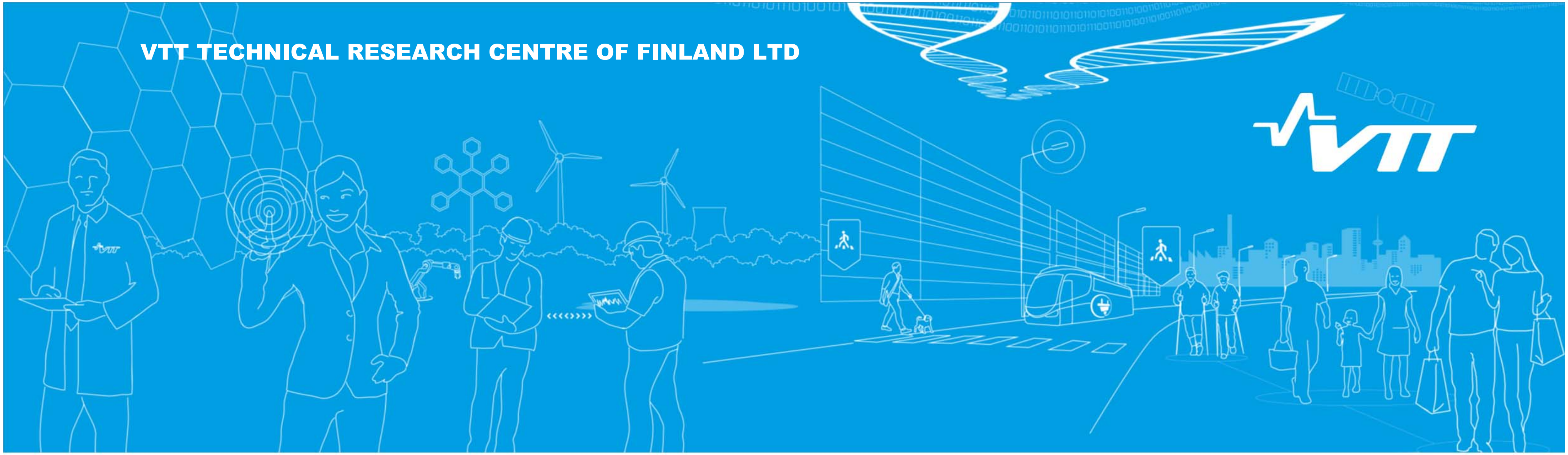


2030 climate policy calls for high RES penetration, can bioenergy offer storage and grid balancing opportunities ?

”Using bioenergy for energy storage and to balance the grid”

Brussels 9.11.2015

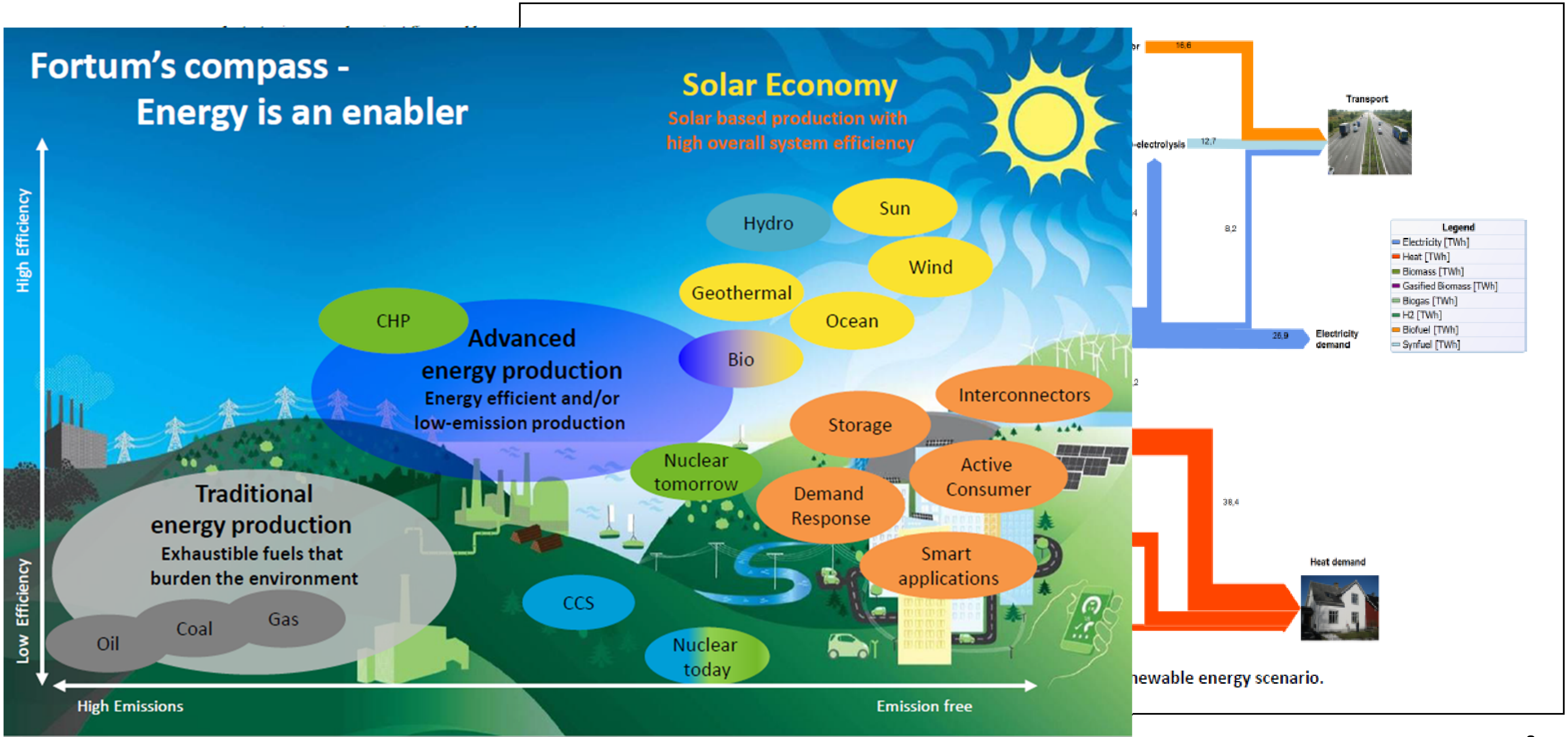
Kai Sipilä, Ilkka Hannula & Tiina Koljonen
VTT

Outline

1. EU 2030 policy - what impact on bioenergy market in heat, power and transportation fuels? No binding targets on RES on MS level, nor in transport by 2030. ETS and NETS, CO2 price?
2. Case Finland,Nord Pool electicity market, share/price of Nordic wind power ? 2030 study is boosting advanced biofuels in NETS
3. How biopower is produced today – and new solutions by 2030 ?
   - Utility co-firing, the price of carbon or future feed in tariffs by 2030 ?
   - Industrial and municipal CHPC+, storage and balancing capability
4. Bioenergy storage and balancing opportunities; solid/gas/liquid
5. Bioenergy sustainability and cascading – any limitations ?
6. Conclusions

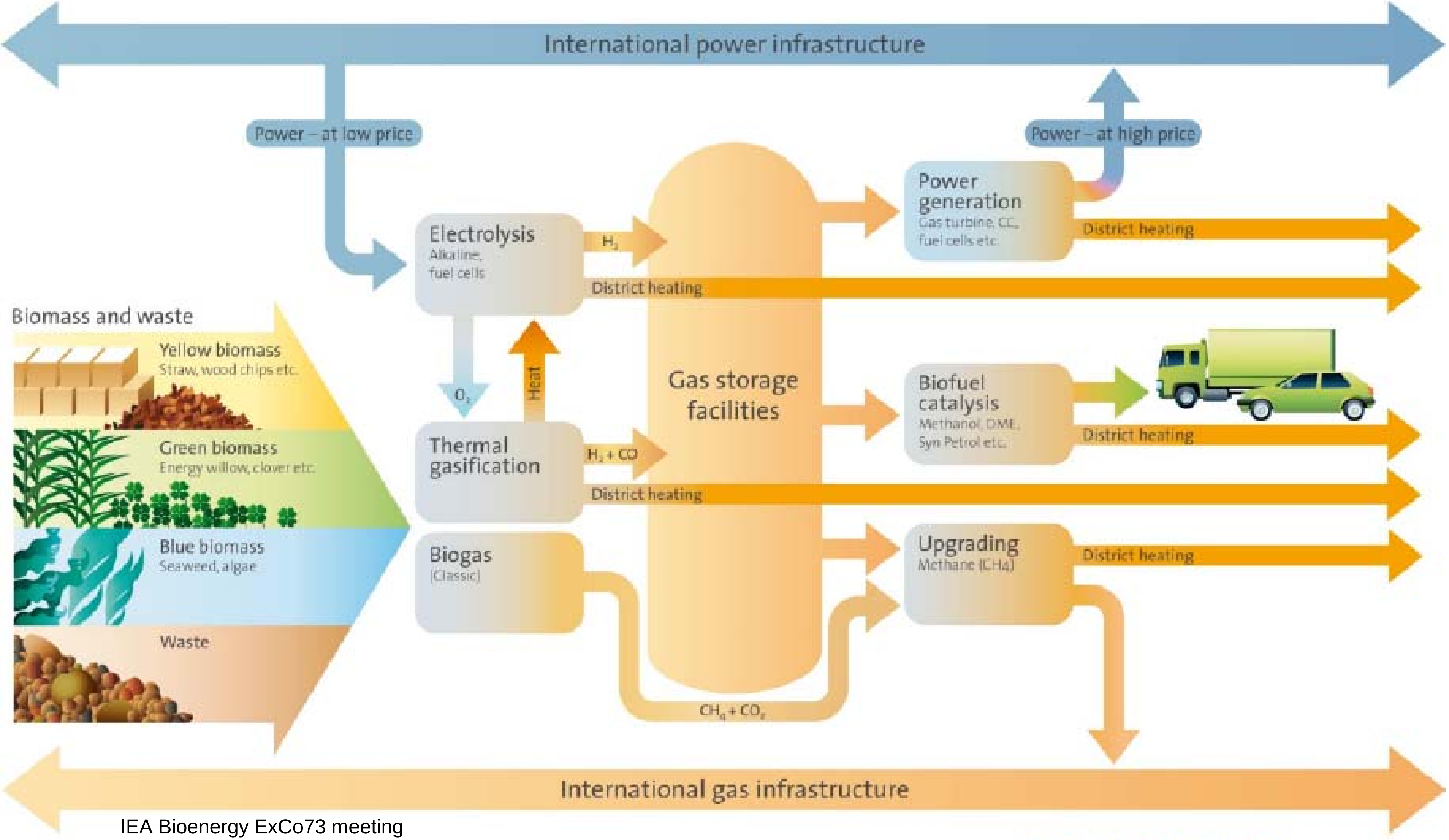
My personal interest started in 2011 and in the 2012 Climate conference of Danish EU Presidence

Coherent Energy and
Environmental System Analysis



How electricity, heat and gas can supplement one another in a fully renewable energy system

DK



IEA Bioenergy ExCo73 meeting
21 May 2014
Bodil Harder
Danish Energy Agency

ENERGI STYRELSEN

Current status - Gross EU electricity production by biomass 2013, GWh

	Total biomass	Municipal Waste (Renewable)	Solid biofuels excluding charcoal	Biogas	Biodiesel	Other liquid biofuels
EU28	157.264	18.641	81.502	52.837	26	4.259
AT	4.635	244	3.759	632	0	0
BE	4.913	657	3.354	775	16	110
BG	110	0	94	16	0	0
CY	49	0	0	49	0	0
CZ	4.061	84	1.683	2.295	0	0
DE	46.570	5.416	11.642	29.234	0	278
DK	4.337	875	3.073	390	0	0
EE	665	0	645	20	0	0
EL	216	0	0	216	0	0
ES	4.697	0	3.789	908	0	0
FI	11.993	395	11.458	140	0	0
FR	4.931	1.827	1.598	1.506	0	0
HR	124	0	48	77	0	0
HU	1.832	136	1.428	267	0	0
IE	485	69	229	187	0	0
IT	17.094	2.206	3.680	7.449	8	3.751
LT	357	19	279	59	0	0
LU	94	36	2	56	0	0
LV	501	0	215	286	0	0
MT	6	0	0	6	0	0
NL	5.956	2.076	2.899	980	0	0
PL	8.622	8	7.924	690	0	1
PT	3.053	286	2.517	250	0	0
RO	251	0	202	49	0	0
SE	11.449	1.701	9.609	20	0	119
SI	262	0	120	141	1	0
SK	911	21	677	213	0	0
UK	18.495	1.986	10.577	5.931	0	0

Aebiom yearbook

Gross electricity production from solid biomass in the European Union in 2012 and 2013 (TWh)*

Country	2012 Electricity only plants	2012 CHP plants	2012 Total electricity	2013 Electricity only plants	2013 CHP plants	2013 Total electricity
Germany	5.288	6.803	12.091	5.199	6.444	11.643
Finland	1.220	9.485	10.706	1.490	9.968	11.457
United Kingdom	7.008	0.000	7.008	10.577	0.000	10.577
Sweden	0.000	10.507	10.507	0.000	9.609	9.609
Poland	0.000	9.529	9.529	0.000	8.024	8.024
Spain	1.587	1.809	3.396	1.703	2.086	3.789
Austria	1.365	2.400	3.765	1.124	2.635	3.759
Italy	1.545	1.024	2.569	2.132	1.532	3.664
Belgium	2.609	1.076	3.684	2.218	1.136	3.354
Denmark	0.000	3.175	3.175	0.000	3.025	3.025
Netherlands	2.383	1.577	3.960	1.699	1.230	2.929
Portugal	0.786	1.710	2.496	0.736	1.780	2.516
Czech Republic	0.468	1.348	1.816	0.015	1.668	1.683
France**	0.039	1.586	1.625	0.069	1.529	1.599
Hungary	1.218	0.115	1.333	1.377	0.093	1.470
Slovakia	0.008	0.716	0.724	0.000	0.722	0.722
Estonia	0.374	0.611	0.985	0.030	0.615	0.645
Lithuania	0.000	0.176	0.176	0.000	0.279	0.279
Romania	0.053	0.140	0.193	0.000	0.263	0.263
Ireland	0.164	0.020	0.184	0.215	0.014	0.229
Latvia	0.006	0.059	0.065	0.007	0.208	0.215
Slovenia	0.000	0.114	0.114	0.000	0.119	0.119
Bulgaria	0.000	0.065	0.065	0.000	0.065	0.065
Croatia	0.000	0.037	0.037	0.000	0.048	0.048
Luxembourg	0.000	0.000	0.000	0.000	0.002	0.002
European Union	**26.122**	**54.082**	**80.204**	**28.591**	**53.093**	**81.684**

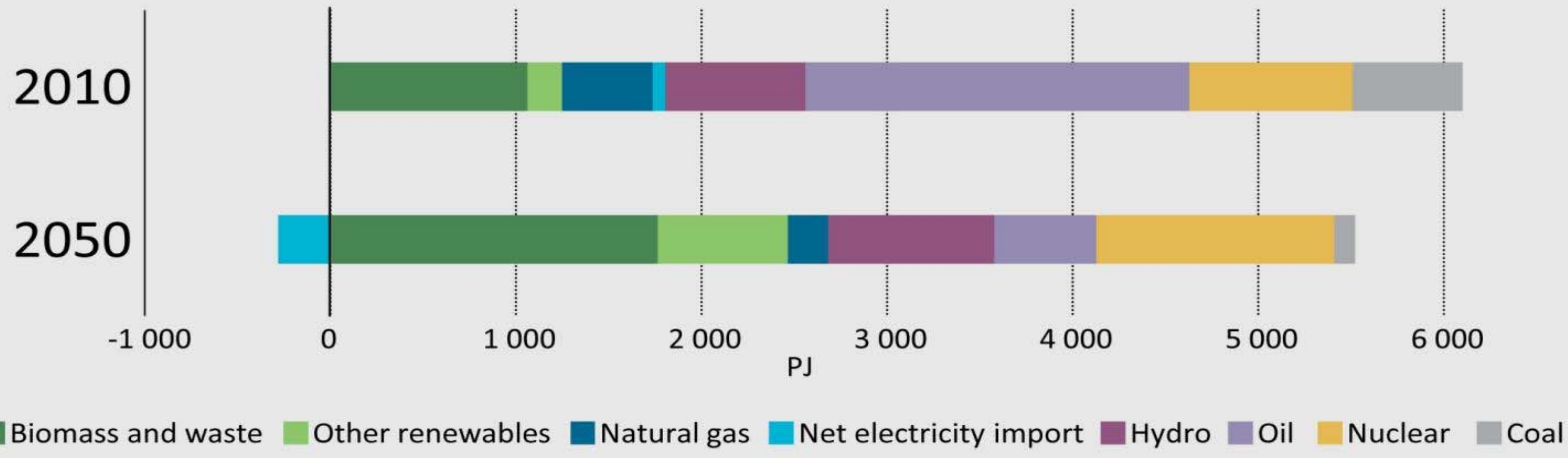
** Estimate. ** Overseas departments not included for France.* ***Source: EurObserv'ER 2014***

CHP

EurObservÉR 2014

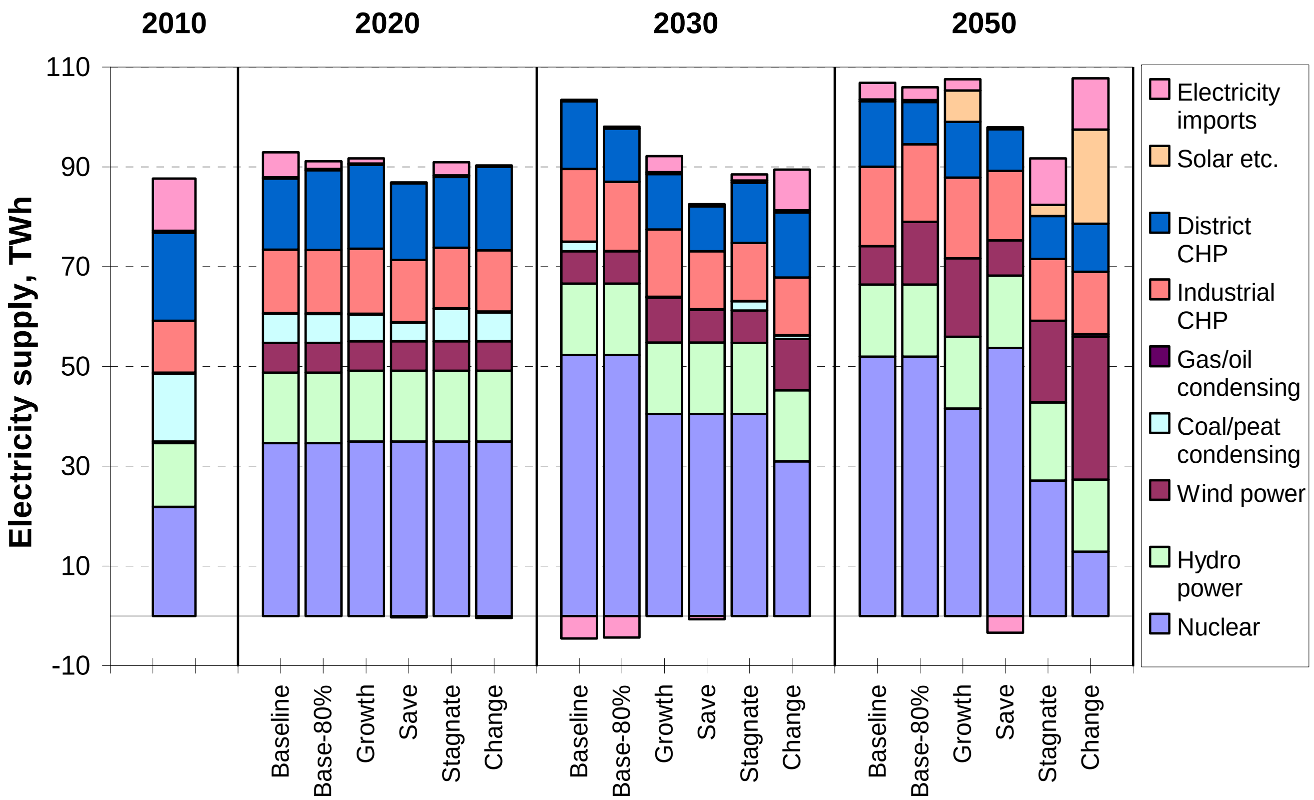
Nordic total primary energy supply in the Carbon-Neutral Scenario

http://www.nordicenergy.org/project/nordic-energy-technology-perspectives/



Biomass replaces oil to becomes the largest energy source, growth in wind power contributes to net electricity export in 2050

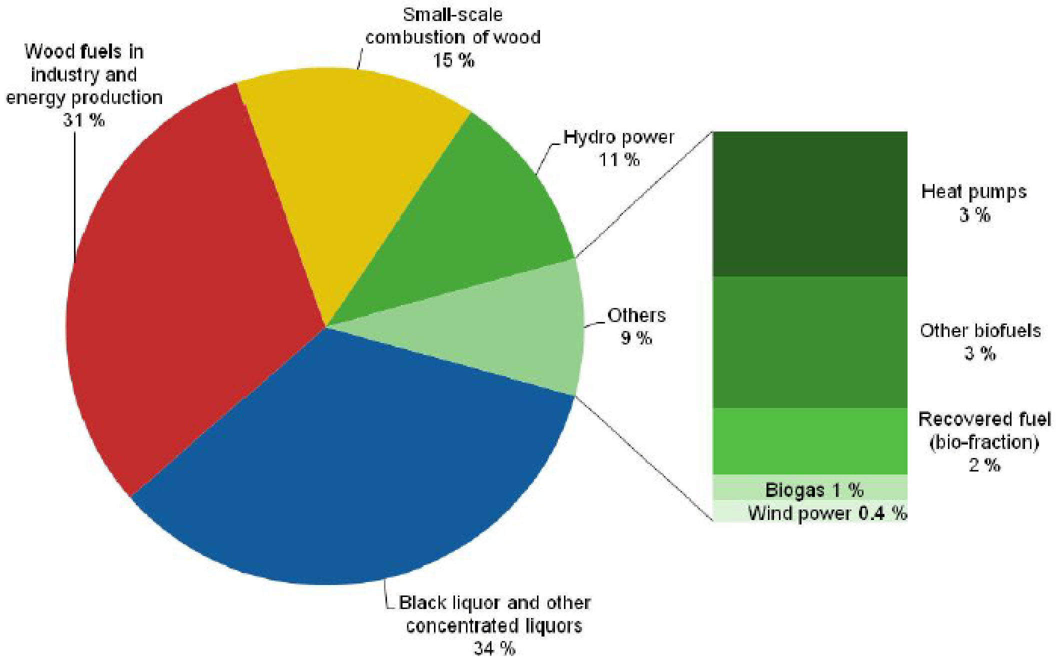
- The change scenario included app. 45% solar & wind from total electricity demand
  - Modelling of storages in TIMES
  - No new nuclear
  - Structural changes of the industrial and residential sectors
  - Optimistic scenarios for cost development of solar and wind

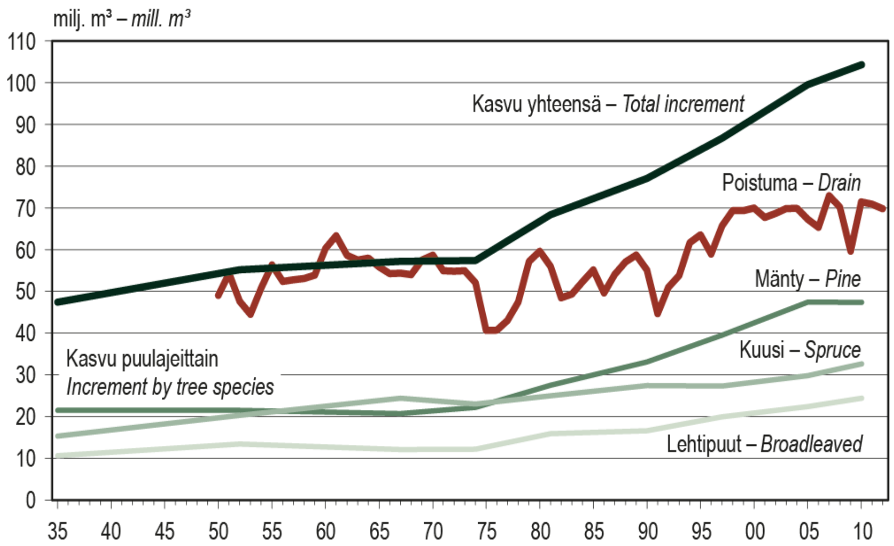


The 2020 RES target for Finland is 38% from final energy consumption, which is reached mainly by increasing the use of wood energy from mill and forest residues

A long tradition of sustainable forest management has doubled the growth of the Finnish forests

Consumption of renewable energy sources 2011





Lähde: Metsäntutkimuslaitos – *Source: Finnish Forest Research Institute*

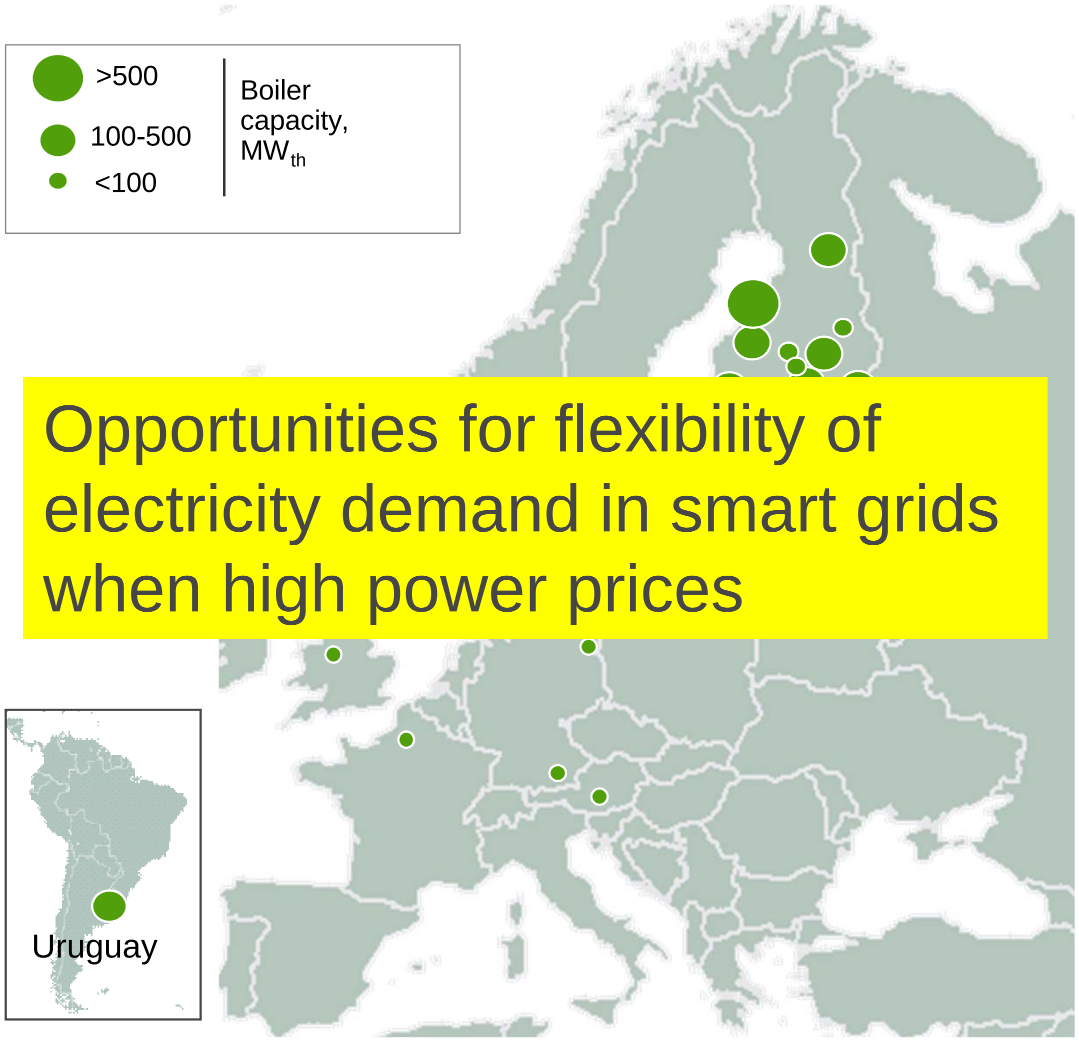
Puuston kasvu ja poistuma
Annual increment of growing stock and drain

Metsätilastollinen vuosikirja 2013

Forest Industry CHP is a major player in biomass-based energy generation…

The Biofore Company UPM

- UPM operates over 1,000 MWe of biomass capacity
- **UPM is the second largest biomass-based electricity generator in Europe**
- We have invested € 1,4 billion in biomass-based renewable energy at the production sites since 2000 doubling the capacity
- 13 new and modern biomass- based CHP plants
- A new CHP plant is starting up in Germany in 2014



Opportunities for flexibility of electricity demand in smart grids when high power prices

VTT (VTT Technical Research Centre of Finland) is an internationally networked, multi-technological research centre that produces high-quality technological solutions and innovation services for its customers. VTT contributes to the international competitiveness of its customers, and thus promotes sustainable development, employment and well-being in society. Every third Finnish technology innovation includes VTT know-how. There are 2,900 experts from various fields working at VTT. VTT's annual turnover is EUR 320 million. VTT's main offices are located in Espoo, Tampere, Oulu and Jyväskylä.

PRESS RELEASE
Free for publication on 16 June 2014 at 1 p.m.

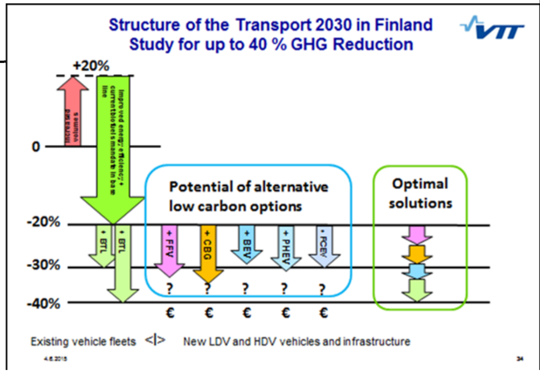
Increase in the Use of Biofuels the Most Cost-Effective Way for Finland to Achieve the Goals of the EU's 2030 Climate and Energy Package

VTT and the Government Institute for Economic Research (VATT) have completed a study commissioned by the Ministry of Employment and the Economy and the Ministry of the Environment, assessing the impact of the EU's 2030 Climate and Energy Framework on Finland's energy system and national economy. The increased use of second-generation biofuels in road transport would provide Finland with the most cost-effective way of achieving the greenhouse gas emissions goals presented in the policy framework for the sector outside of the emissions trading system. The impact on the national economy caused by the policy framework is estimated to remain moderate, although there are still uncertainties in the estimates.

In January 2014, the European Commission published an policy framework concerning the 2030 climate and energy policy goals, where a 40% reduction in greenhouse gas emissions is proposed for 2030 compared to the emissions in 1990. With regard to the EU's emissions trading sector (EU ETS), the reduction goal is 43%, and for sectors outside the emissions trading sectors it is 30% from the 2005 level.

In the project implemented by VTT and VATT, the impact of the emission goals on Finland's energy system and the national economy was assessed. In the project, calculations were made using three different scenarios, where Finland's emission reduction goal was 32, 36 or 40 per cent in the sectors outside the EU ETS, which inclide transport, building heating, waste treatment, agriculture, and some industries. In the emissions trade sector, the price of an emission right was assumed to rise to the level of EUR 50/t CO_2 due to the proposed EU policy. VTT made the calculations using the TIMES-VTT energy system model, where the greenhouse gas reduction measures are presented by sector.

Biofuels comprise up to 40 per cent of transport



TECHNOLOGY • RESEARCH • HIGHLIGHTS • VISIONS • SCIENCE
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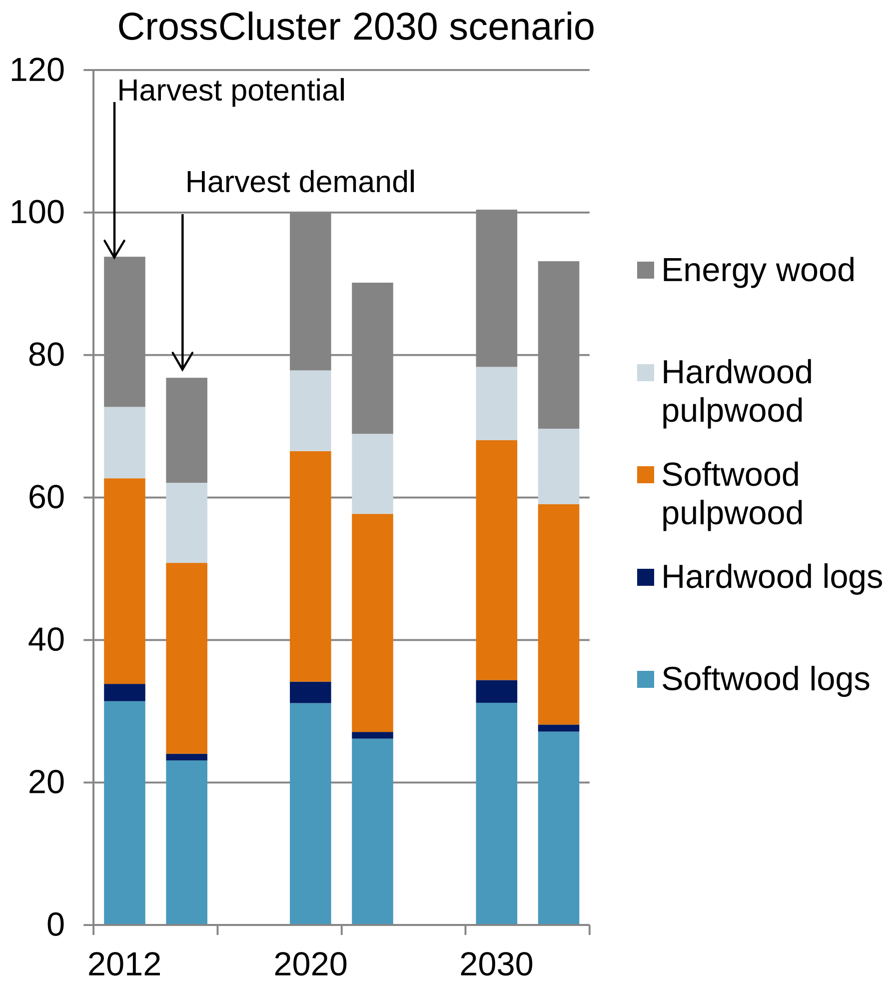
EU:n 2030 -ilmasto- ja energiapaketin vaikutukset Suomen energiajärjestelmään ja kansantalouteen

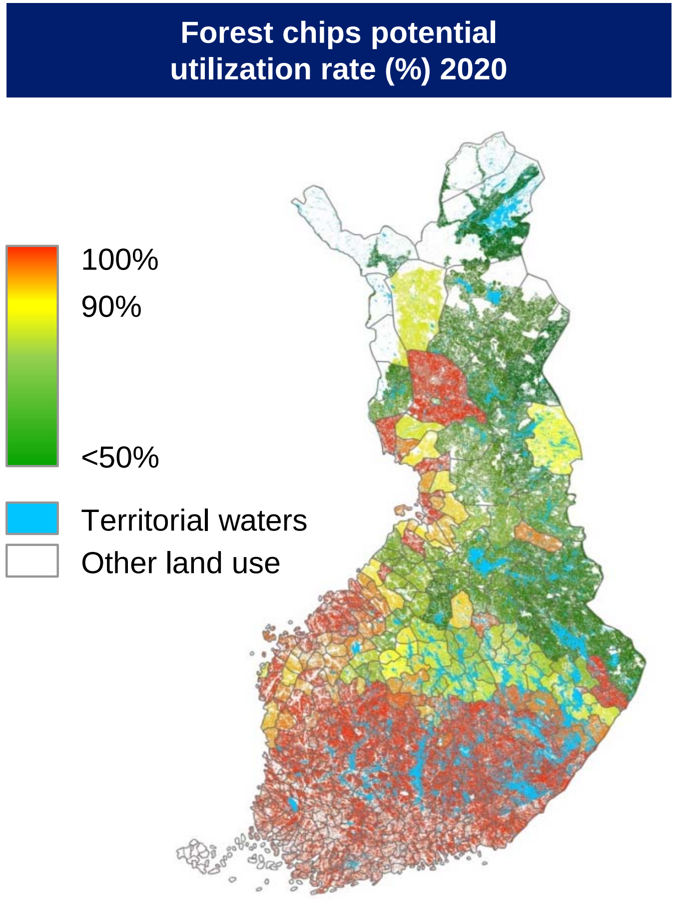
Taustaraportti

Tiina Koljonen | Esa Pursiheimo | Antti Lehtilä | Kai Sipilä | Nils-Olof Nylund | Tomi J. Lindroos | Juha Honkatukia

FINNISH WOOD BALANCE – MAXIMIZING CASCADING

Wood balance in Finland is expected to be tight when approaching 2030





Bioenergy technology offerings;

1. Biomass pellet, TOP and bio-oil **cofiring** and co-gasification **in PC boilers** – various units in operation (> 50 PC boilers in EU)
2. Multifuel **fluid bed boilers**, BFB and CFB, 0-100 % of biomass
3. Cofiring in **gas turbines and/or engine** power plants gas/liquid, tested and some units in large scale operation, many in small scale
4. Which requirements/paying capability of balancing the grid or energy storage ? Or bioenergy products on ETS and/or NETS ?
5. **Heat production (+solar)** in small, medium and larges scale boilers,
6. Coal/Bio+SolarPower; CSP and fluid bed boiler (in Spain)
7. **Biogas and P2G in natural gas grid**; storage and balacing power
8. Production of **liquid biofuels** by syngas-BTL or fast pyrolysis, doupling of gasification-BTL output boosted by P2G/L
9. **Premium quality solid biomass** by waste (+solar) heat drying/pellet

Flexibility is the key

- Integrating wind power and PV is less costly if one can:
  - Balance large areas – wind power variability and uncertainty decrease with increasing spatial scale
  - Act few hours ahead – forecast errors decrease considerably
- Increase flexibility:
  - Transmission capacity – also for balancing
  - Reservoir hydro power is flexible – within the reservoir limits
  - Thermal power plants are flexible – part-load operation somewhat less efficient, and engines better than gas turbines
  - District heating systems can offer strong flexibility (electric boilers, heat pumps, large heat storages, cooling)
  - Markets in the future: demand side flexibility, more liquid intra day markets, shorter gate closures

Source: Juha Kiviluoma

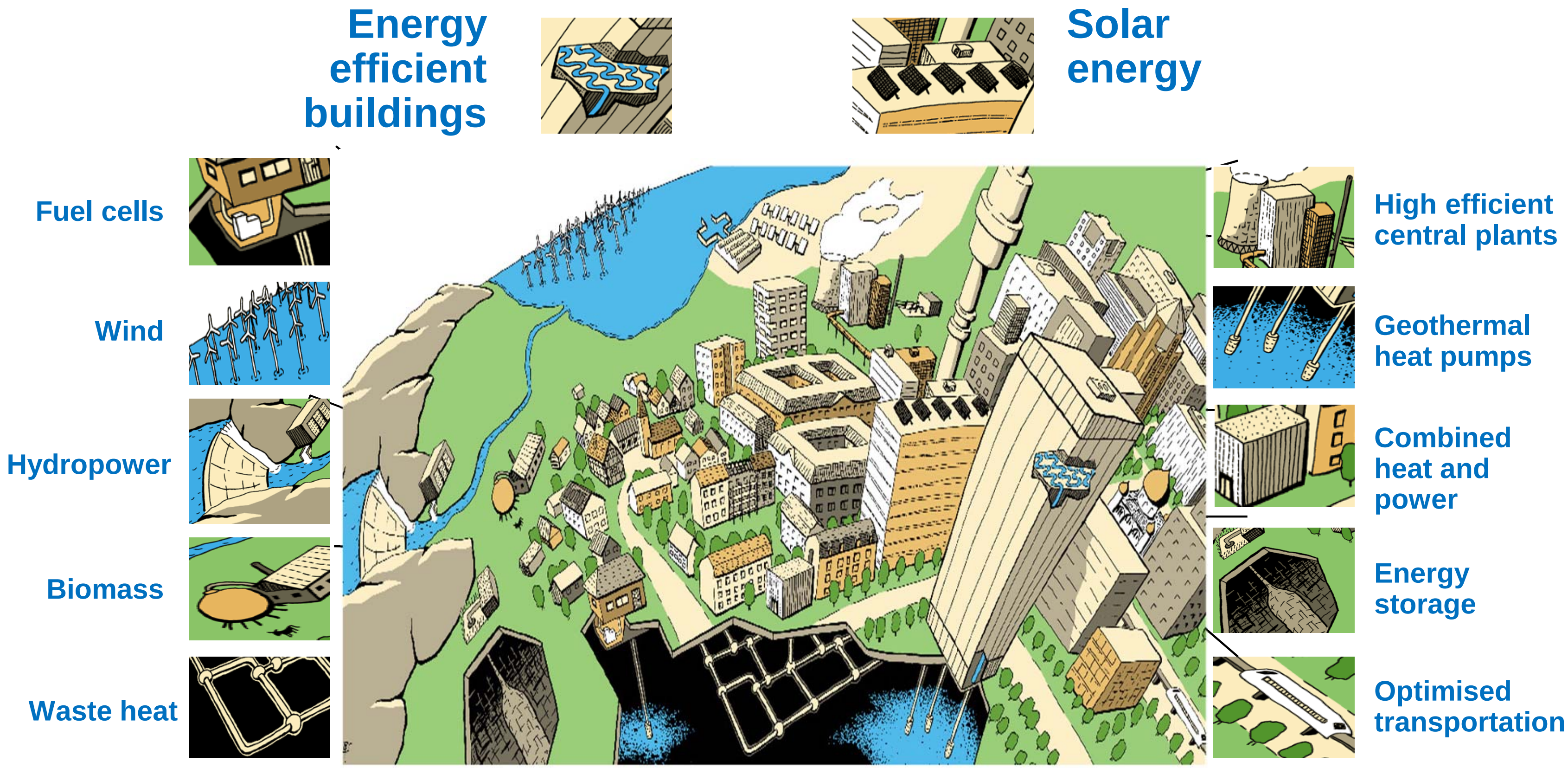
What is the value of flexibility?

- A central question to be modelled and analysed is the value of flexibility in the current and future systems:
  - What is the value of flexible generation?
  - What is the value of flexible demand?
  - What is the value of energy storage?
  - What is the value of combination of these options.

- Challenge: The value of flexibility should be considered on different levels:
  - Different operational time scales, in different geographic regions, and in different market regions.
  - The distribution of the value of flexibility to the different participants in energy systems is also an important question.

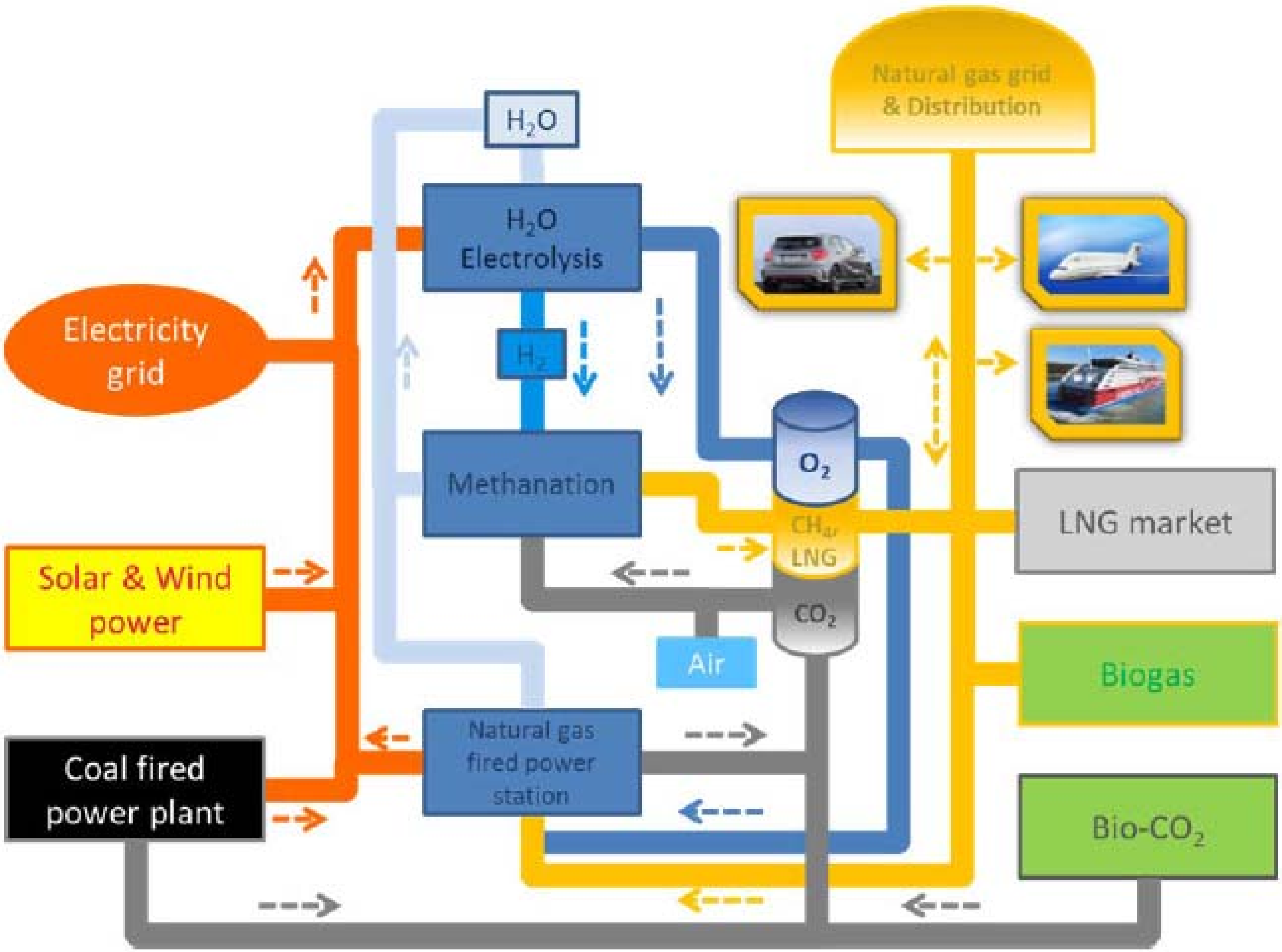
Example: A sustainable district

... is attained by a combination of existing technologies that can be used in the specific local context to achieve the required level of energy consumption.



Economic efficiency by integrated system optimisation

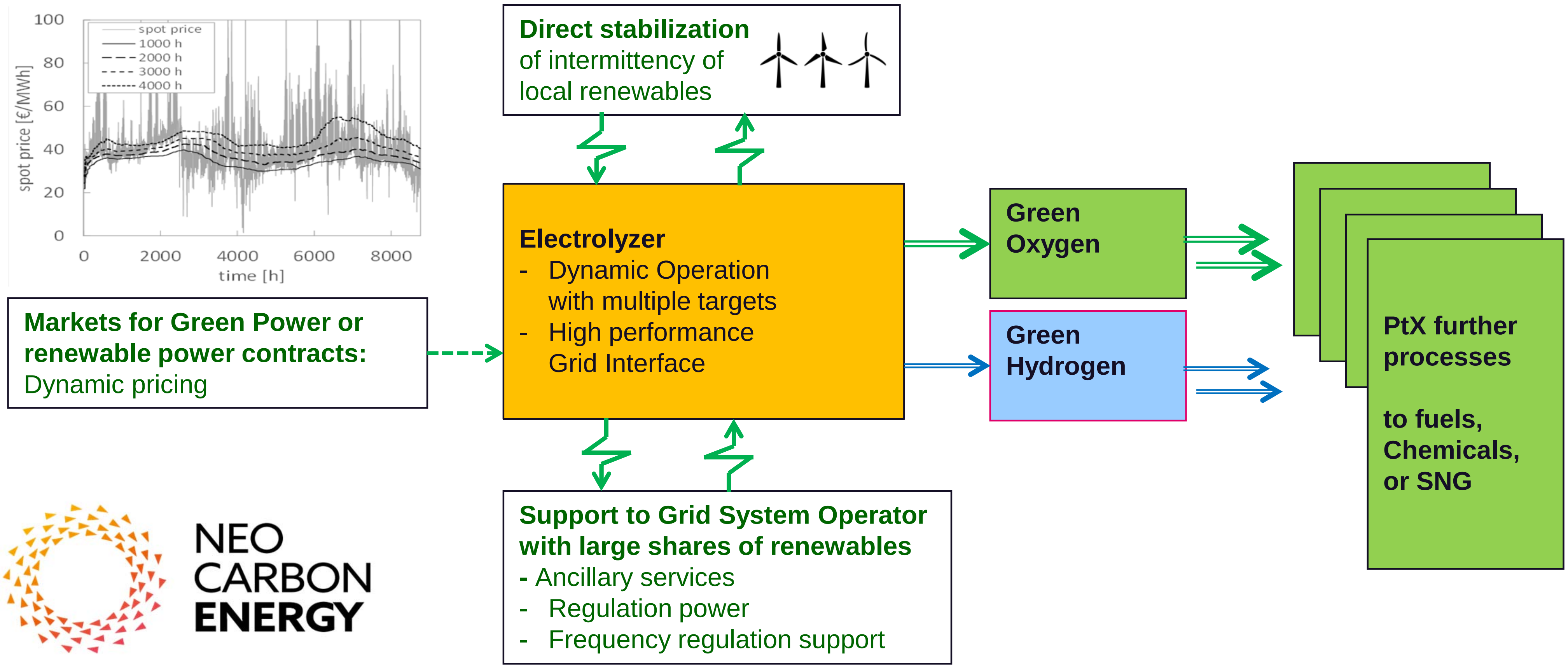
Methane economy (P2G)



PtX Electrolyzer Operation Optimization for power grids with large share of intermittent renewables

Why:

- Increased operational profitability in dynamic power grid environments with large shares of intermittent renewables.
- Define **Green Hydrogen** and **Green Oxygen** production, prerequisite for **100% Green Fuels**



NEO CARBON ENERGY

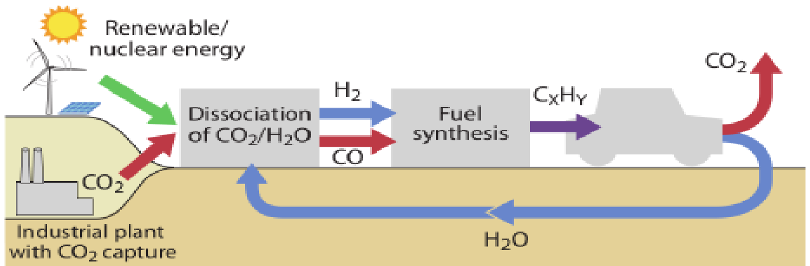
Methane,
Diesel
Gasoline

Assesment of solid wood based transportation fuels, and P2G costs in Finland 2030 - Ilkka Hannula, VTT

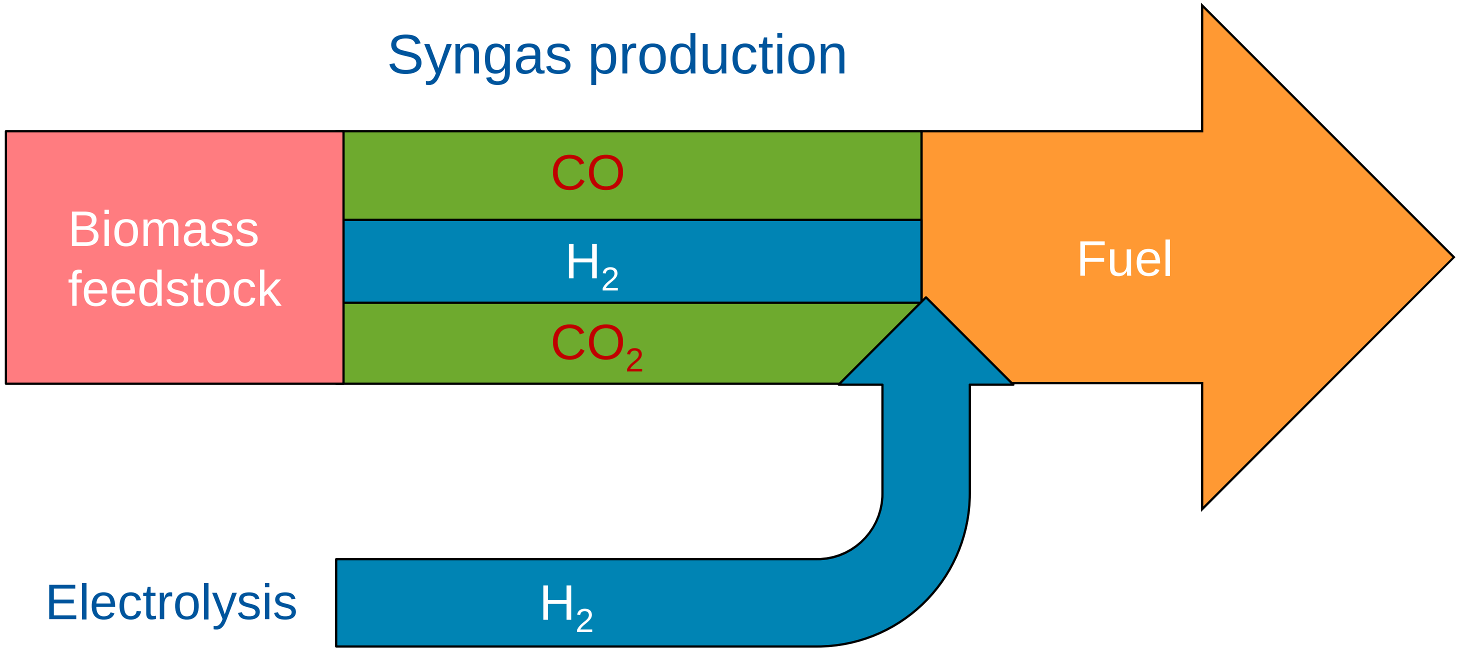
	€/MWh	€/GJ	€/toe	€/t$_{\text{-g-ekv}}$	€/L$_{\text{g-ekv}}$
Biomethane forest residues	64	18	**792**	901	**0.57**
Biomethanol	74	21	**924**	418	**0.66**
bio-FT/MTG	81	23	**1012**	1012	**0.73**
biohydrogen	58	16	**669**	1919	**0.52**
P2G methane	133	37	**1628**	1851	**1.19**
P2G methanol	144	40	**1760**	796	**1.29**
P2G FT/MTG	173	48	**2112**	2112	**1.55**
P2G hydrogen	96	27	**1129**	3239	**0.86**
Hybridimethane	82	23	**1012**	1151	**0.73**
Hybridimethanol	88	24	**1056**	477	**0.79**
hybridi-FT/MTG	99	28	**1232**	1232	**0.89**

Based on assumption; Fuel production output 200 MW (~140 000 toe/a), biomass price 18 €/MWh, electricity 50 €/MWh, CO_2 40 €/t. g-ekv = gasoline equivalent

Ilkka Hannula, Co-production of synthetic fuels and district heat from biomass residues, carbon dioxide and electricity: Performance and cost analysis, Biomass and Bioenergy, Volume 74, March 2015, Pages 26-46, ISSN 0961-9534, http://dx.doi.org/10.1016/j.biombioe.2015.01.006.



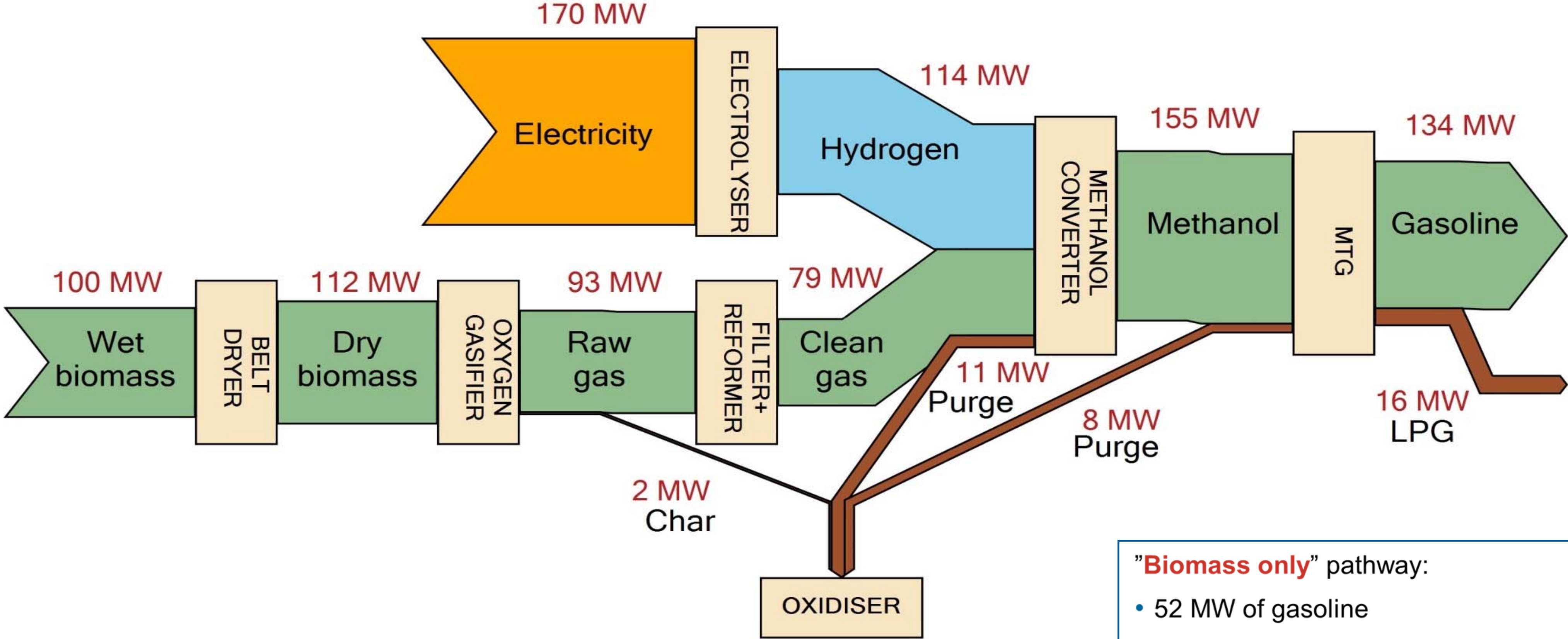
P2G Boosted Syngas Process: Despite challenges related to CO_2 hydrogenation, the potential increase in fuel output is significant.



Methane
Methanol
FT diesel
Gasoline
BioJet
Chemicals

Source: Ilkka Hannula

Douple output - Gasoline via enhanced oxygen gasification



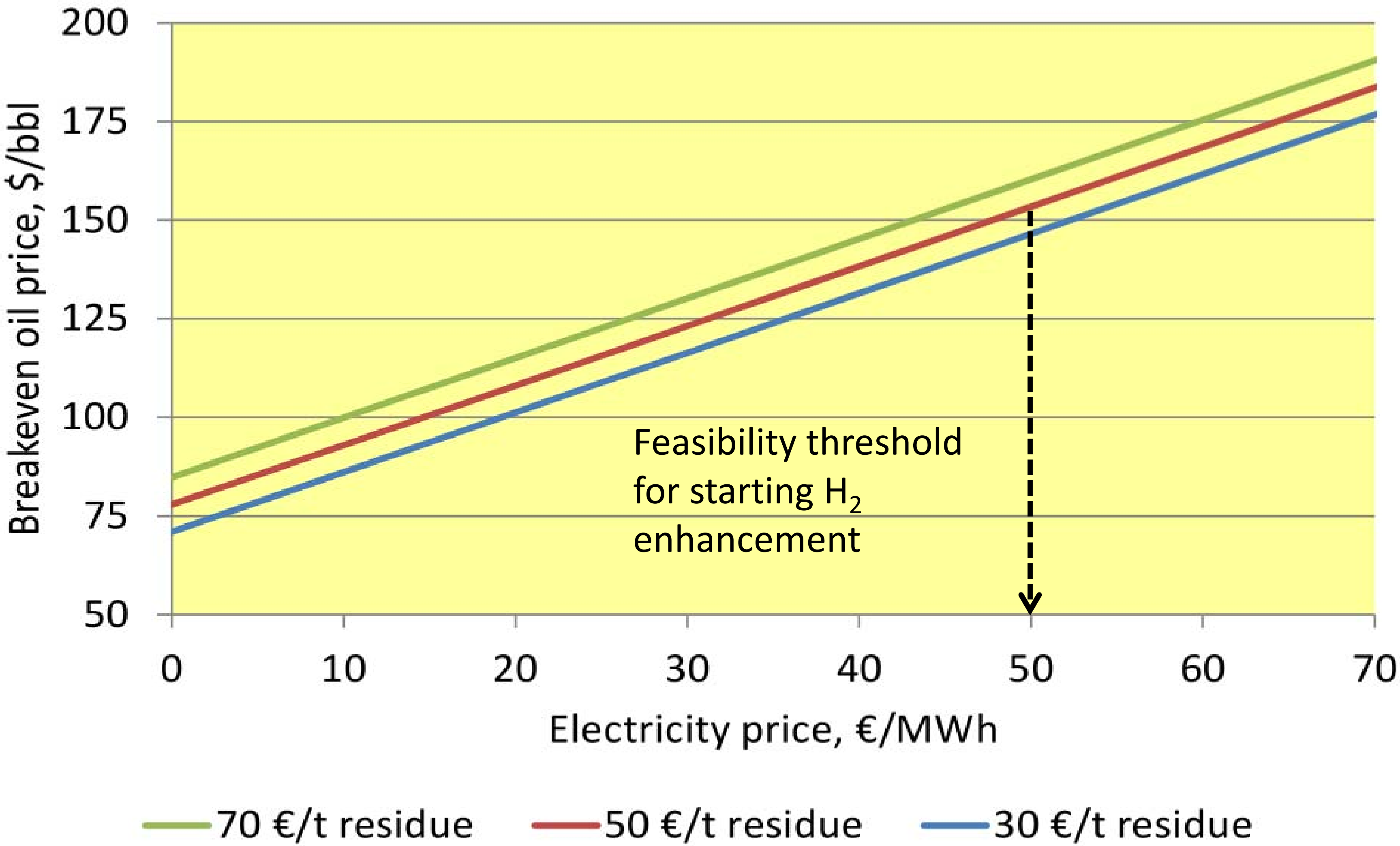
"**Biomass only**" pathway:

- 52 MW of gasoline
- 31 % carbon utilisation

Bioenergy **with hydrogen** supplement:

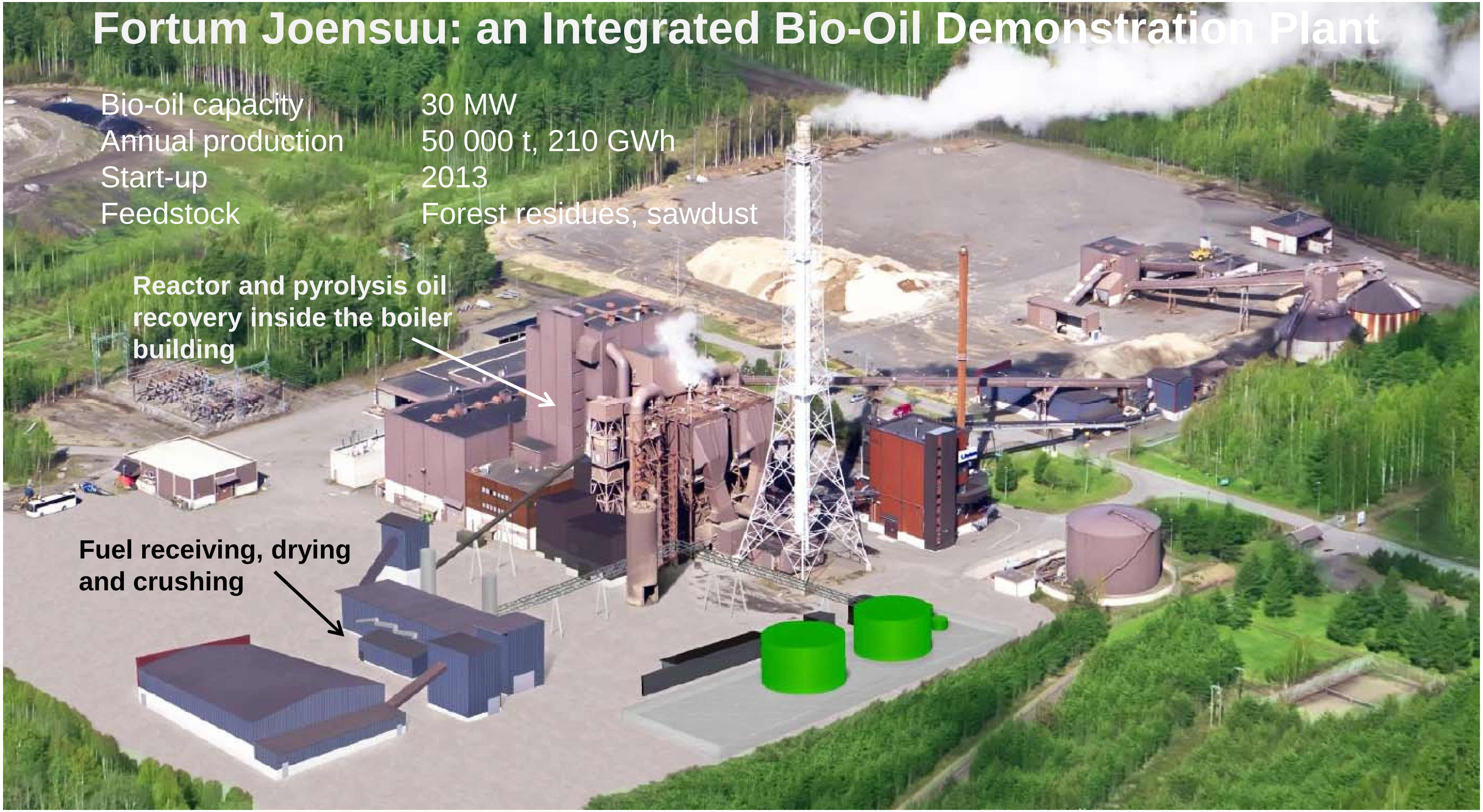
- 134 MW of gasoline
- 79 % carbon utilisation

Source: Ilkka Hannula

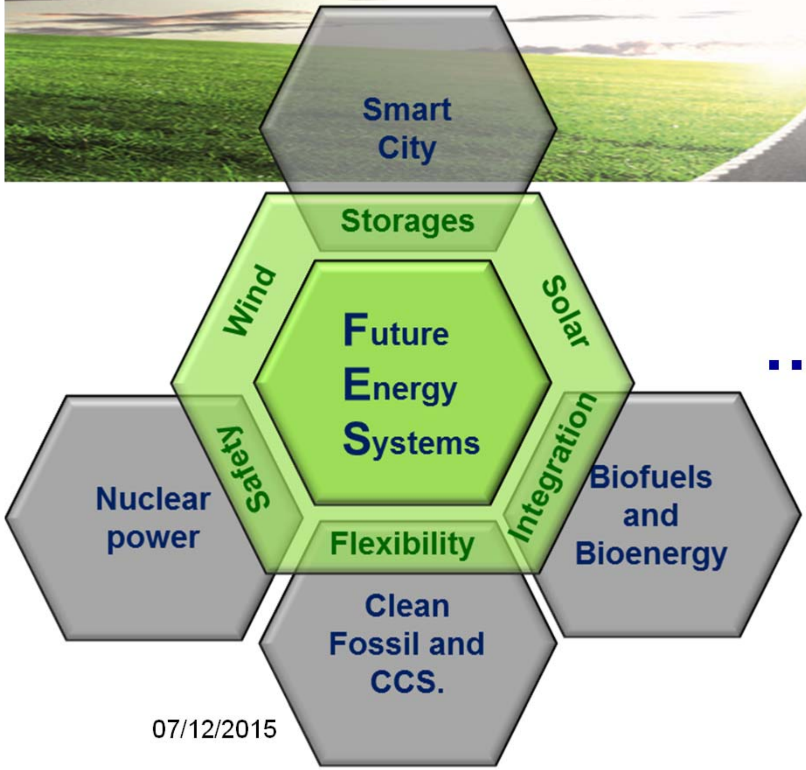


200
175
150
125
100
75
50
Breakeven oil price, $/bbl
0
10
20
30
40
50
60
70
Electricity price, €/MWh
Feasibility threshold
for starting H_2
enhancement
70 €/t residue
50 €/t residue
30 €/t residue

Case: Wood fuel oil for oil boilers and turbines/engines



Energy system transition is here …



… how does it effect in Your market place?

Thank you !

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