LUT
Lappeenranta
University of Technology

Energy Systems Developments

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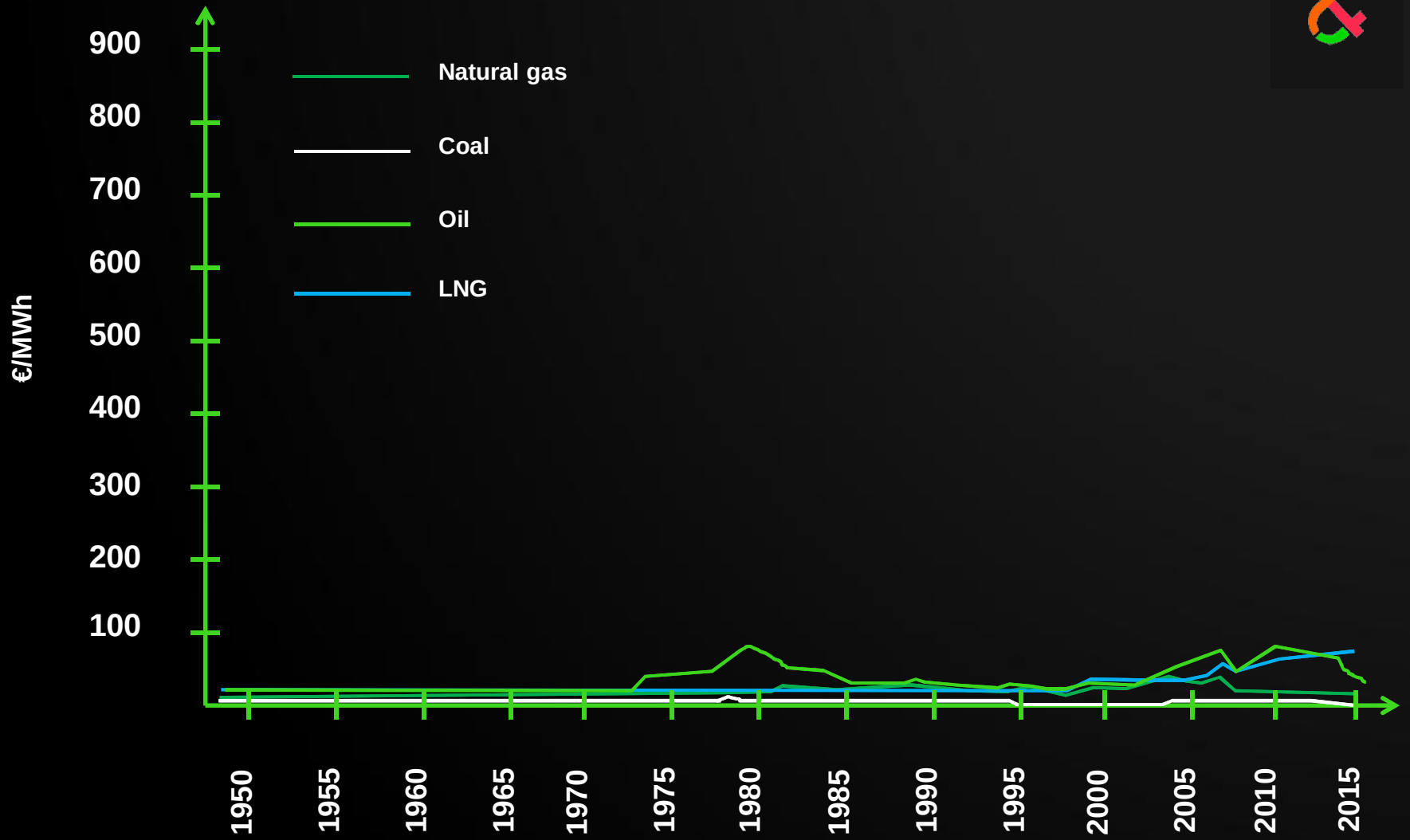
Energy Market – Driving Forces

Recarbonization

Mass production based technology

Weather dependent power production with low operational costs



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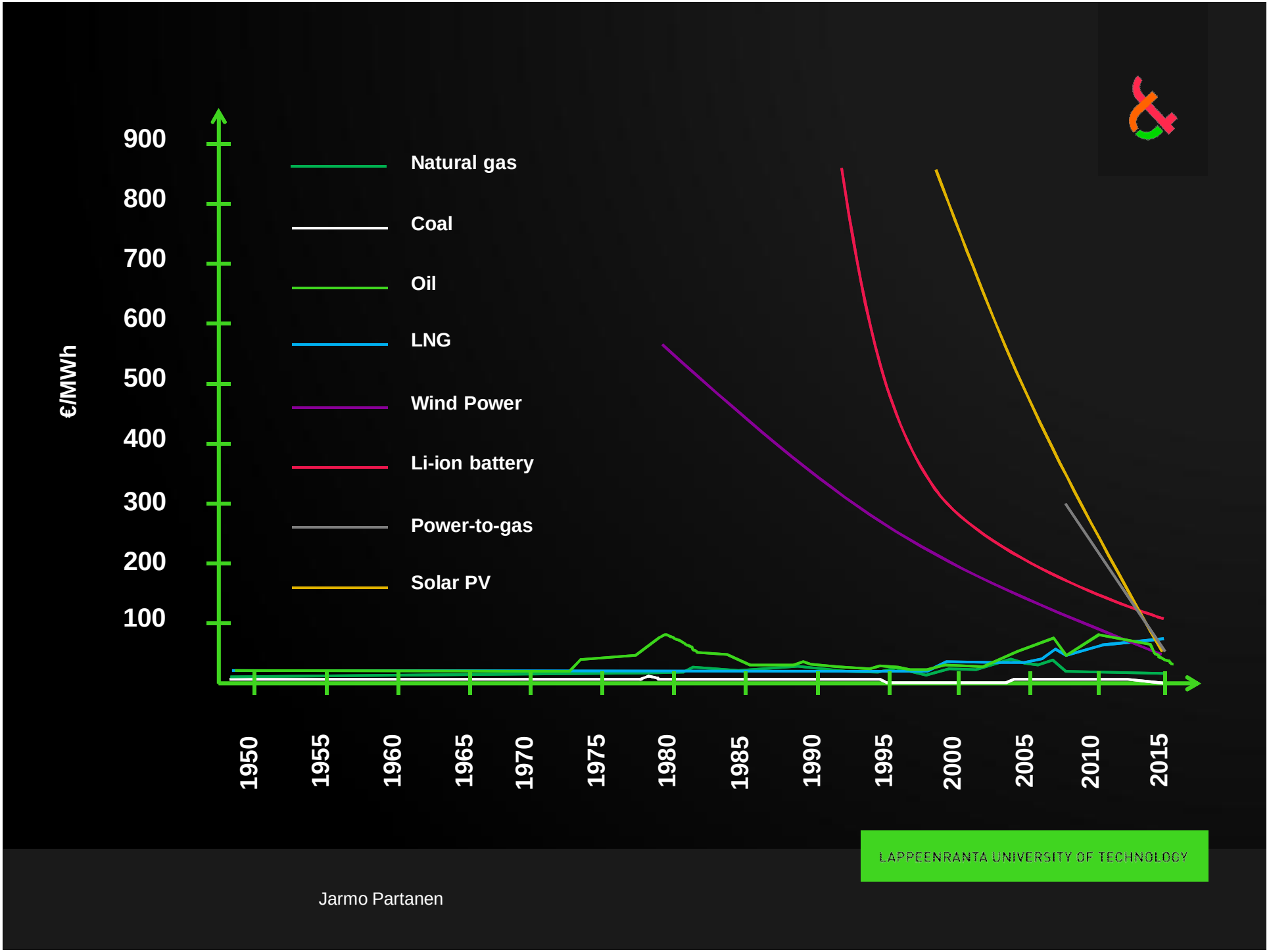

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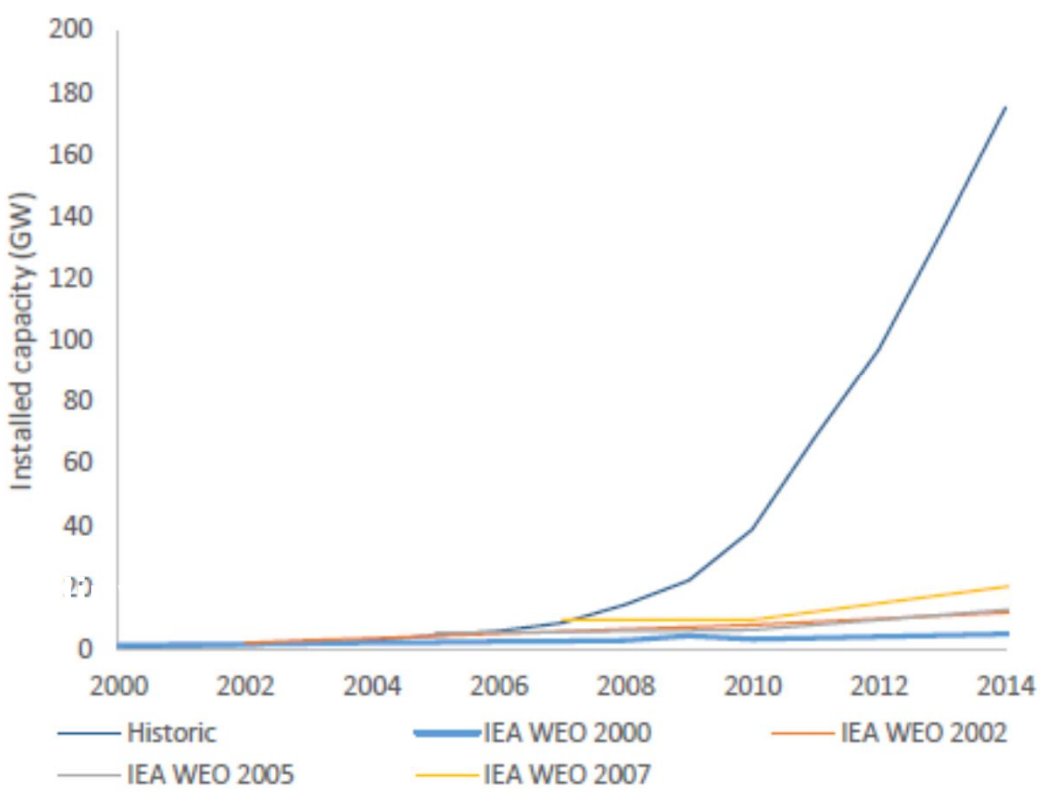
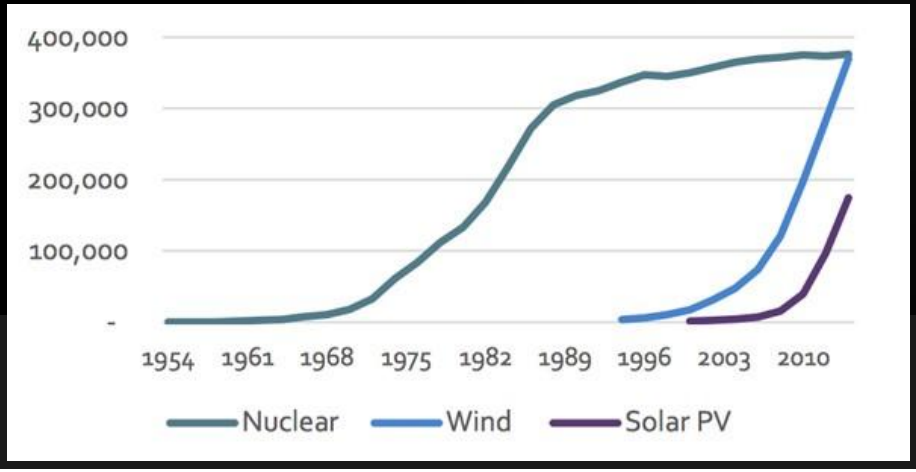
Jarmo Partanen

Growth of PV has suprised all experts

Wind power is most affordable way (LCOE) to produce electricity in many areas

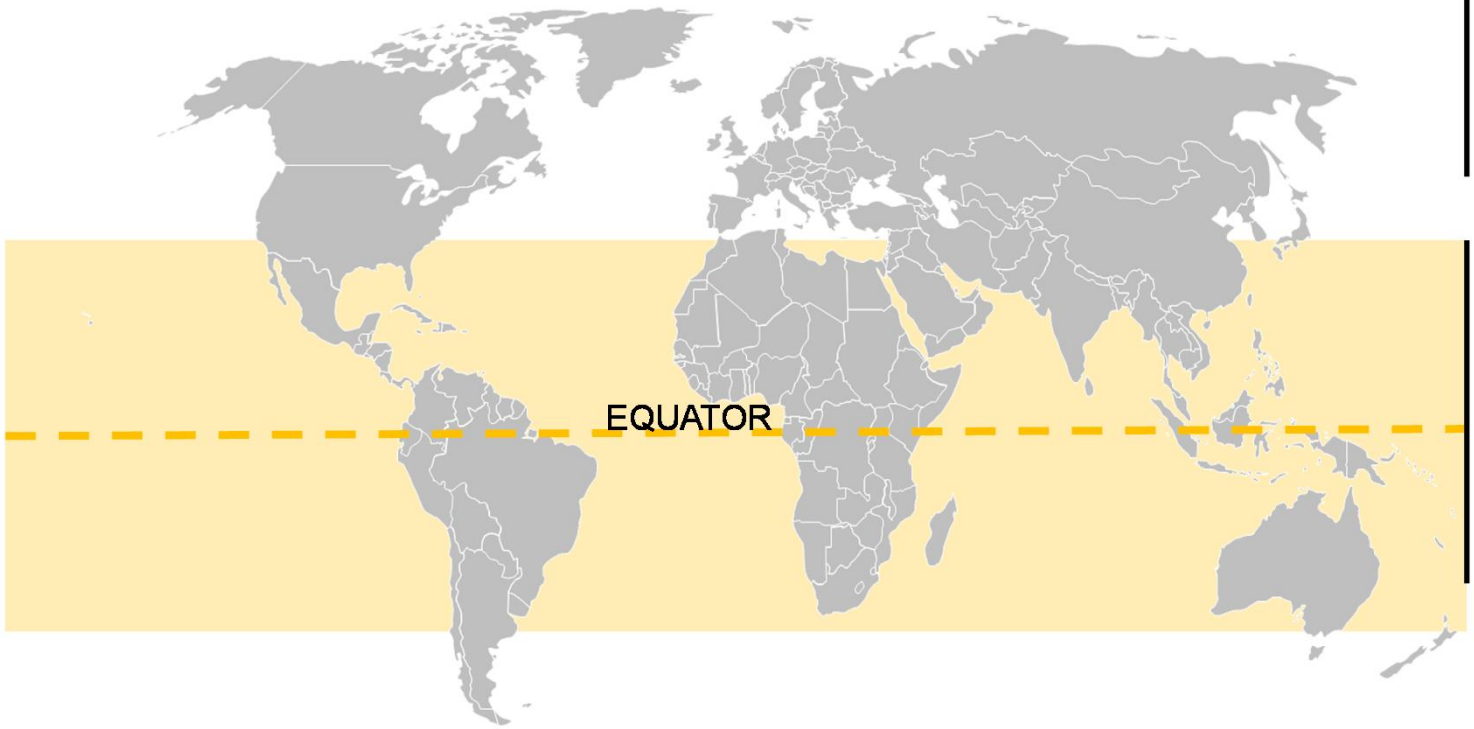
Figure i.1: IEA solar PV capacity forecasts against actual





Future energy system features:

- **Security of Supply** a limited resource
- **Energy** a non limited resource



- Clear Seasonality
- Wind most competitive
- Intermittent power

- Low seasonality
- PV most competitive
- Intermittent power

NOTE: Solar and wind resources and CAPEX may largely vary by individual projects, even on same region, thus impacting LCOE. Hence, figures are indicative and do not aim to present our geographical preferences for given technologies but rather illustrate progress of wind and solar globally, long-term.

PV LCOE assumptions based on EU PV Technology Platform report and EU PVSEC 2015 paper (lead author Fortum solar technology manager Dr. Eero Vartiainen)

LCOE assumptions:

- 7% real WACC
- CAPEX, OPEX globally uniform; lifetime solar 30y, wind 25y
- Wind and solar: internal assumptions that solar utilisation to increase by 7,5% and wind by 15% from 2016 to 2030
- Uniform 20% corporate tax assumed

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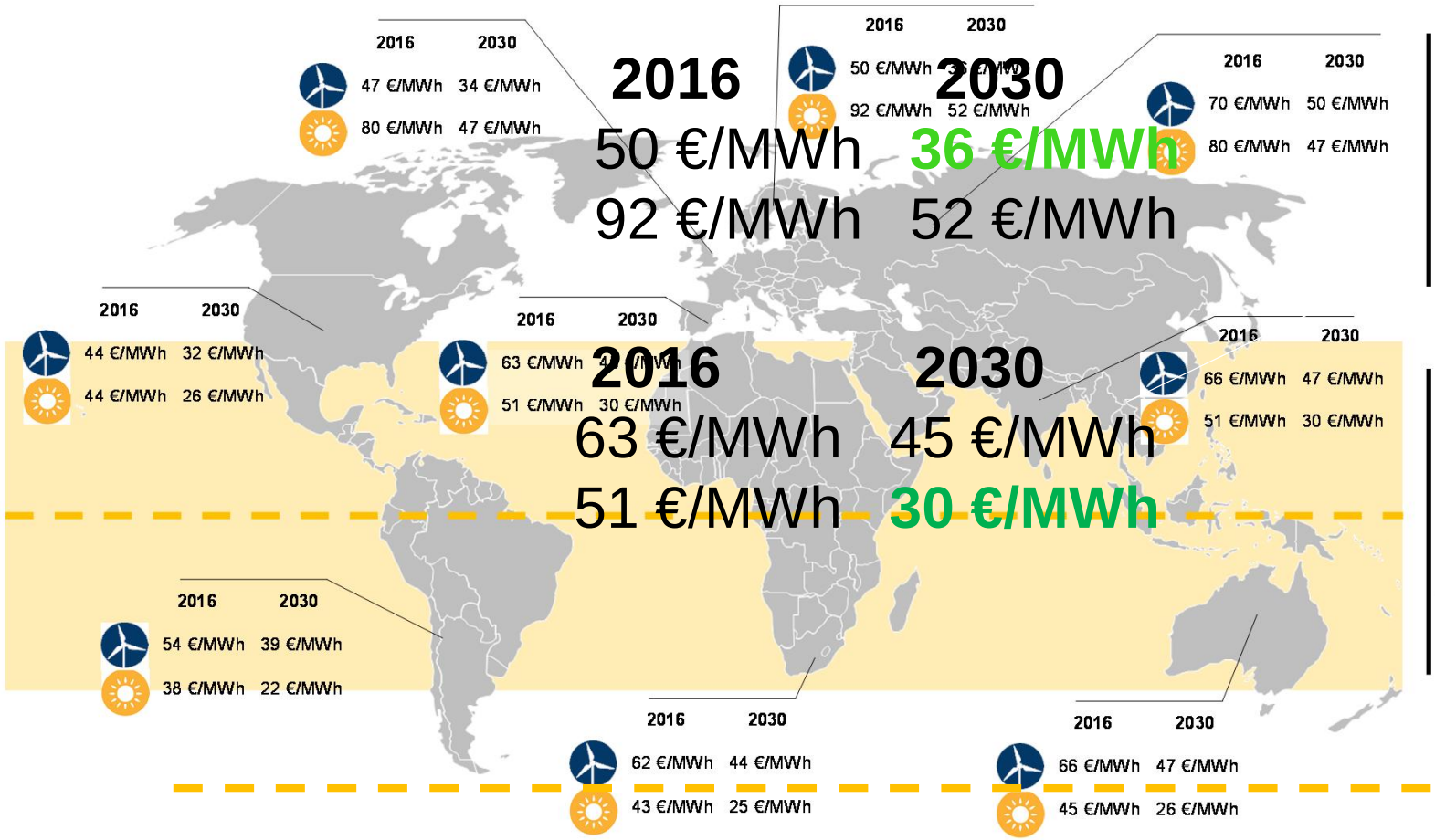

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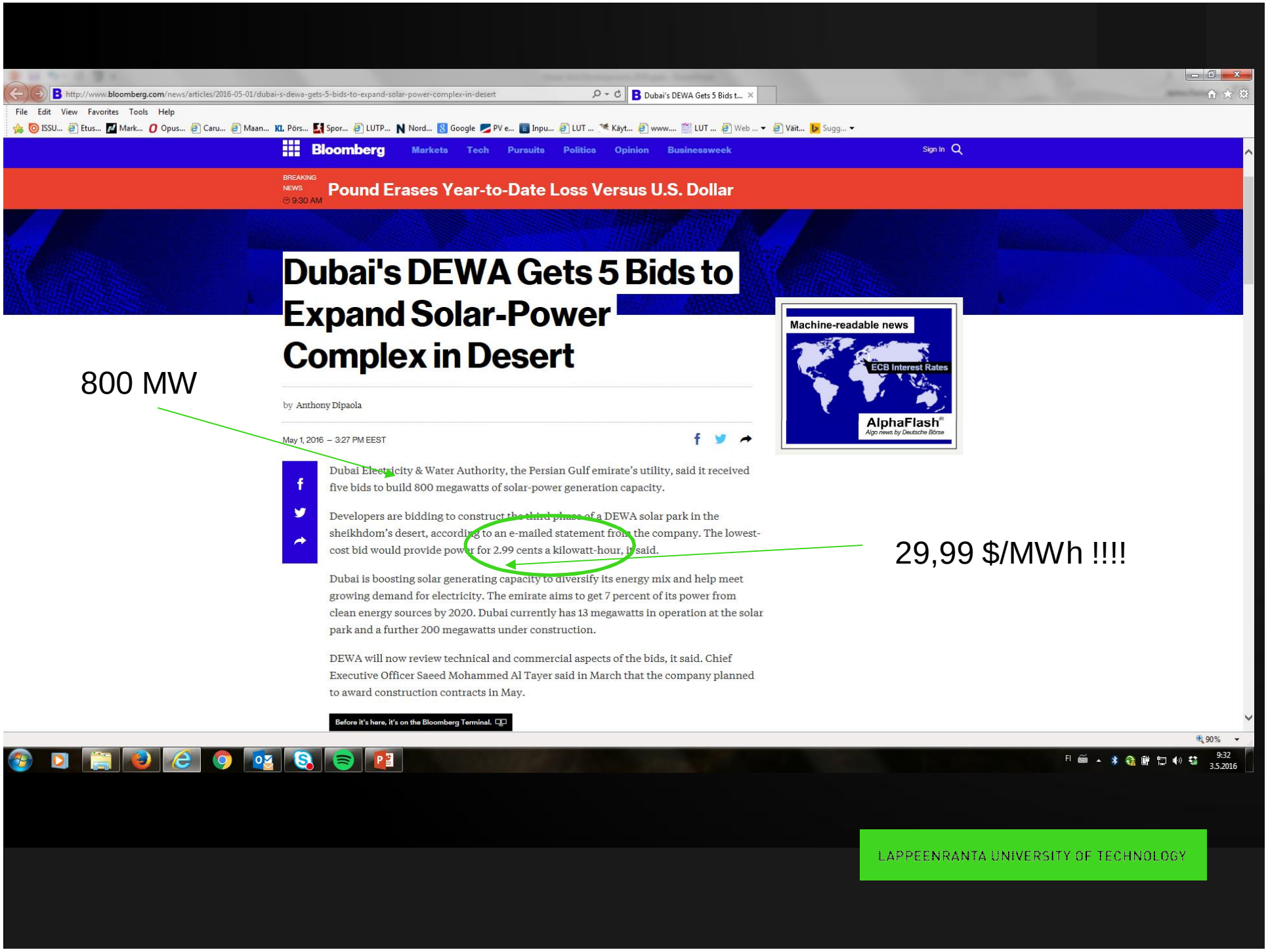
Fortum


http://www.bloomberg.com/news/articles/2016-05-01/dubai-s-dewa-gets-5-bids-to-expand-solar-power-complex-in-desert
Dubai's DEWA Gets 5 Bids t...
File Edit View Favorites Tools Help
Bloomberg
Markets Tech Pursuits Politics Opinion Businessweek
Sign In
BREAKING NEWS
9:30 AM
Pound Erases Year-to-Date Loss Versus U.S. Dollar
Dubai's DEWA Gets 5 Bids to Expand Solar-Power Complex in Desert
by Anthony Dipaola
May 1, 2016 – 3:27 PM EEST
Dubai Electricity & Water Authority, the Persian Gulf emirate's utility, said it received five bids to build 800 megawatts of solar-power generation capacity.
Developers are bidding to construct the third phase of a DEWA solar park in the sheikhdom's desert, according to an e-mailed statement from the company. The lowest-cost bid would provide power for 2.99 cents a kilowatt-hour, it said.
Dubai is boosting solar generating capacity to diversify its energy mix and help meet growing demand for electricity. The emirate aims to get 7 percent of its power from clean energy sources by 2020. Dubai currently has 13 megawatts in operation at the solar park and a further 200 megawatts under construction.
DEWA will now review technical and commercial aspects of the bids, it said. Chief Executive Officer Saeed Mohammed Al Tayer said in March that the company planned to award construction contracts in May.
Before it's here, it's on the Bloomberg Terminal.
Machine-readable news
ECB Interest Rates
AlphaFlash
Algo news by Deutsche Börse
800 MW
29,99 $/MWh !!!!
90%
9:32
3.5.2016

WORLD RECORD: 3-CENT WIND, SUB-4-CENT SOLAR (UNSUBSIDISED)

Bloomberg NEW ENERGY FINANCE

ONSHORE WIND

Location:	Morocco
Bidder:	Enel Green Power
Signed:	January 2016
Price:	US$ 3.0 c/kWh

SOLAR PV

Location:	Coahuila, Mexico
Bidder:	Enel Green Power
Signed:	March 2016
Price:	**US$ 3.6 c/kWh**

Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons

NEO CARBON ENERGY

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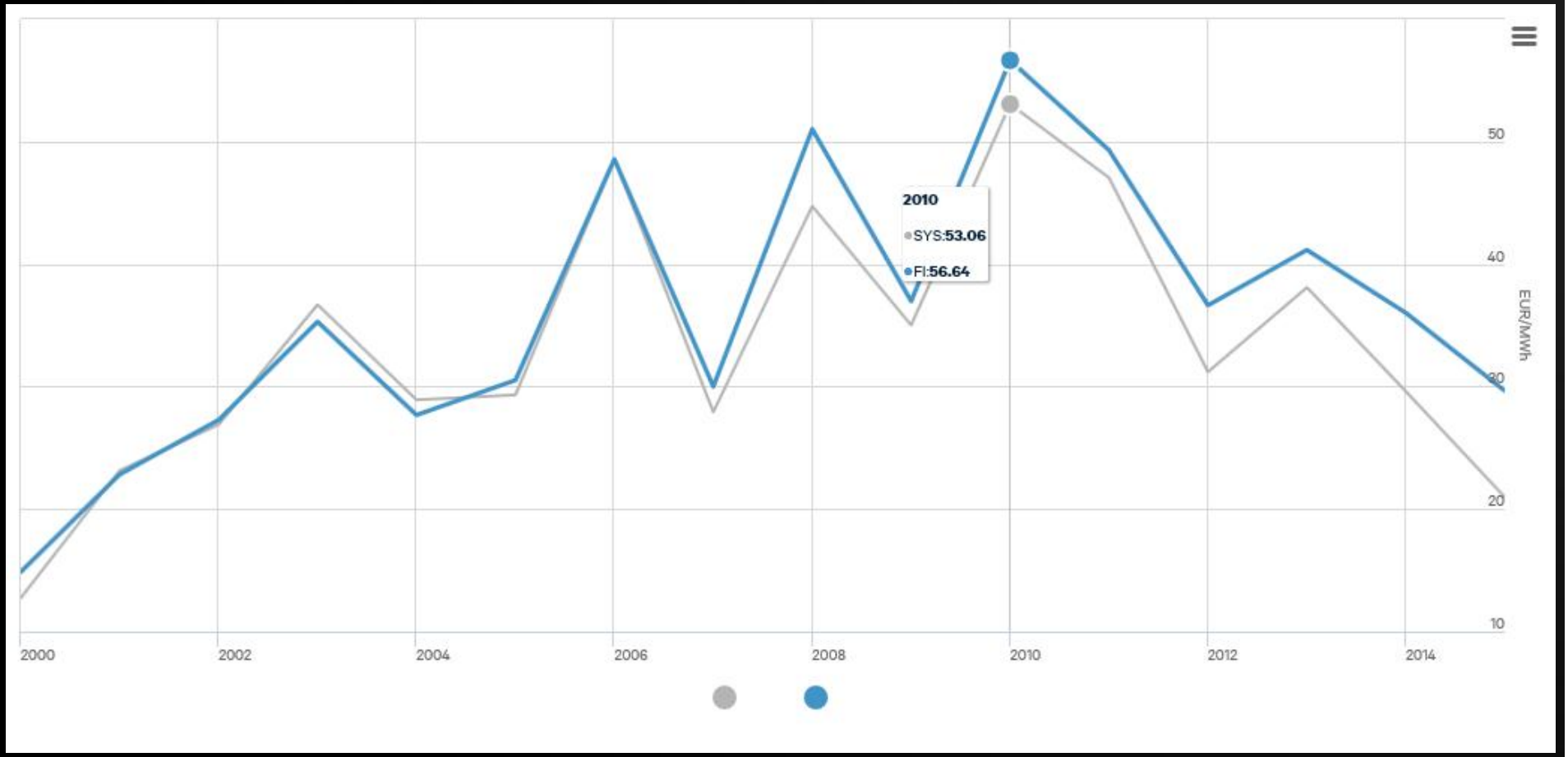
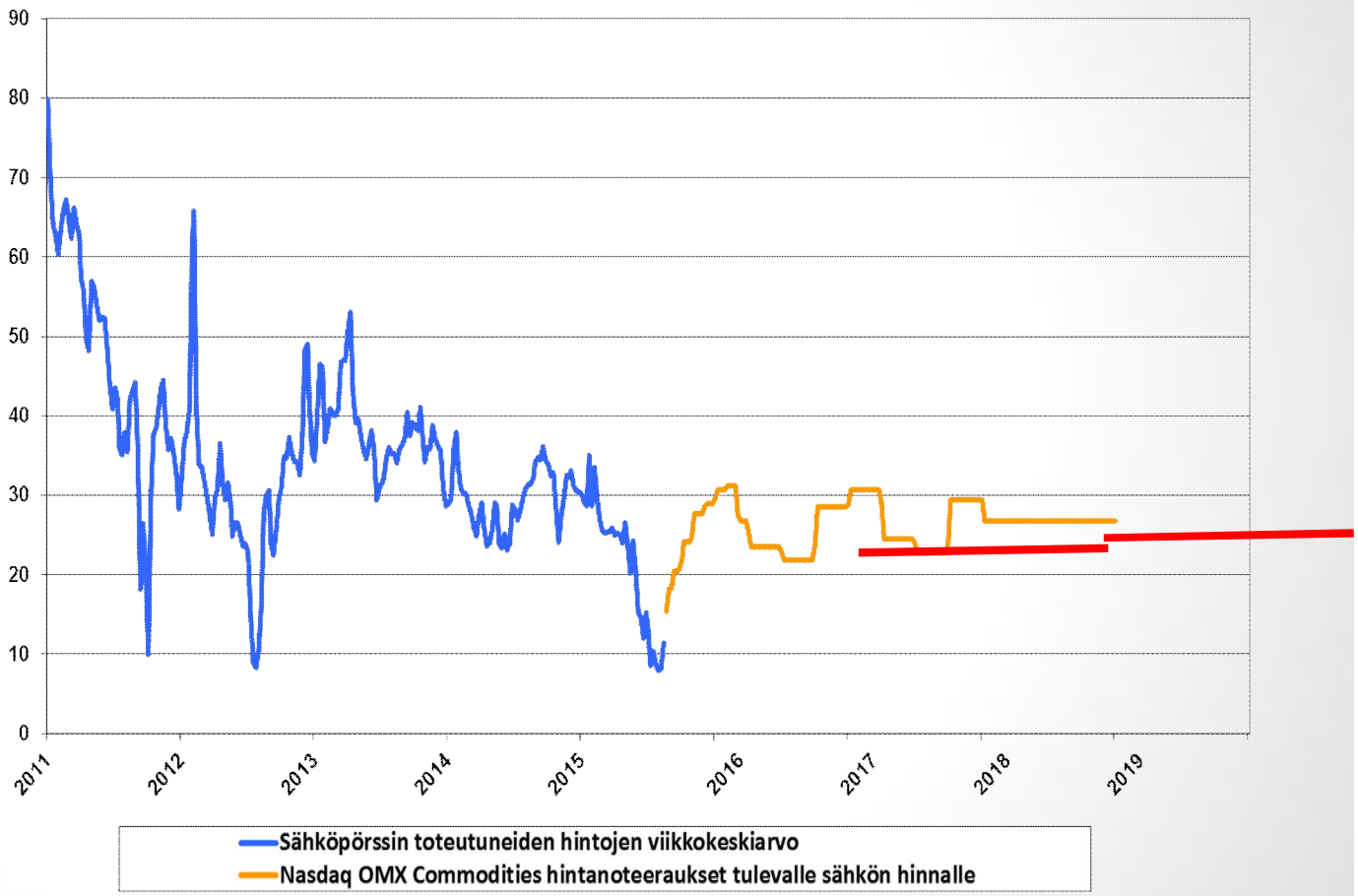
Electricity Market – Spot price in Nordic Market, annual average 2000-2015



Sähköpörssin toteutunut hinta ja tulevaisuuden hintanoteeraukset 18.8.2015

- Kuvassa ovat kahden vuoden toteutuneiden päivähintojen viikkokeskiarvot ja tulevaisuuden hintanoteeraukset 18.8.2015
- Tulevaisuuden hintanoteeraukset (finanssituotteiden hinnat) kertovat markkinatoimijoiden hintakehitysodotuksista .

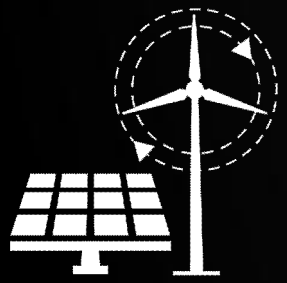


18.8.2016

18.8.2015

Lähde: SKM Syspower

Electricity Market – Driving Forces



- Mass production based technology
- Weather dependent electricity production
- Low operation costs
- Weather dependent electricity distribution

- Unlimited sustainable, cost efficient energy source

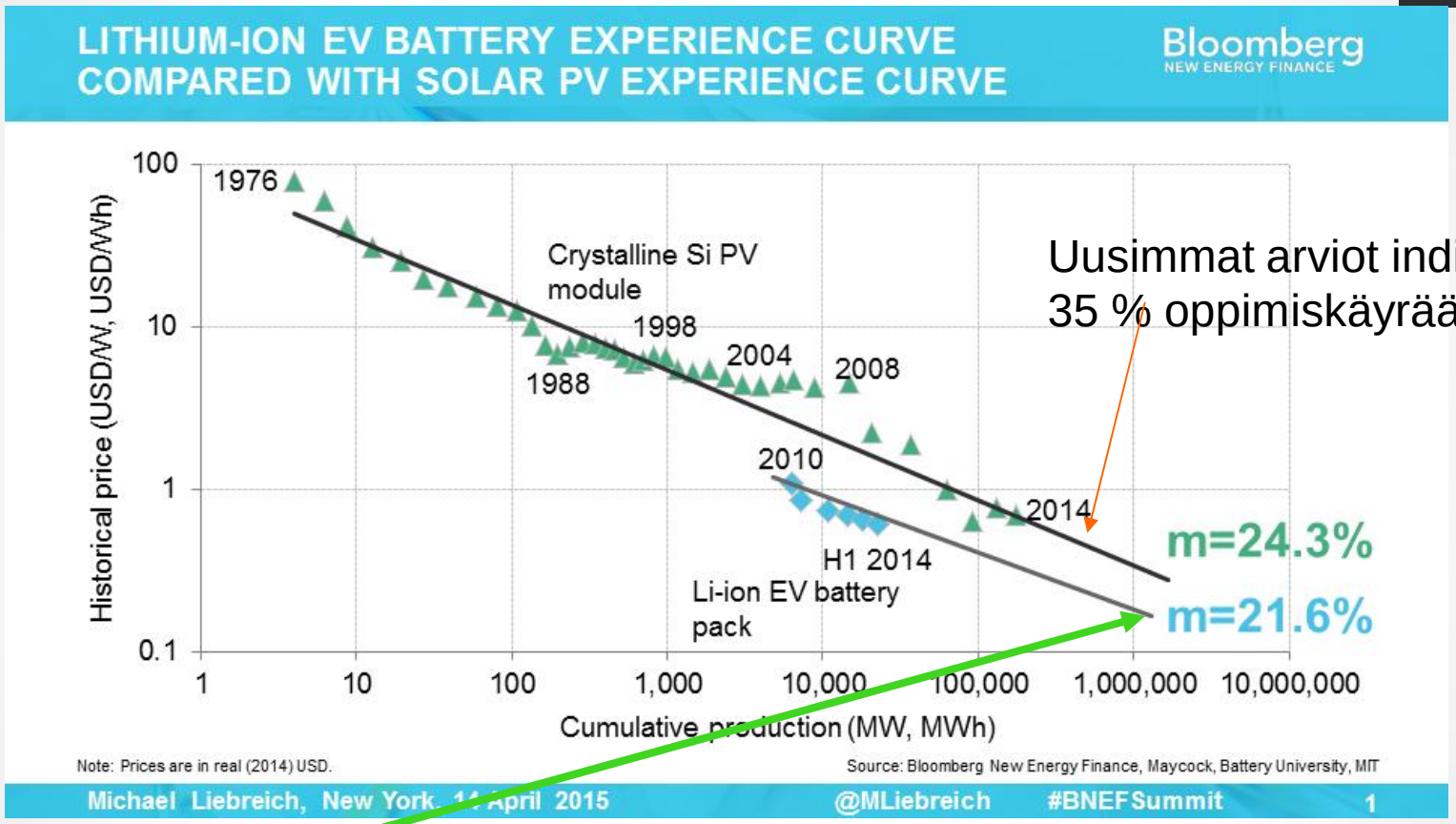
- Unstable energy market and grids, power balance
- Abnormal low market prices
- How to keep lights on?

- Energy storages

Storage is a new component in electricity power system. Main goal is to reducethe total costs of system, to reduce the total capacity (investments) of energy system (resource efficiency))

Akkujen hintakehitysarvio,

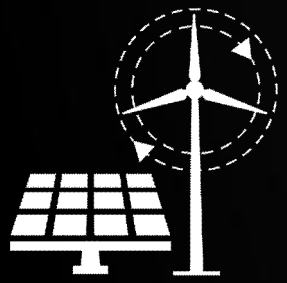
oppimiskäyrä; -20 % per kapasiteetin tuplaus



Uusimmat arviot indikoivat
35 % oppimiskäyrää PV:lle!

1 000 000 MWh on 500 milj. 20 kWh akkua a' 4000 €

Electricity Market – Driving Forces



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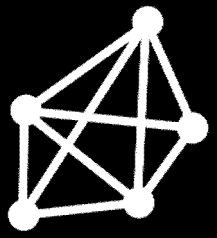


- Digitalization

'Unlimited', low cost potential to control demand (power) "on line"

- Efficient use of capacity of energy system
- Power balance management
- Improvement oif cyber security together with local production and storages

Electricity Market – Observations

Market model/operation changes

- Operating costs of renewable based production are extremely low (< 10 €/MWh)
- Hydro, wind, solar and nuclear based production will be always first in the market

- Competitiveness of production will be based on investment costs/W + running hours + capability for flexible operation

- New earning possibilities for active demand reponse including storages

- Grid tariffs have to/will be based on kWs ordered/measured instead of kWhs

-> From energy efficiency to capacity efficiency and flexibility capability

Electricity Market – Chances

Market model chances

- Extremely cheap electricty (energy) in summer time (+ some other time periods)
  - Benefit to industry and services
  - kWh-based grid tariff and fixed electricity tax constitutes an obstacle to apply cheap energy
  - Grid tariffs based kWs will be one solution having incentives to improve capacity efficiency, too
- Earning possibilities for active demand reponse including storages
  - Demand response will be one key element in management of security of supply
- From day ahead energy market to market based on capacity efficiency and flexibility capability (this is not a capacity market having fixed compensations per kW)

Electricity Market – Chances

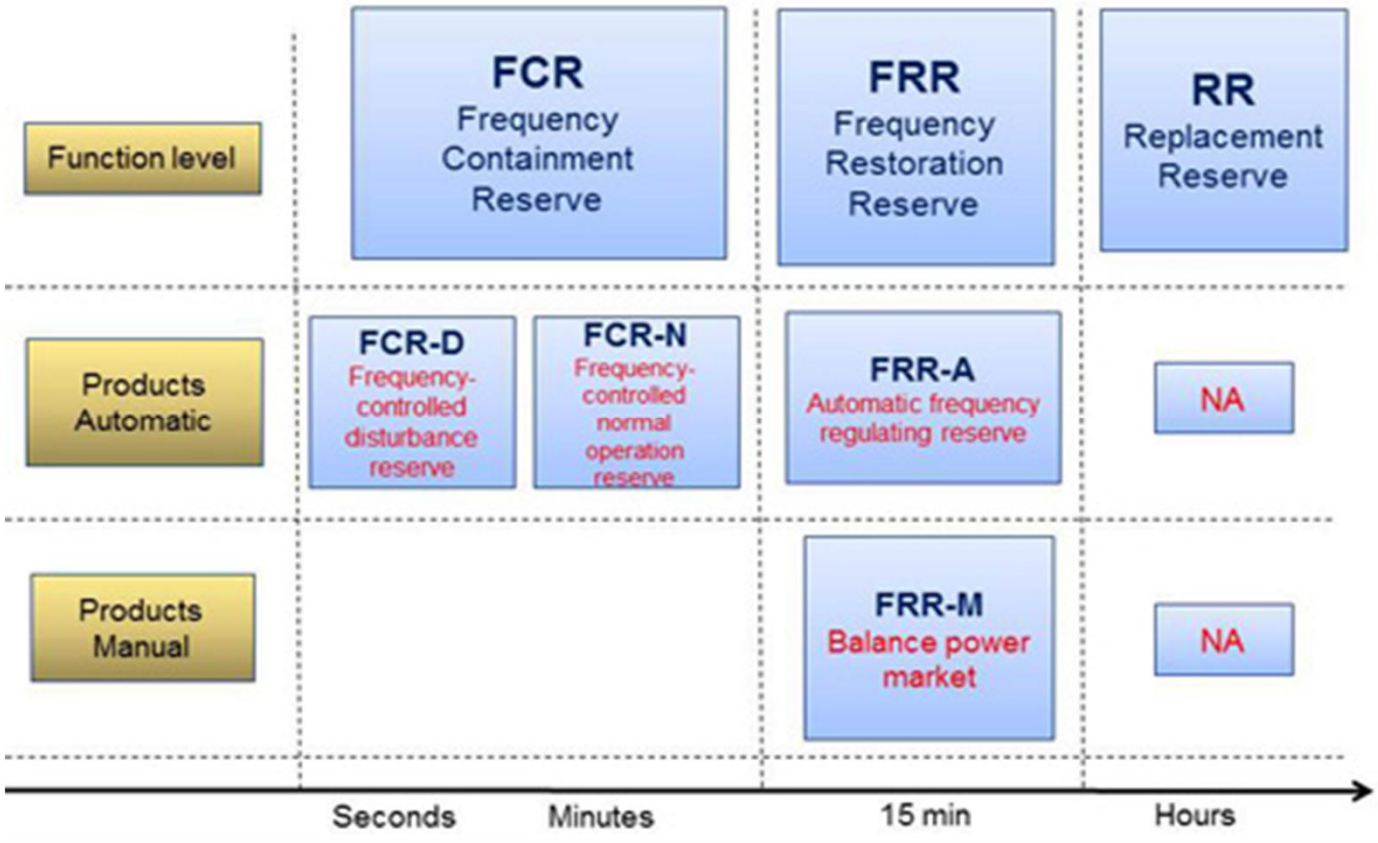
Market model challenges/chances

- Higher costs for balance differences (estimated-real), shorter time periods
- How to stimulate investments?
  - Value high enough in flexibility market
  - ”High” carbon tax or emission price
    - Technology independent incentive for carbon free production
    - Income to state instead of costs of subsidies
- Security of supply and self-sufficiency are two different matters
  - ”Too” dramatic communication of power peaks in Jan 2016, there were no problems/actions to manage the demand, even prices were low

Some facts in Finland

- 100 % penetration of smart meters with
  - Hourly based energy metering -> hourly based balance settlement
  - Spot price based products to ratail market customers
  - Voltage quality measurements
  - Outage data
  - Detection of serious faults in low voltage networks (zero conductor damages)
  - > 2000 MW potential of heating loads for demand response activities
- **Forerunner in development of services for flexibility market (Fingrid, TSO)**
- Possibly a power band based DSO tariffs (€/kW,a) in near future
- Leading technology in electricity distribution automation and power electronics, development of LVDC technology
- Criterias for maximum durations of interrruptions in DSO's networks, 6/36 h

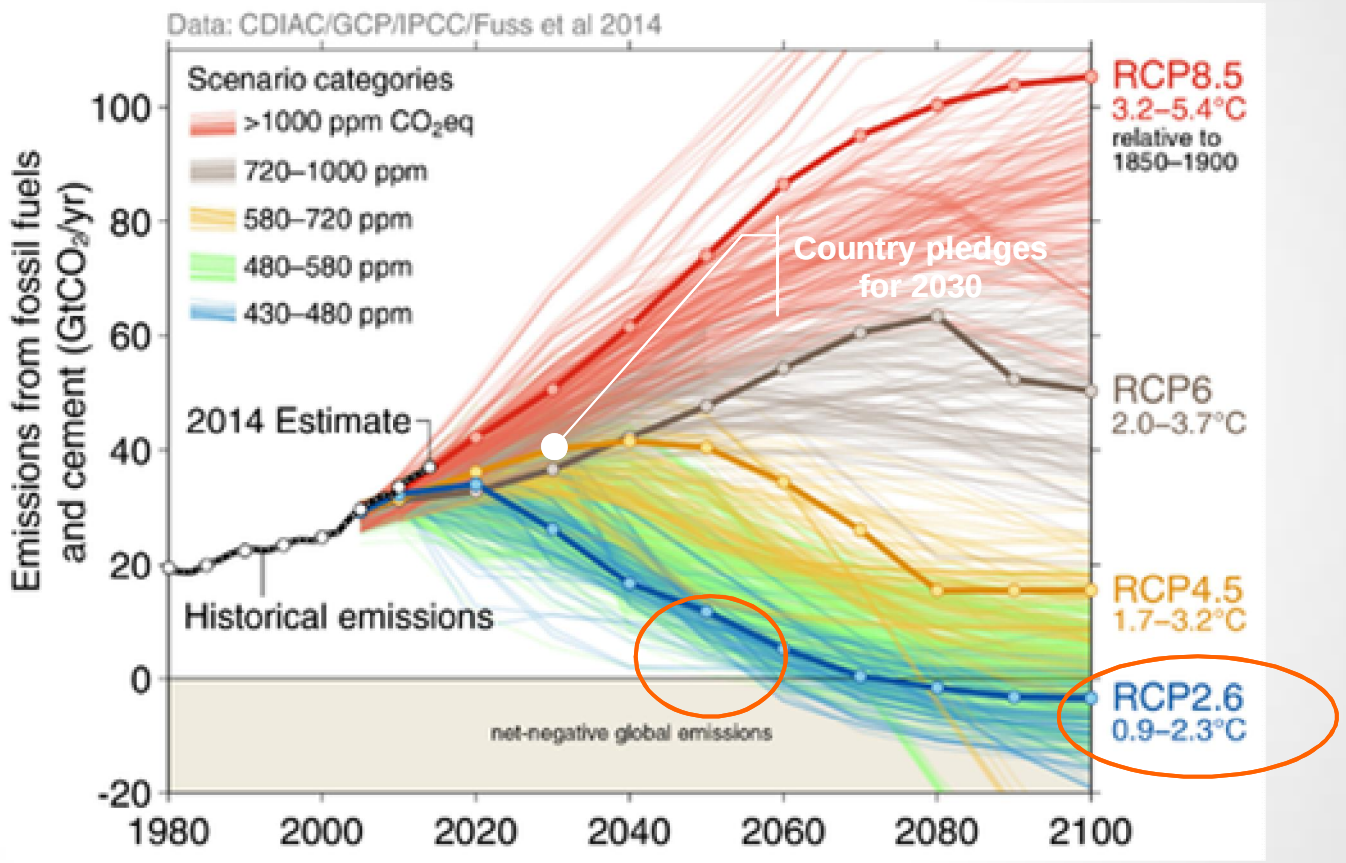
Flexibility Market in Finland, Fingrid



Prices in flexilibity market, frequency control
Theoretical earning with 1 kW controlable power

Annual product	**Normal reserve FCR-N €/MW,h**	**Disturbance reserve FCR-D €/MW,h**
2011	9,97	1,48
2012	11,97	2,80
2013	14,36	3,36
2014	15,80	4,03
2015	16,21	4,13
2016	17,42 **(152 000€/MW,a)**	4,50 **(39 420 €/MW,a)**
Hourly product		
2015	**195 000 €/MW,a**	**126 000 €/MW,a**

What did we agree in Paris 2015?



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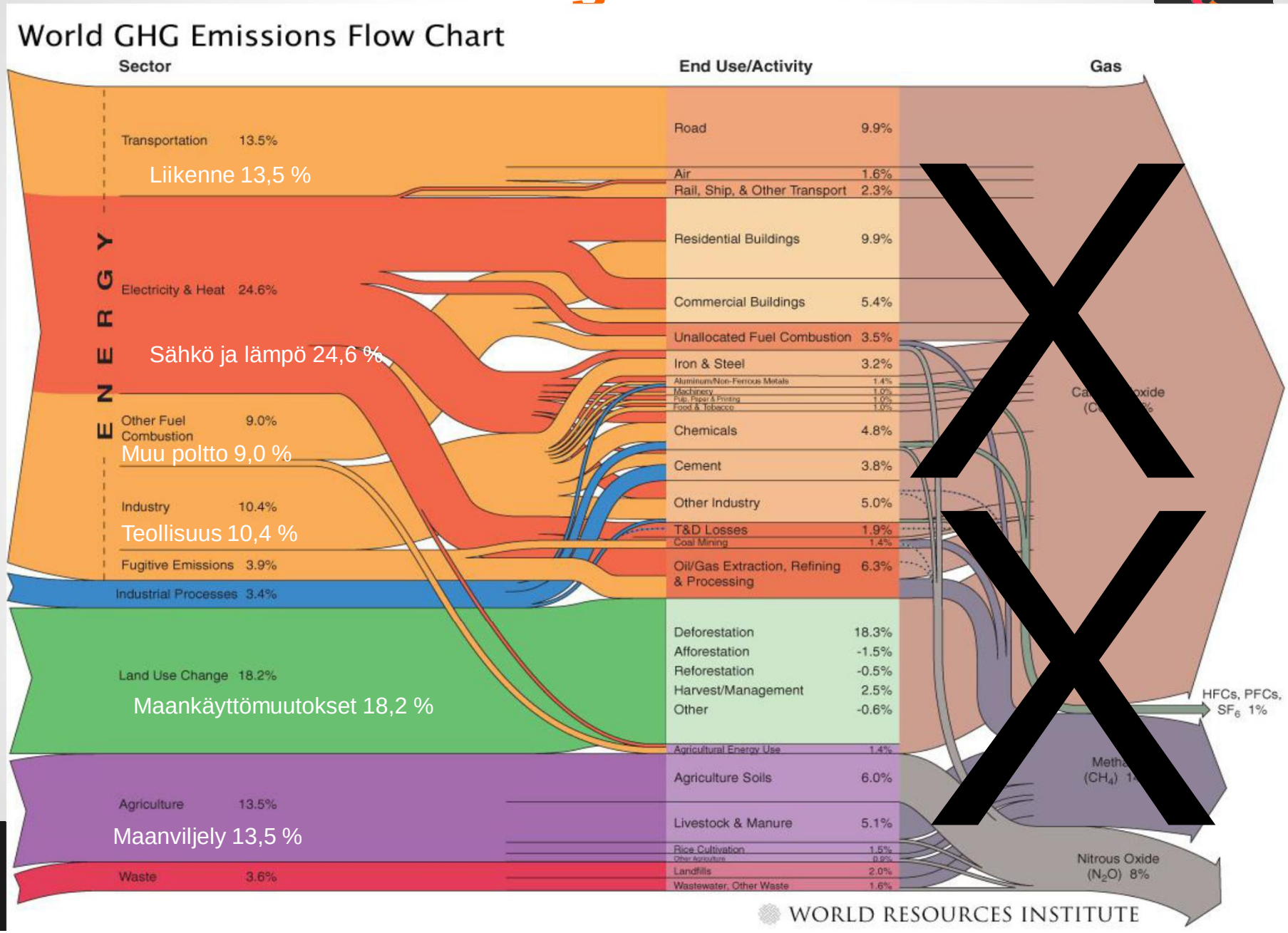

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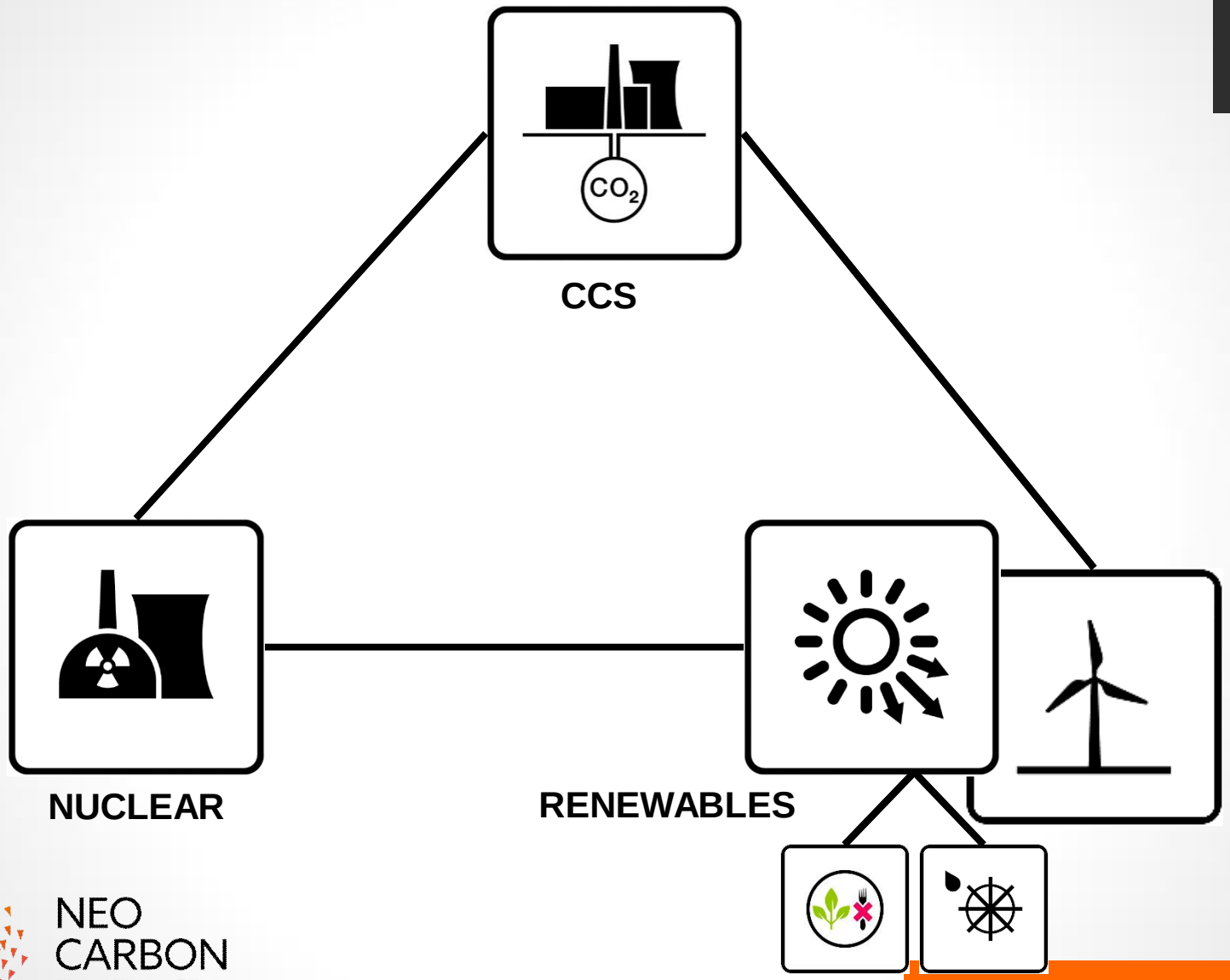
- **Short term politics. Unclear view of global challenges and business possibilities – "headache of next generation"**

THE OPTIONS FOR ENERGY SOURCES



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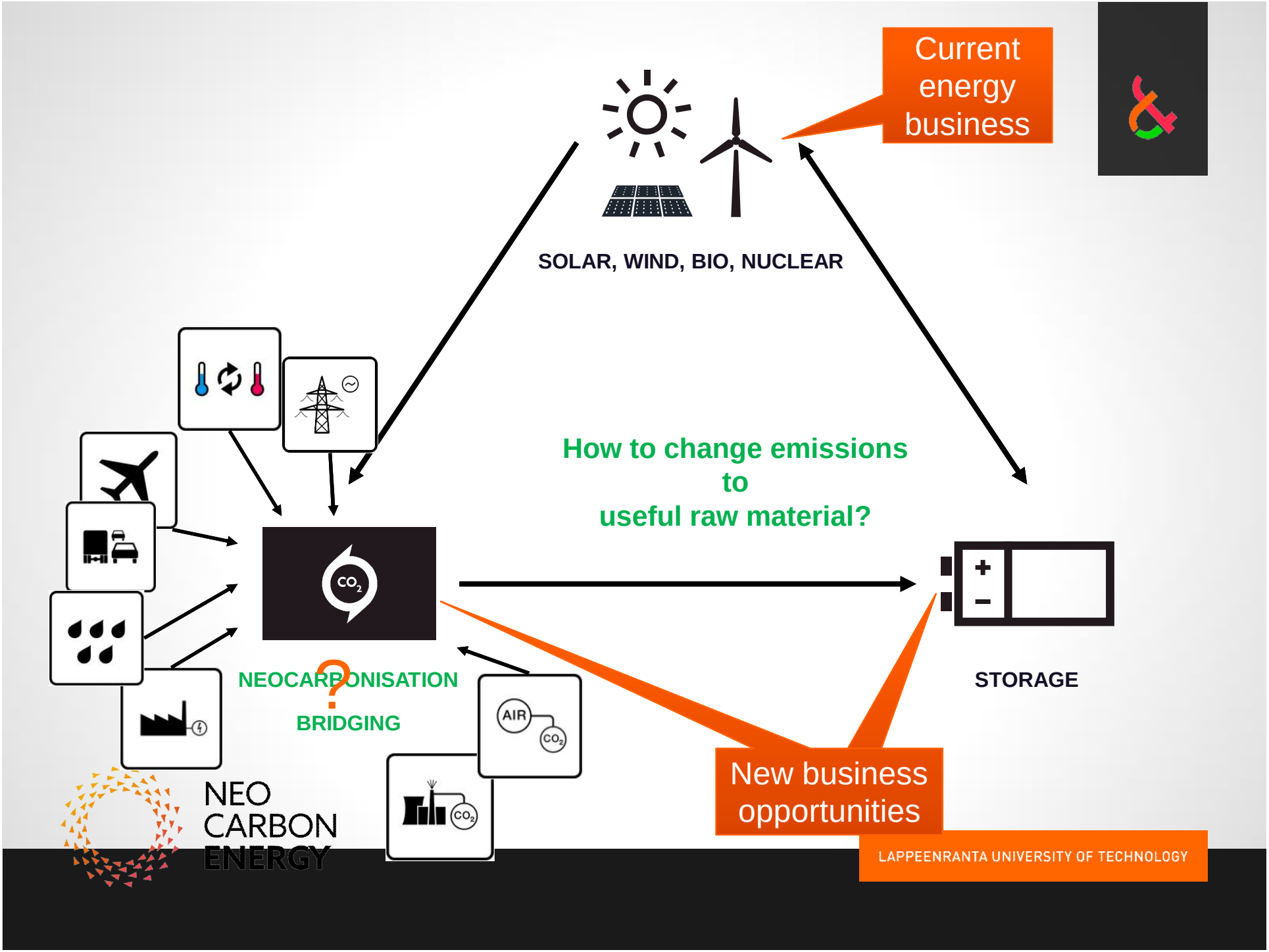
Current energy business
SOLAR, WIND, BIO, NUCLEAR
How to change emissions to useful raw material?
NEOCARBONISATION
BRIDGING
?
STORAGE
New business opportunities
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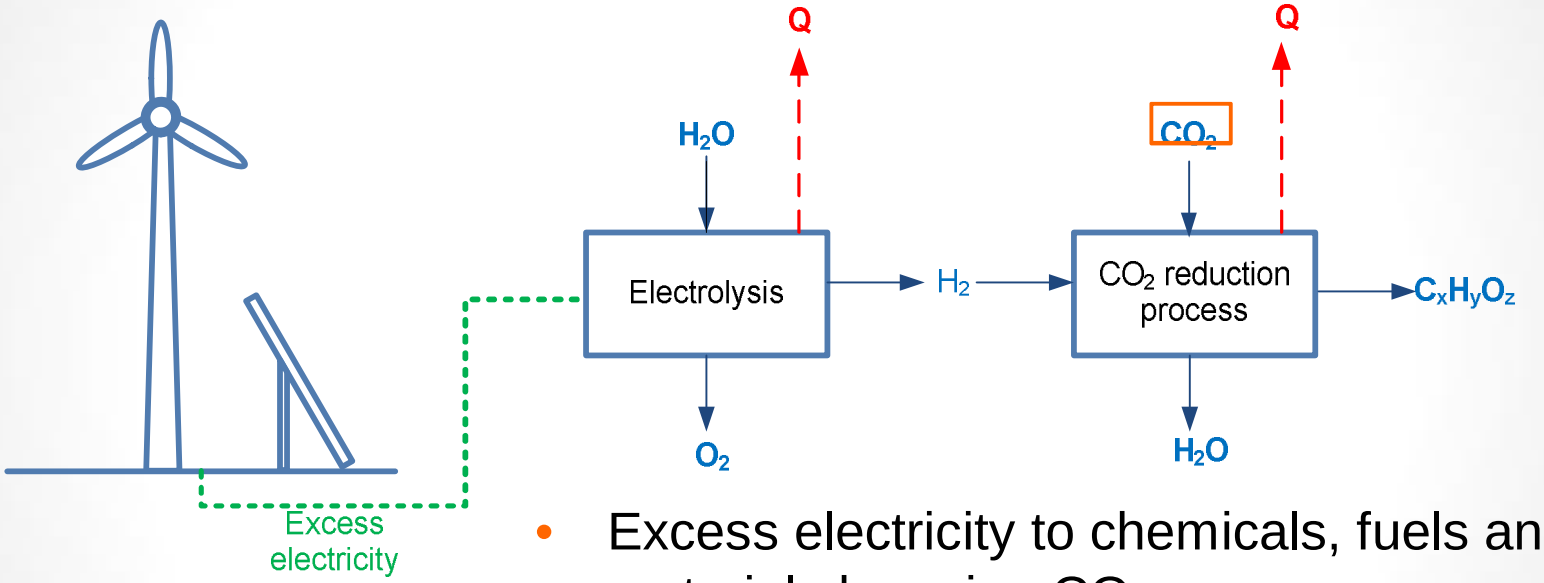
Power-to-x



- Excess electricity to chemicals, fuels and materials by using CO_2
- Replacing crude oil, gas and gas condensates
- Power to fuels - ”sähköpolttoaineet”

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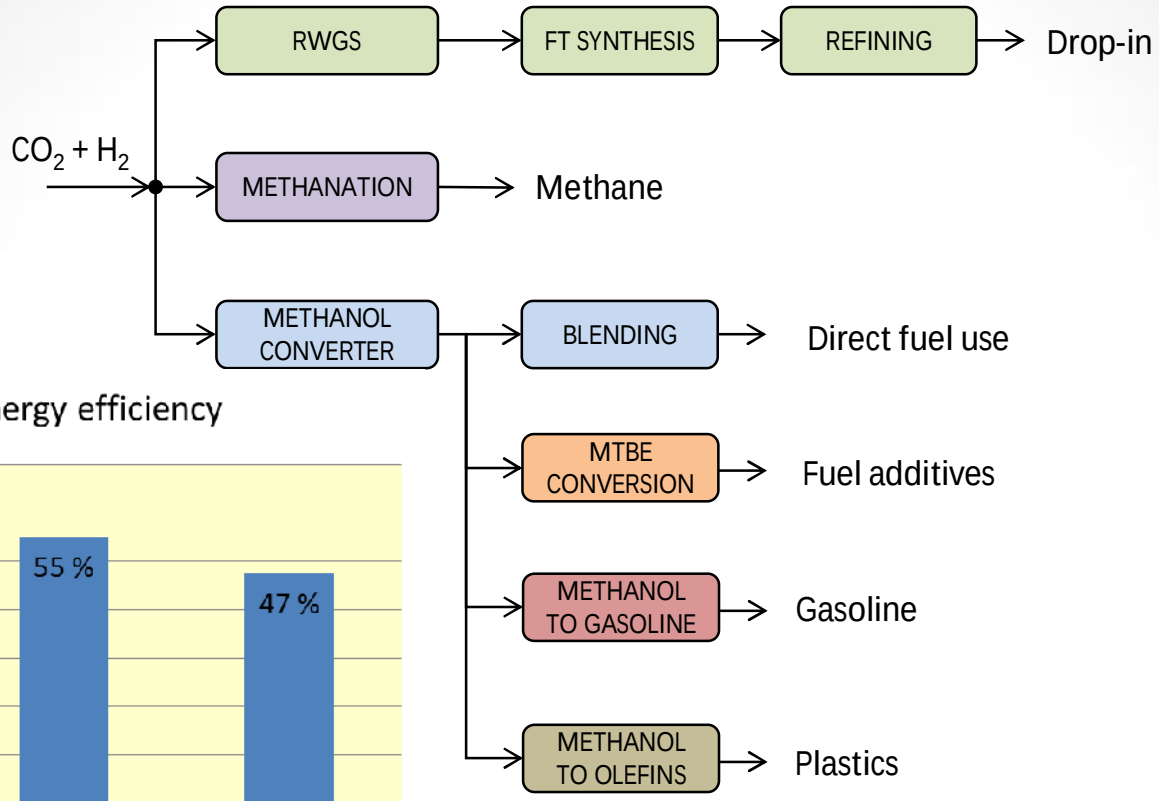
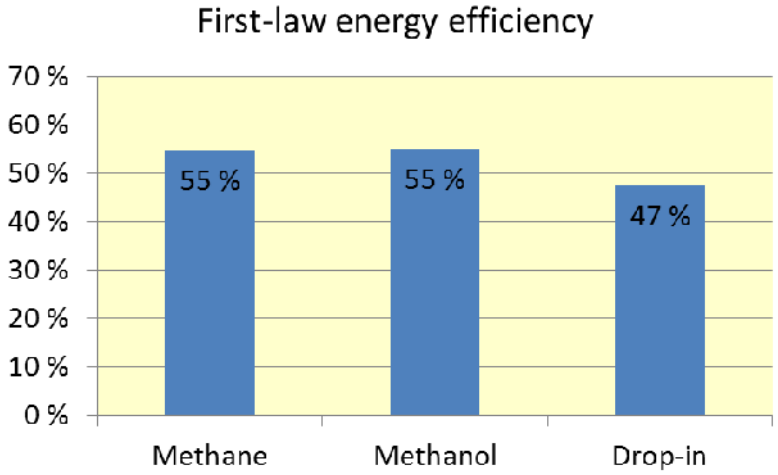
Power-to-x





How to achieve industrial competitiveness?

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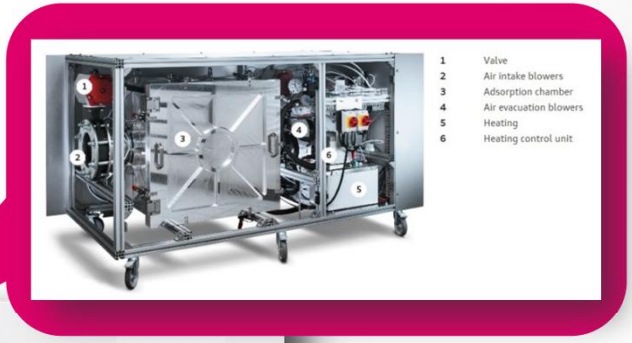
Power-to-X at LUT & VTT, 2017

LUT PV PLANT (EXISTING)

VTT: CO_2 CAPTURE FROM AIR



BUFFER STORAGES

VTT: SYNTHESIS OF CH_4 (SOLAR SNG) AND MeOH

LUT: H_2 PRODUCTION THROUGH ELECTROLYSIS

- SOLAR SNG AND H2 REFILL
- ELECTRICITY CHARGING FOR EV'S
- MeOH FOR PLASTICS SYNTHESIS

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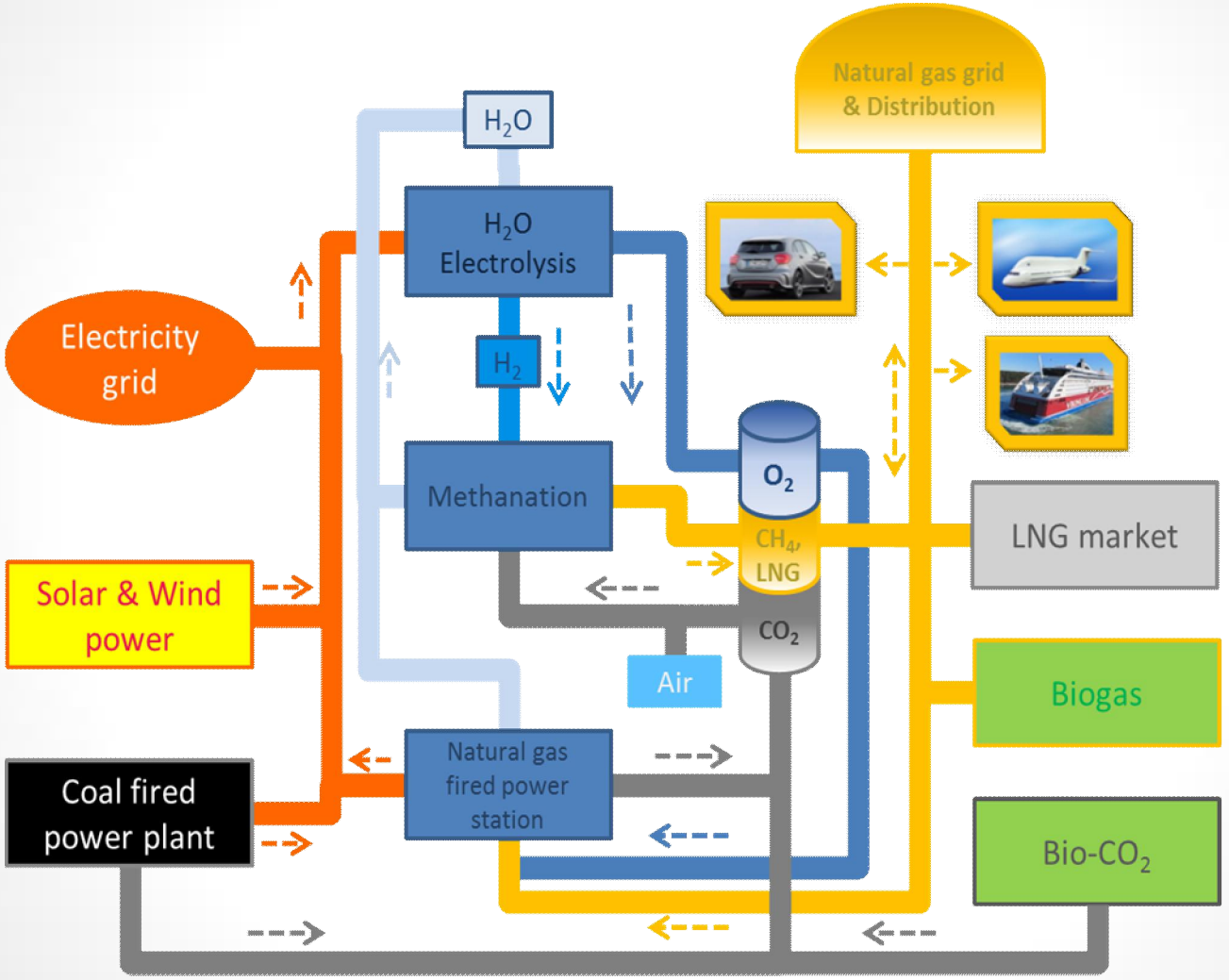
From electricity to gas, seasonal storage & clean fuel
System level view



Electricity has an enormous history but the future is … unbelievable

Cost efficient, clean and unlimited energy source

Heat, cooling, working power

Electricity based fuels, food

Jarmo Partanen