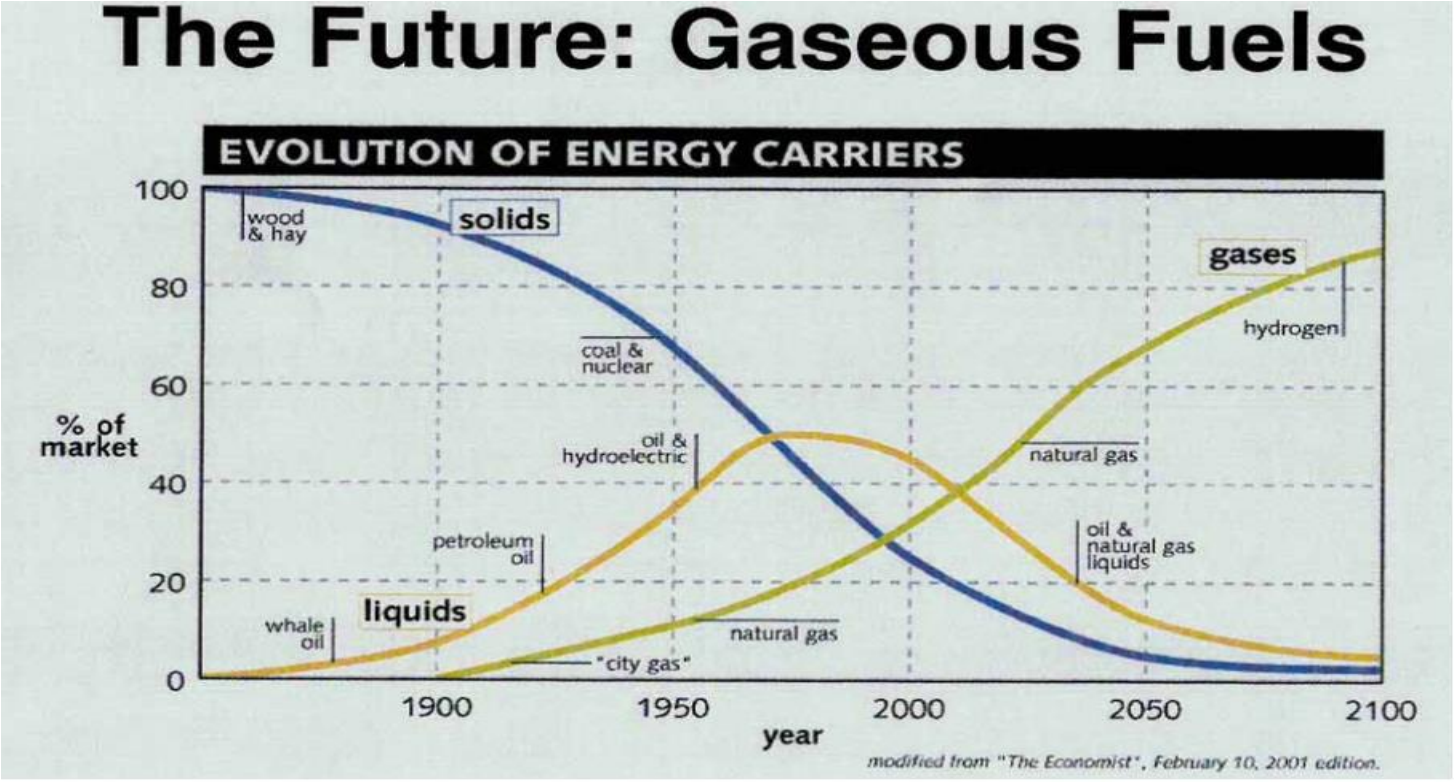


- Wood and other wastes
  - Many material use options, but ultimately energy conversion
  - Highest conversion efficiency by synthetic biogas (SBG) technology

Thermal efficiency of conversion of wood to gaseous and liquid biofuels	
SBG (gaseous)	80 %
DME (gaseous)	67 %
Methanol (liquid)	66 %
FT liquids	45 %

Secondary energy forms

- Gaseous fuels
  - Suitable for all heat engines and fuel cells for conversion of chemical energy to mechanical or electric energy
  - Potential for lowest emissions (inherently)



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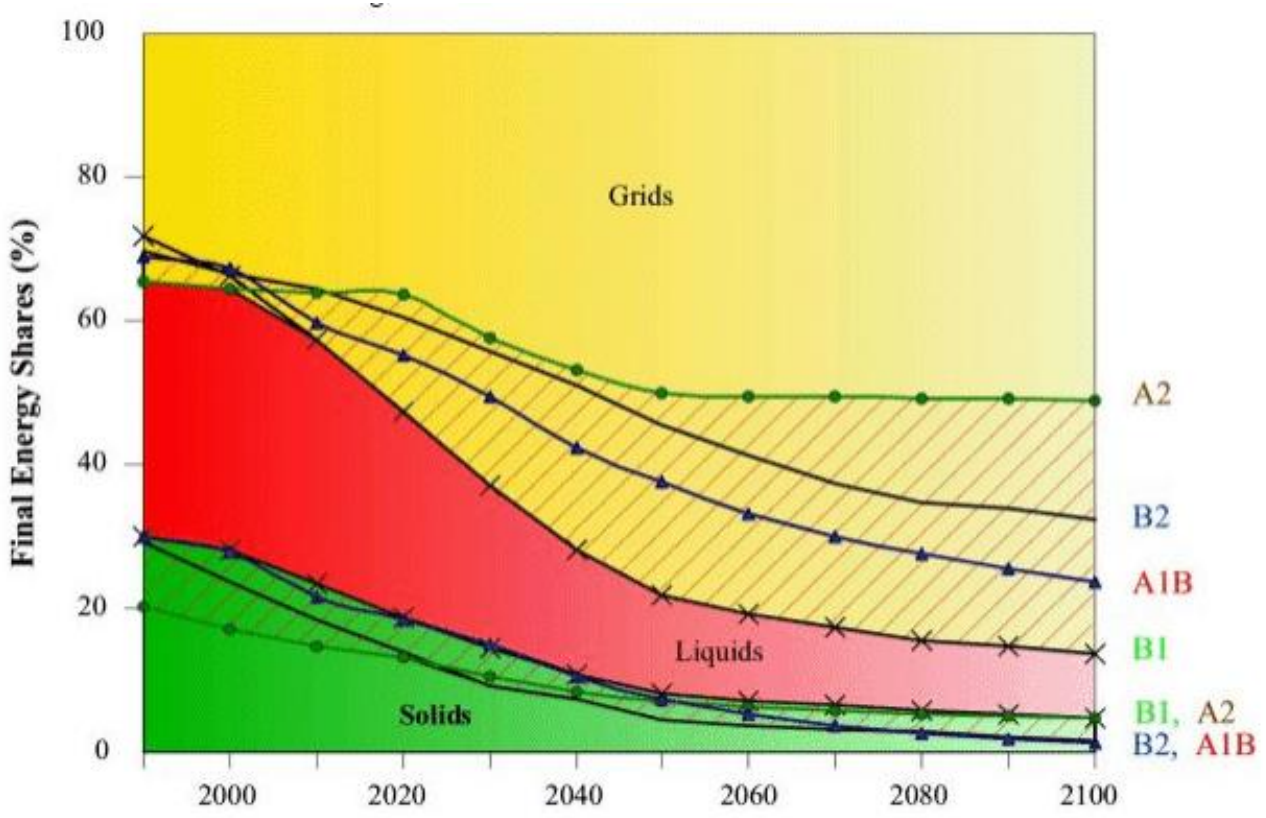
- In sustainable modern society secondary energy is delivered mostly in forms of
  - Gaseous fuels
  - Electricity



IPCC 2000

3. SOLAR ECONOMY

- In sustainable modern society most energy originates from primary energy sources with the lowest environmental impacts and largest resources
  - Solar
  - Wind
  - Etc.

⇒ Solar economy

  - Secondary energy mostly as gaseous fuels and electricity

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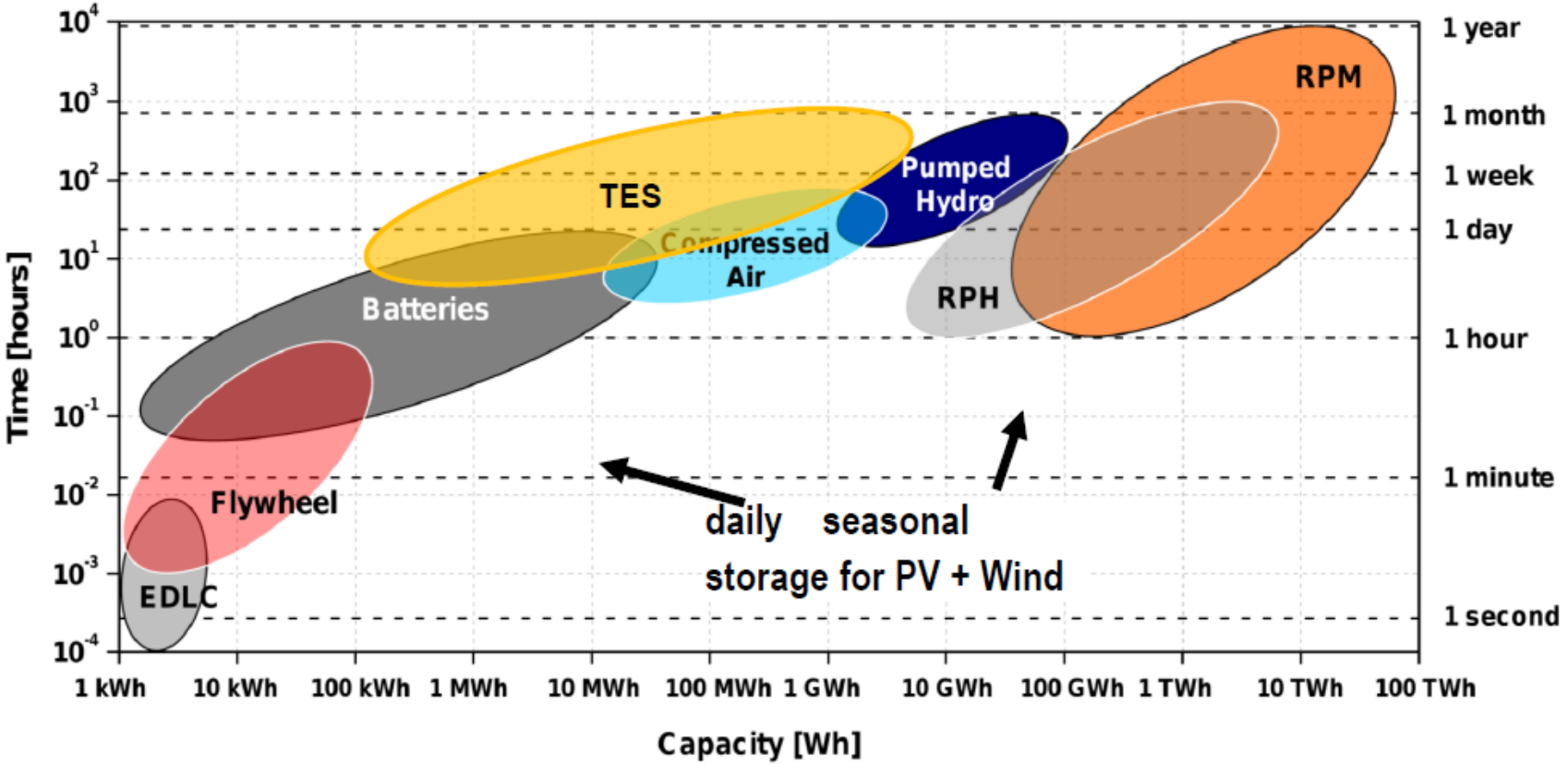
- As the cleanest and the most abundant renewable energy sources are intermittent, they require storage
- Methane offers the largest and longest duration storage potential of all alternatives
  - Currently 200 TWh in German gas grid (while in German power grid only 0.014 TWh)
  - Currently 2000 TWh in UNECE countries
  - Mature technology

Storage options in General and P2G (RPH, RPM)



Key insights:

- gas is the only long term energy storage
- RPM might be favoured due to an evolutionary transition process

source: Breyer Ch., Rieke S., et al., 2011. Hybrid PV-Wind-Renewable Methane Power Plants – A Potential Cornerstone of Global Energy Supply, 26th EU PVSEC, Hamburg

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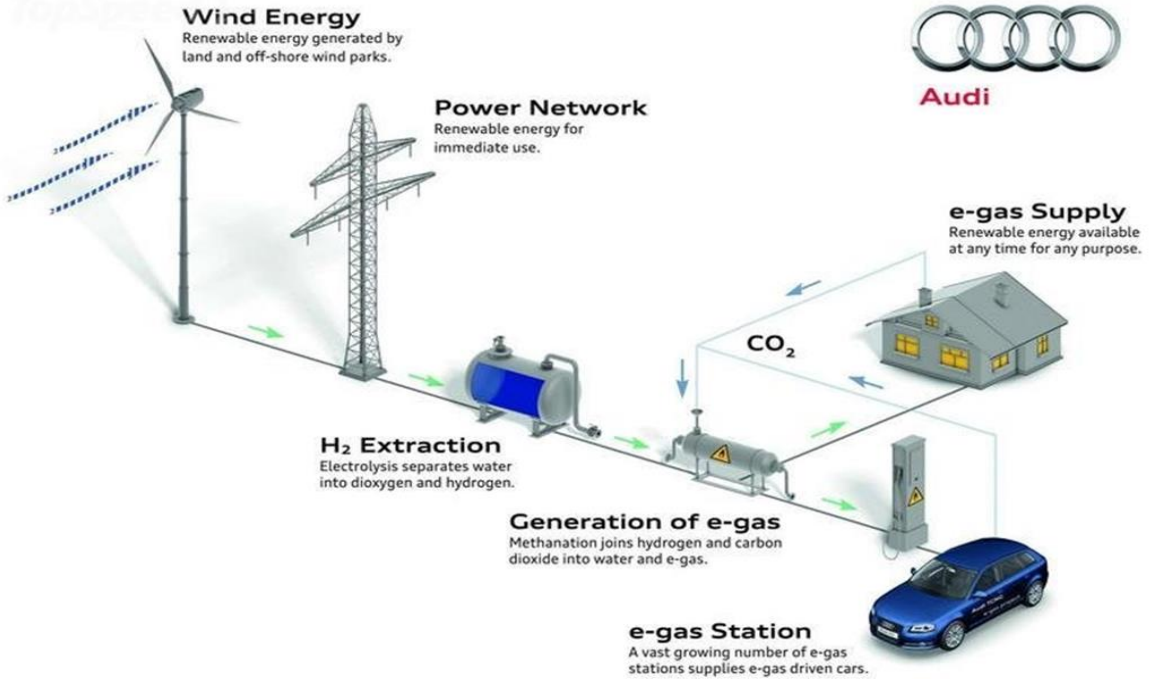
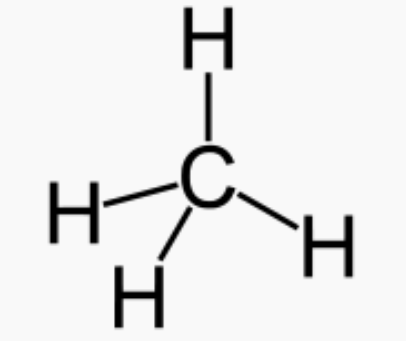
This leads to solar and wind methane



4. CONCLUSION

- All leads to renewable methane economy as a backbone of sustainable modern society



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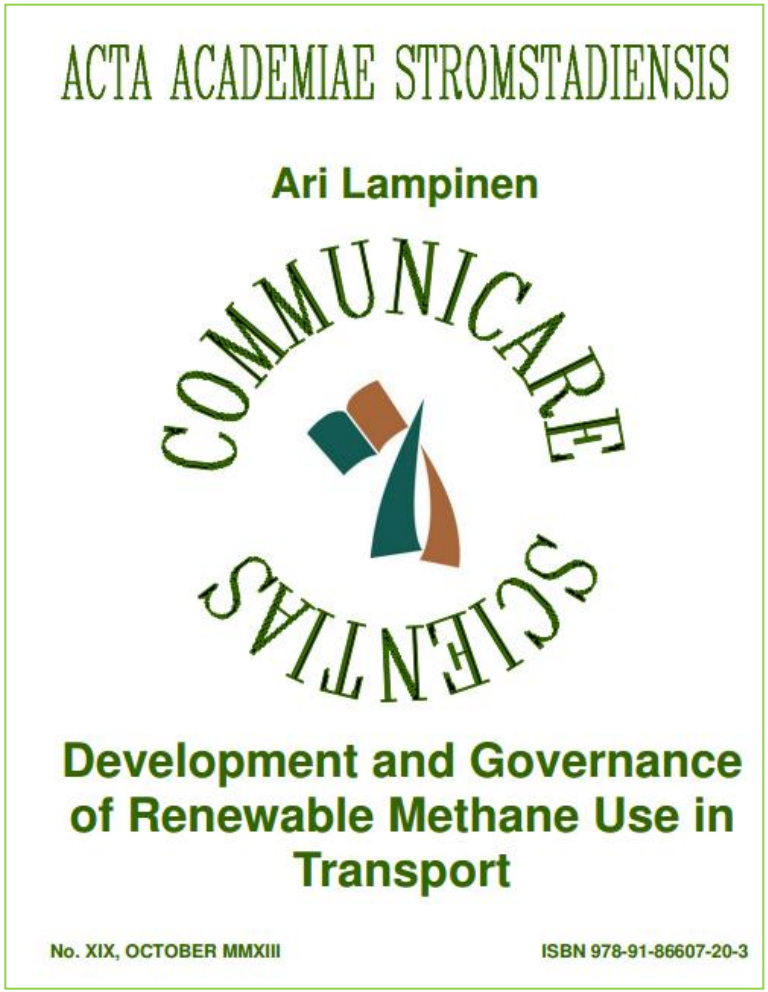

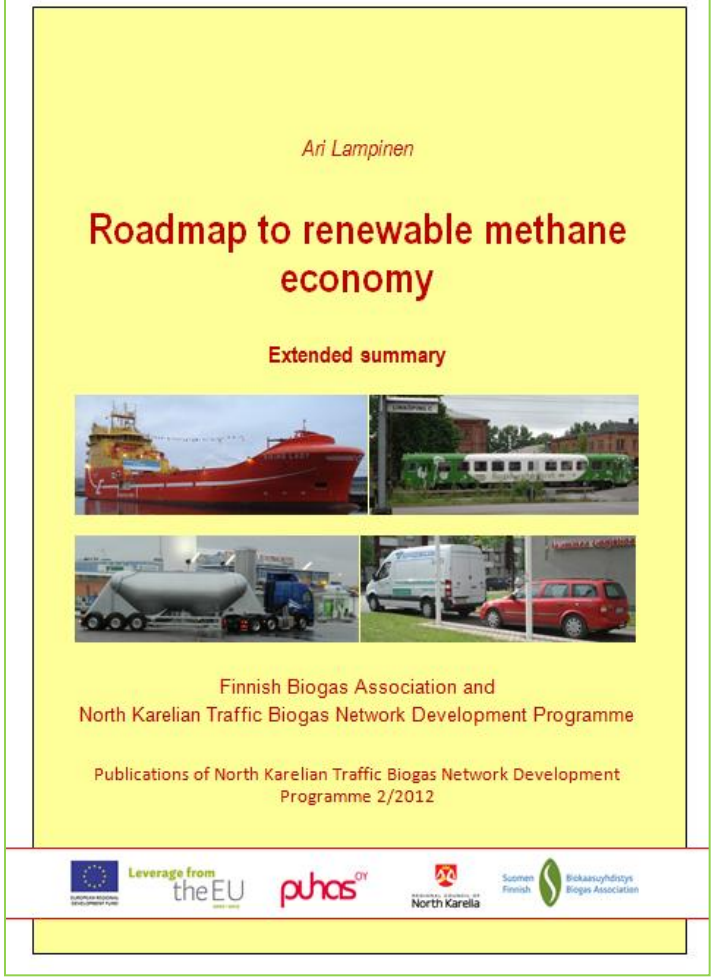

Available at renewable methane server http://www.cbg100.net/in-english/