SUSTAINABILITY OF CONSUMPTION AND PRODUCTION

Distributed energy production in Finland

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30.6.2015

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1. Defining distributed energy production

- An unequivocal definition would be inadequate and infeasible due to the complexity of the issue
  1. Small-scale production
     - Nominal power output
     - Annual energy output
     - Environmental permits
  2. Local production
     - Production near the point of consumption
     - Local resources (energy sources, technologies, human resources such as labour and know-how)
  3. Production among the energy distribution grid
     - Energy self-sufficiency
     - Consumers point of view: sole consumption vs. the combination of consumption and production

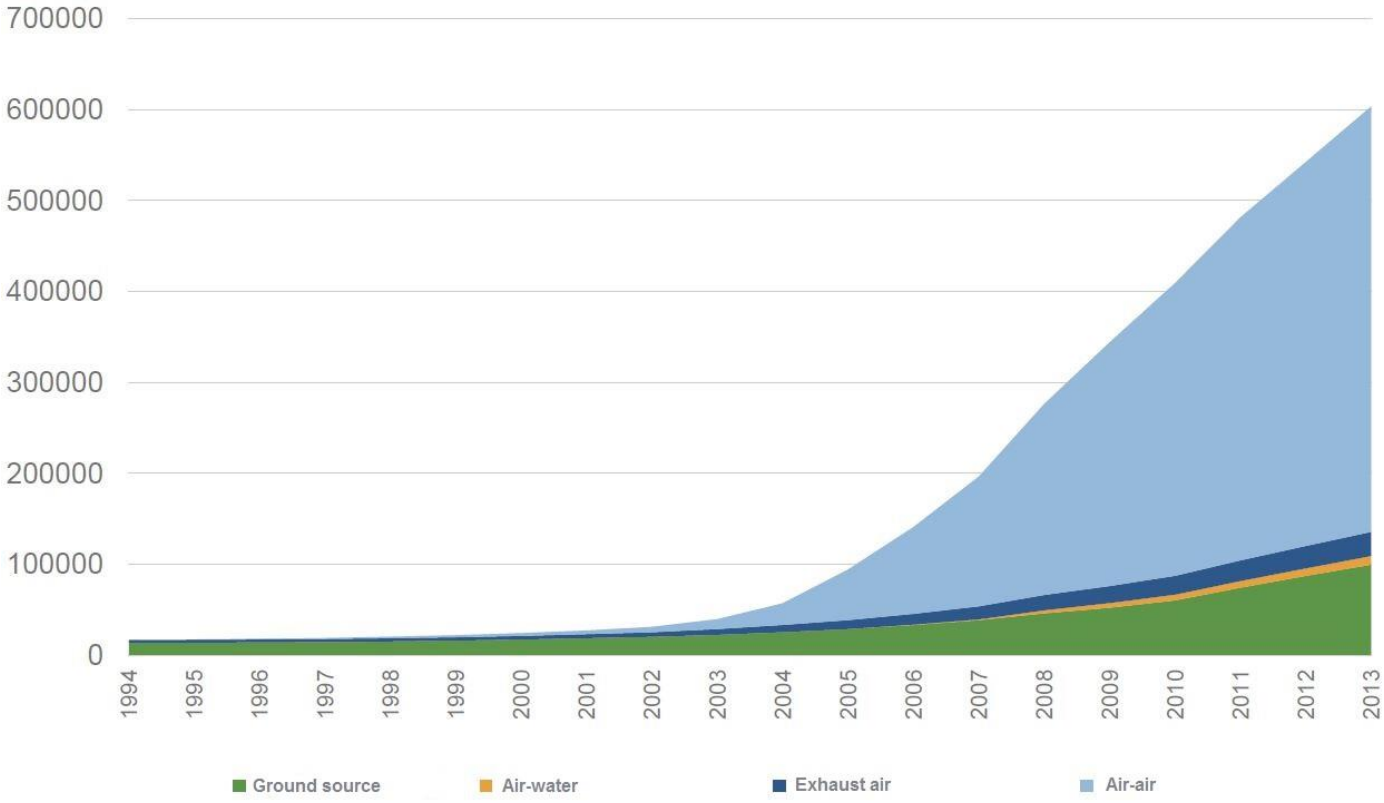
2. Potential production methods and technologies

- Most distributed energy production methods and technologies rely on renewable energy sources
  1. Solar energy (photovoltaics and solar heat)
  2. Small-scale wind power
  3. Small-scale hydropower
  4. Heat pumps
  5. Distributed thermal power and small-scale CHP (Combined Heat and Power)

3. The significance of distributed energy production

- General consensus: the role of distributed energy production will increase
- There is a lack of broad and detailed numerical estimates
  - Difficulties related to the definition and the compilation of relevant statistics
- Particularly the recent development of heat pumps has been systematically underestimated
  - Impacts on the consumption of electricity

3. The significance of distributed energy production



The number of heat pumps in Finland has grown very significantly during the last decade. Source: Finnish heat pump association SULPU.

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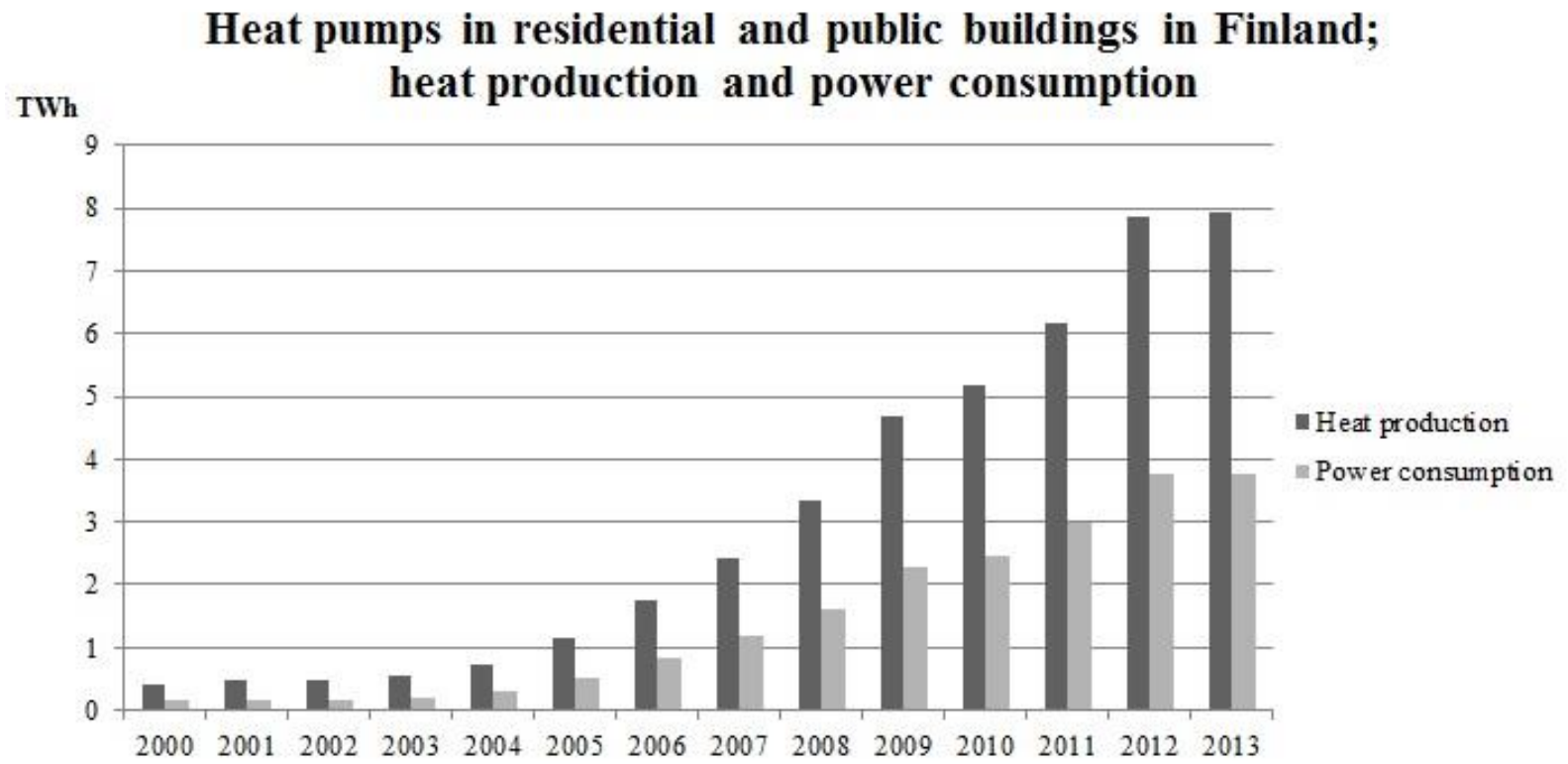
3. The significance of distributed energy production



The recent development of heat production and power consumption illustrates the remarkable role that heat pumps (installed in residential and public buildings) have nowadays. Data source: Statistics Finland.

4. Central themes related to distributed production

- Distributed production and electric power network
  - Production among the distribution network and network access issues
  - Transmission of electricity and the design of the grid
- Distributed heat production and district heat
  - Both production and consumption are local in nature
  - Major restrictions due to the design of CHP-plants
- Regional aspects and the geographical distribution of the production potential
  - Urban vs. rural areas: density of population and the scale of heat and power consumption
  - The availability of raw materials (e.g. biomass)

5. Distributed energy production and emissions in air

General remarks

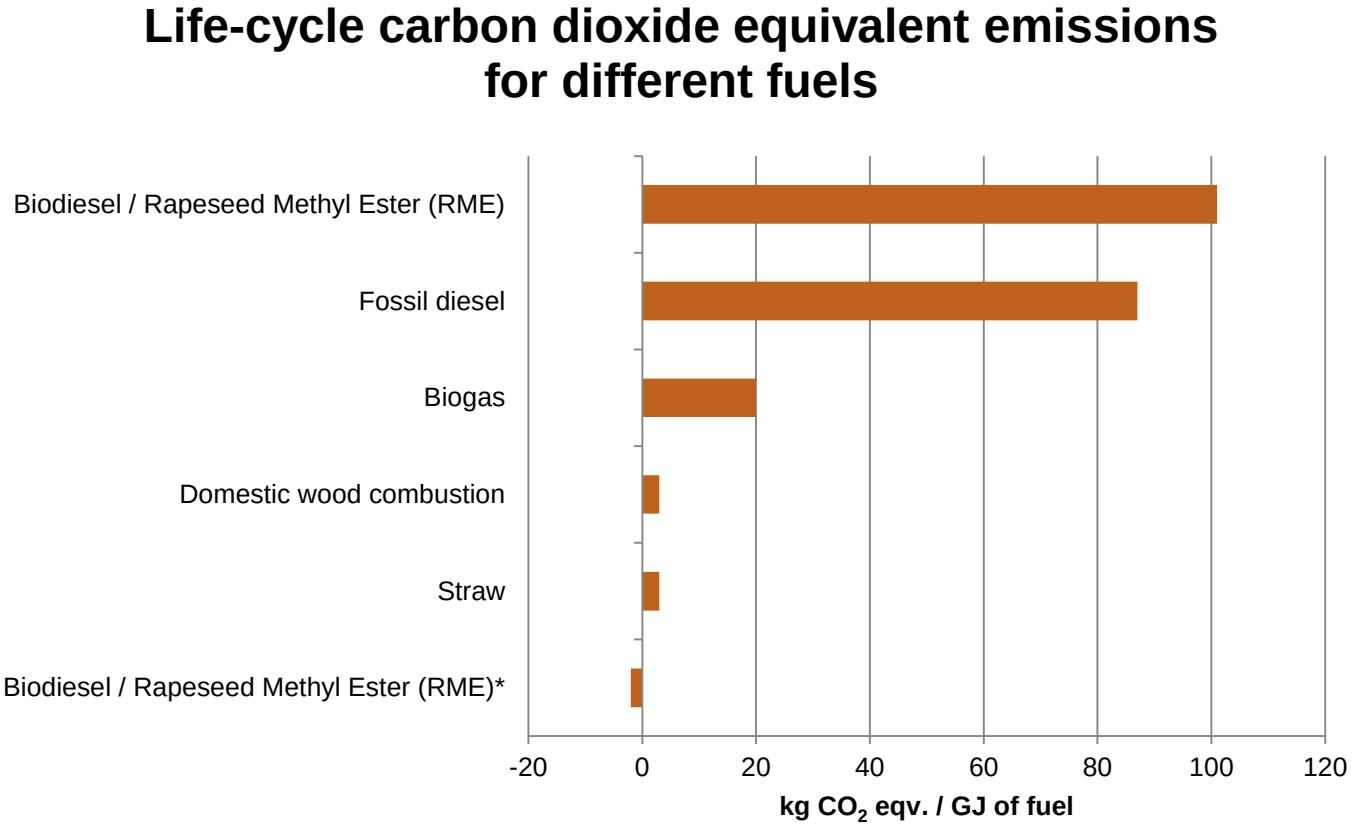
- The management and abatement of emissions in air is one of the main concerns related to distributed production
- Especially among combustion-based energy production large-scale solutions may be more efficient with regard to the overall amount of emissions; this is due to:
  1. Advanced technologies (efficient emission reduction techniques)
  2. Small number of organized actors
  3. Legislative regulation and strict emission limits
  4. High-rise smokestacks prevent detrimental local concentrations

5. Distributed energy production and emissions in air

Greenhouse gases

- The usage of biomass and biofuels in combustion-based energy production
  - Theoretical carbon-neutrality vs. life cycle approach (the role of production and transportation etc.)
  - Local resources cause less transportation-related carbon emissions
- Heat pumps demand significant amounts of electricity
  - Carbon emissions from electric power plants?
  - Situation in mid-winter:
    1. The reduced overall efficiency of heat pumps (due to cold weather) leads to a substantial consumption of electricity
    2. Reserve power plants use fossil fuels during the nation-wide electricity consumption peak
    3. The usage of heat pumps leads to a notable increase in carbon emissions, though they make use of “free” and renewable heat

5. Distributed energy production and emissions in air



The mass of carbon dioxide equivalent emissions per GJ of fuel from the production and combustion of selected fuels. With regard to RME, the emissions are much smaller (*) if the straws would substitute peat in energy production. Data source: Reports of Finnish Environment Institute.

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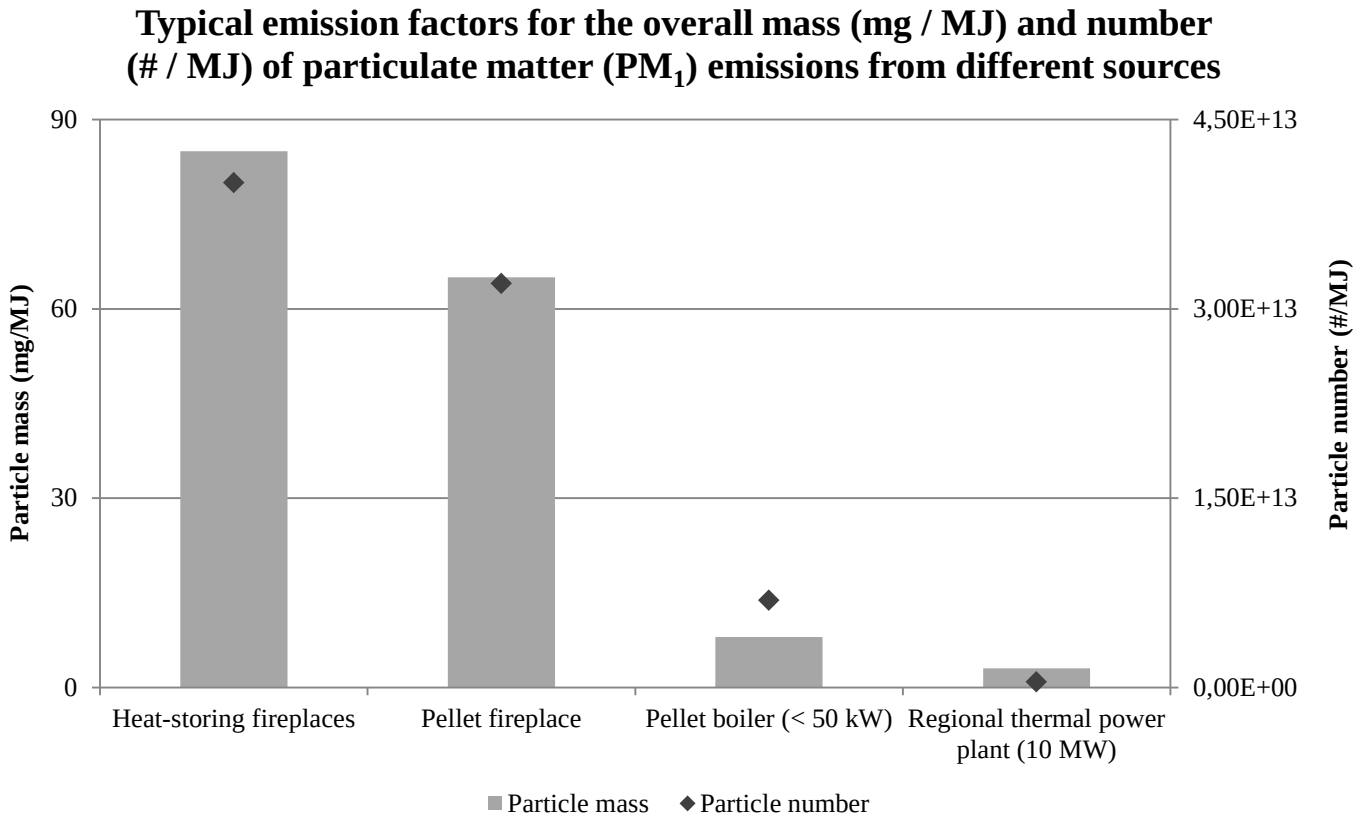
5. Distributed energy production and emissions in air

Air pollutants

- Essential emission species: carbon monoxide, nitrogen oxides, sulfur dioxide, particulate matter and soot
- The amount and quality of the air pollutant emissions are affected by the conditions of combustion and the properties of the fuel in use
  - Distributed production relies on small-scale equipment and mostly on different kinds of biofuels
- Domestic wood combustion covers a remarkable share of distributed heat production in Finland
  - The single most important source of particulate matter emissions, particularly in residential areas

5. Distributed energy production and emissions in air



Many common combustion-based energy producing solutions and techniques differ significantly with regard to the overall mass and number of particulate matter emissions per energy unit. Data source: STTV 2008.

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5. Distributed energy production and emissions in air

Legislation

- The current status of distributed energy production is rather ambiguous with regard to air pollution control legislation
  - Medium-sized combustion plants (MCPs; 1-50 MW) are covered by national legislation
  - The smallest-scale production (less than 1 MW) is not regulated
- Forthcoming EU-wide legislation will alter the situation
  - Ecodesign Directive defines the framework of prerequisites for all commercially available small-scale energy producing appliances
  - MCP Directive will most likely result in tightening up the current national legislation

6. Selected examples and potential solutions

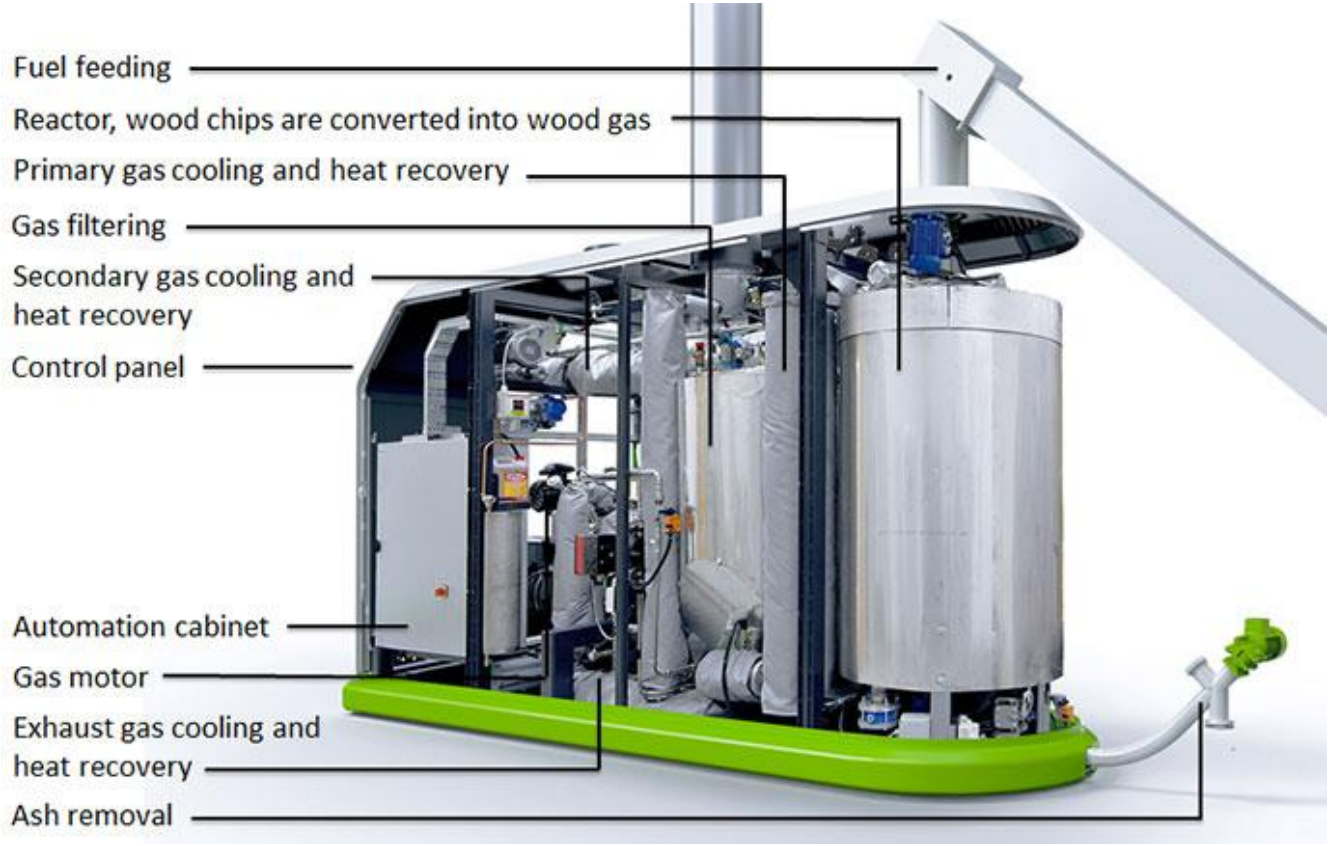
The “eco-village” in Kempele

- A project that aims at energy self-sufficiency and the utilization of local energy resources (i.e. wood-based biofuel)
- The “eco-village” comprises of an off-grid area with ten detached houses, a small-scale CHP plant and a windmill
- The wood-gasification-based CHP plant provides approximately 30 kW of electricity and 70 kW of heat
- The usage of electricity has been constrained (e.g. no electricity-based heating is allowed)
- In case of emergency, backup power plant and battery will provide electricity

6. Selected examples and potential solutions

The off-grid “eco-village” in Kempele with the windmill and the CHP plant in the foreground. Source: Volter.

6. Selected examples and potential solutions



A wood-gasification-based CHP unit from the “eco-village” in Kempele. Source: Volter.

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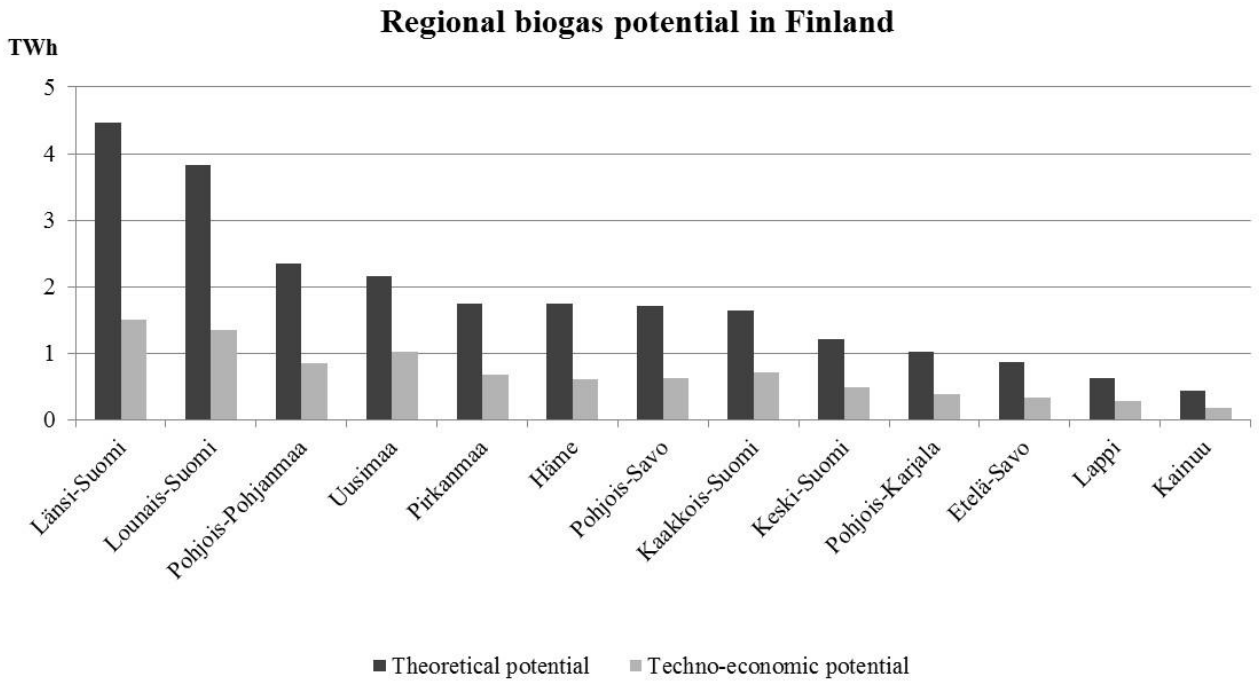
6. Selected examples and potential solutions

Biogas production in farm-based digester plants

- Farm-based plants are typically rather small-scale
  - Annual intake of feed material less than 5 000 t
  - Feed material (manure, plant material, food waste) may be collected from one or more nearby farms
  - The plant usually produces enough heat for the purposes of the farm, also electricity may be generated
- Produced biogas may be utilized as such (local heat or CHP production) or it may be refined further (for use in vehicle transportation)
- Most of the production potential in Finland focuses on the regions of intensive farming (roughly the western parts of Finland)

6. Selected examples and potential solutions



Regional biogas potential in Finland. The three most important regions (Länsi-Suomi, Lounais-Suomi, Pohjois-Pohjanmaa; highlighted in the picture) comprise an area of intensive farming. Source: Tähti & Rintala 2010.

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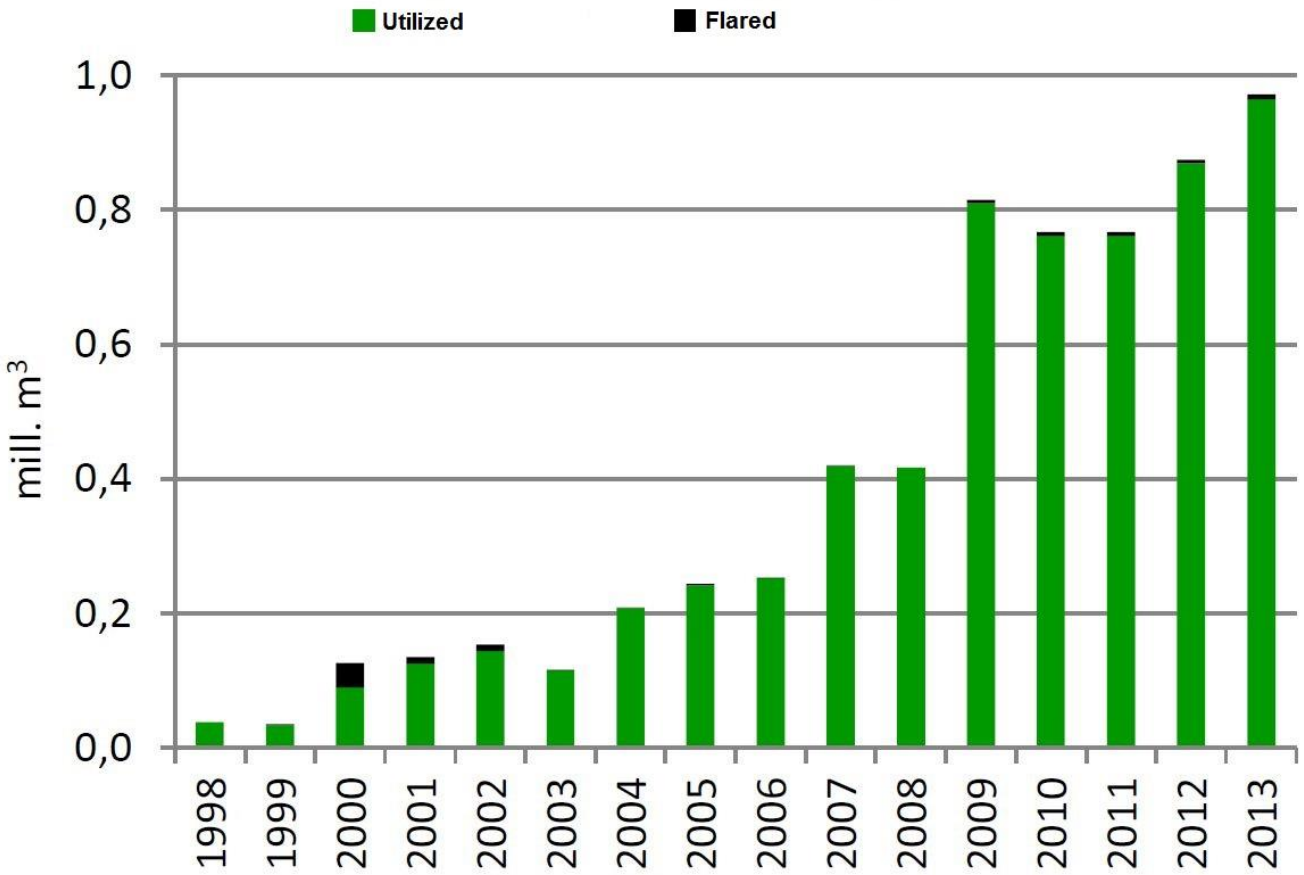
6. Selected examples and potential solutions



Biogas production in farm-based digester plants between 1998 and 2013 (millions of cubic meters). The produced biogas has been utilized very efficiently, as the amount of flared gas is remarkably low. Source: Finnish biogas plant register.

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