



Sustainable Bioenergy
Solutions for Tomorrow

BIOENERGY RESOURCES (CHP) PROVIDING ENERGY SYSTEM FLEXIBILITY

BEST WP1 seminar

Tuesday, November 29, 2016

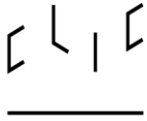
Juha Haakana, Lappeenranta University of Technology



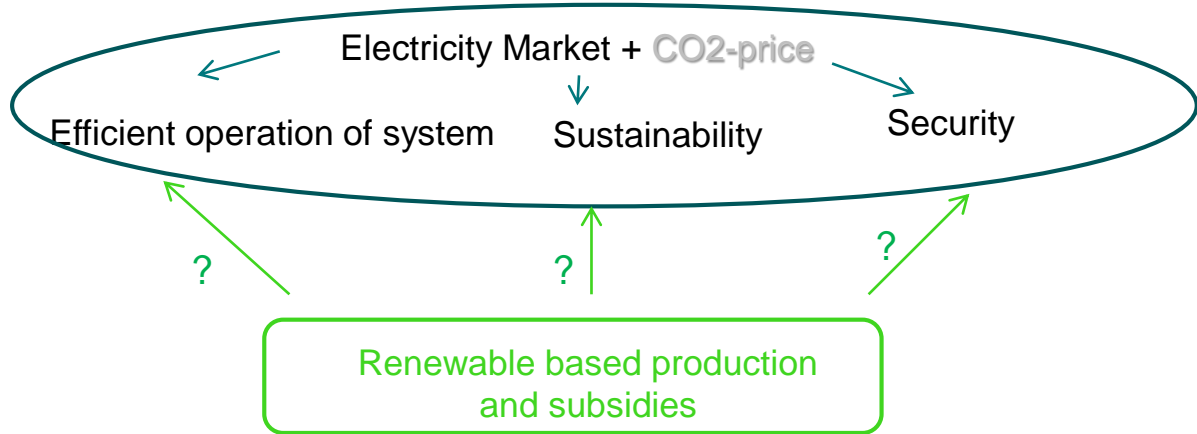
LUT

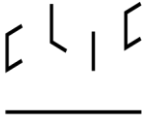
Lappeenranta

University of Technology

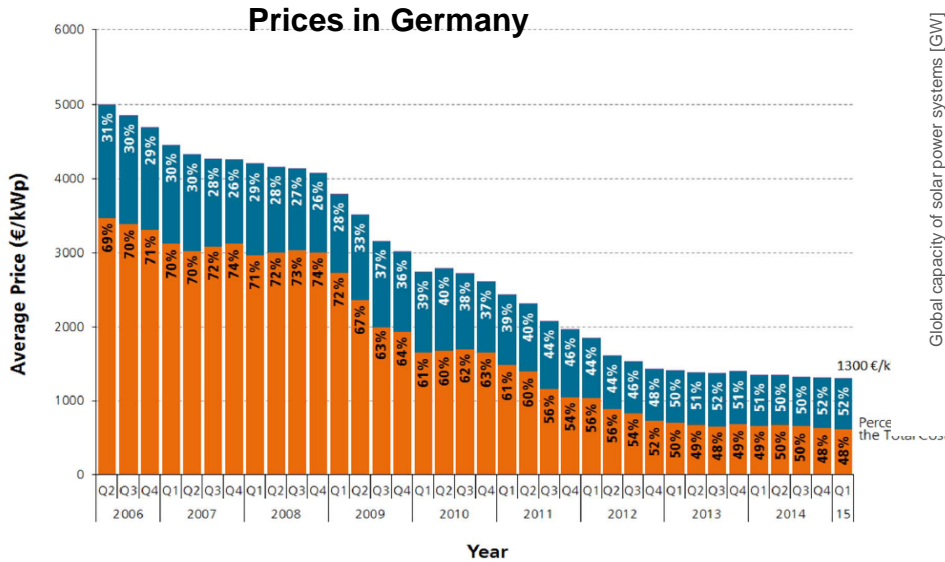


Renewables, security of supply and efficiency



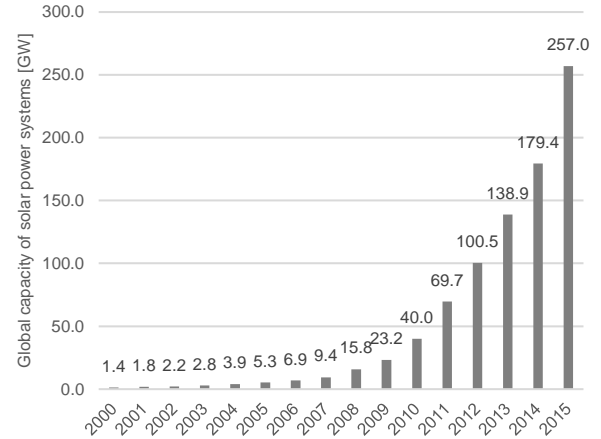


Solar power prices have dropped fast



Source: Fraunhofer ISE "Recent Facts about Photovoltaics in Germany"

Global solar capacity [GW]



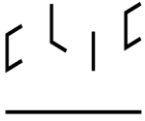
Source: cleantechnica.com



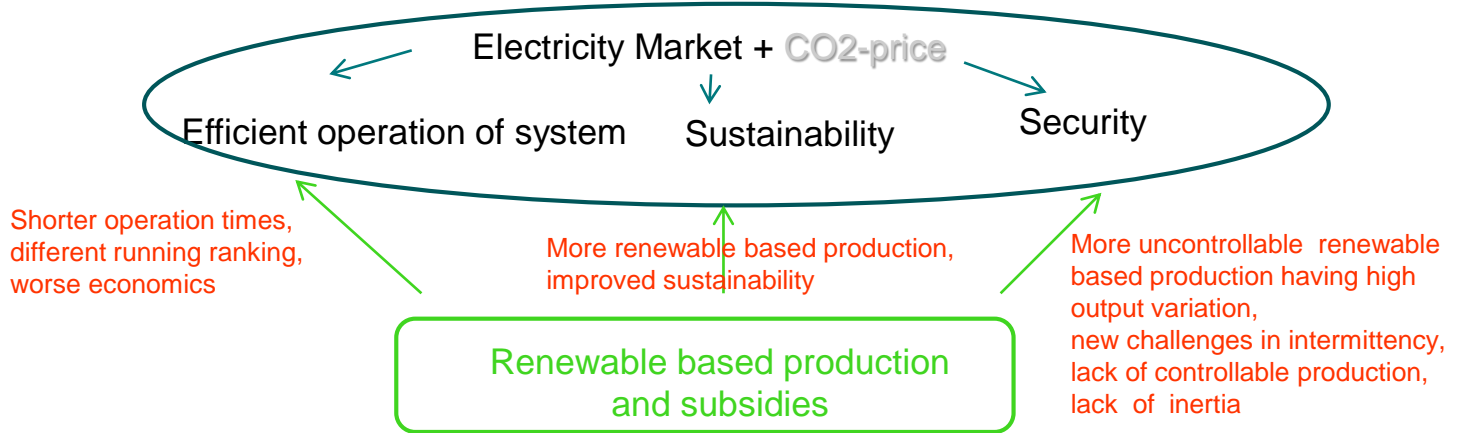
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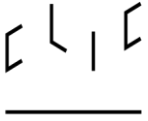


Source: Antti Kosonen

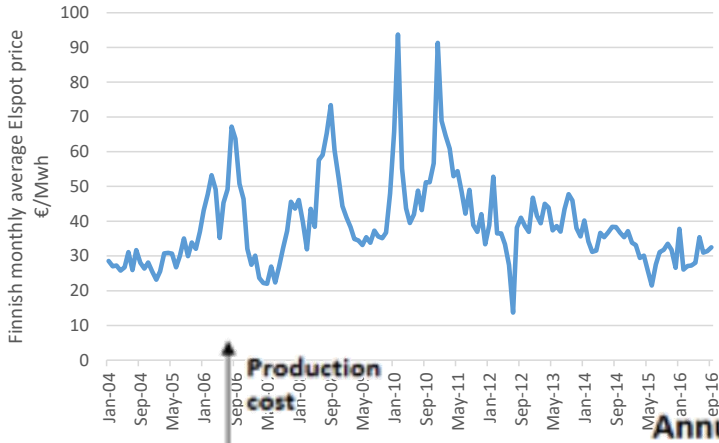


Renewables, security of supply and efficiency



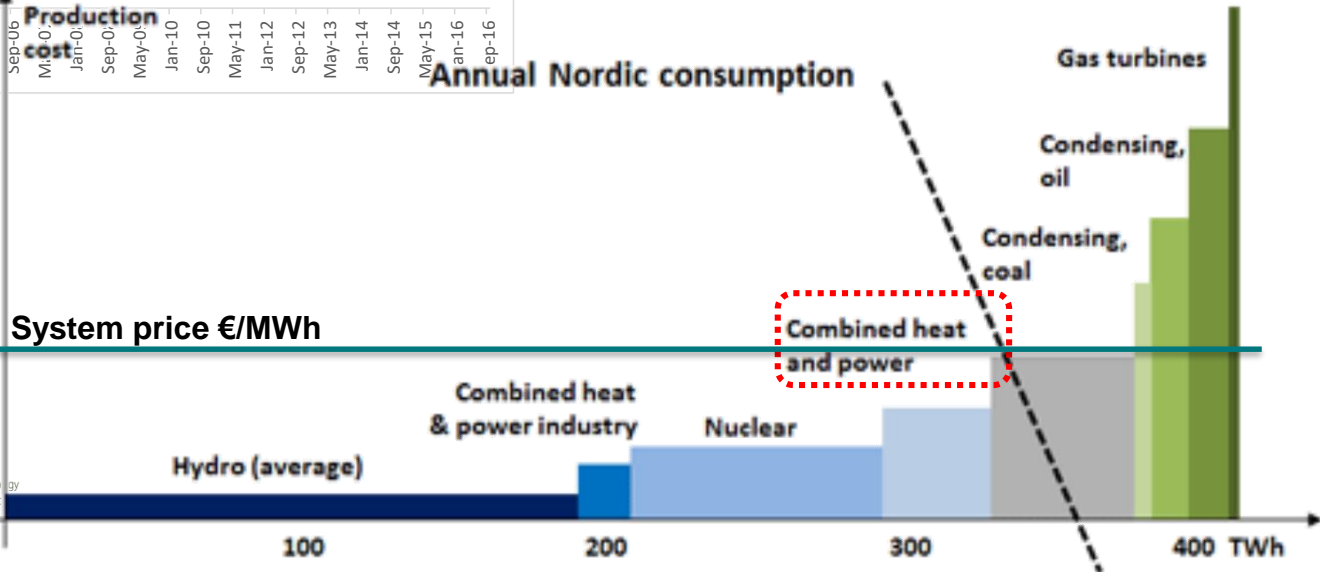


Electricity pricing

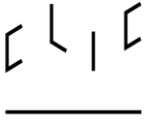


Source:
Nord Pool

CHP is often on the edge

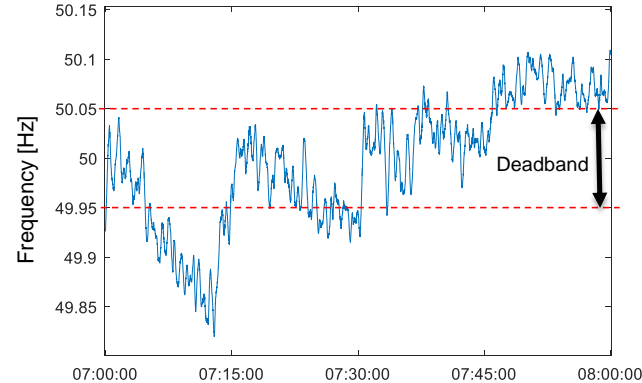


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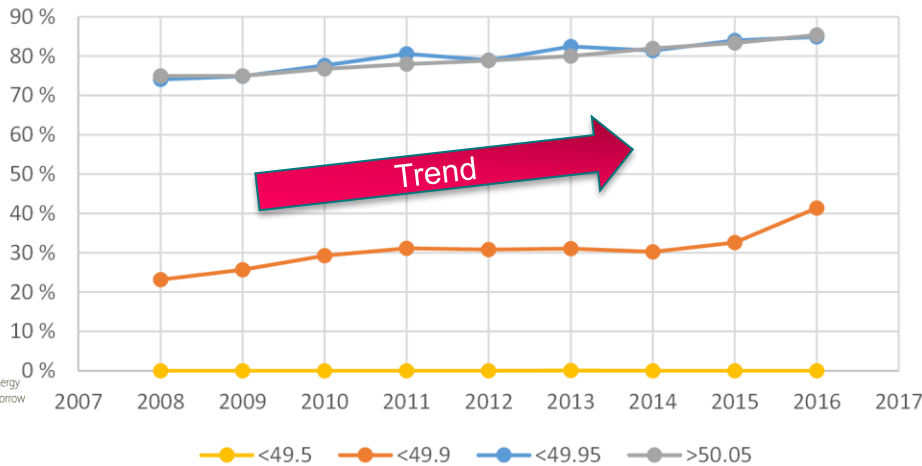


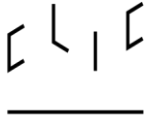
Electrical power system frequency

Frequency deviation has increased considerably between 2008 and 2016

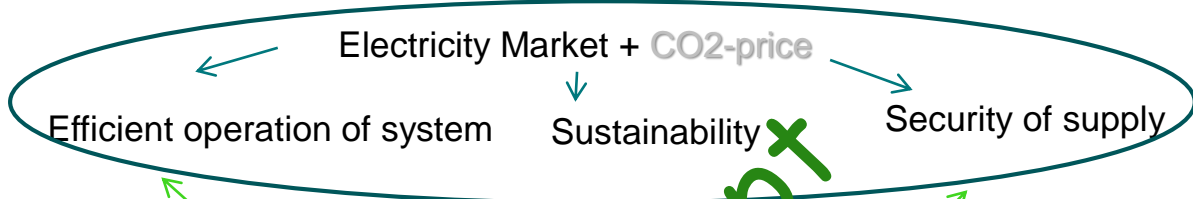


Proportion of hours exceeding frequency limits





Renewables, security of supply and efficiency



Shorter operation times, different running ranking, worse economics

More renewable based production, excellent sustainability

More uncontrollable renewable based production having high output variation, new challenges in intermittency, lack of controllable production, lack of inertia

How to solve the problem ?

Renewable based production and subsidization

Role of CHP

When ?

How ?

Profitability ?

Acceptability ?



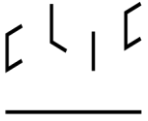
Low price of electricity – incentives for investments ?

Capacity Market?

Payments of readiness to produce electricity or reduce consumption



Smart Grids Concept



Electricity markets

Participation in new energy market sectors

Heat market

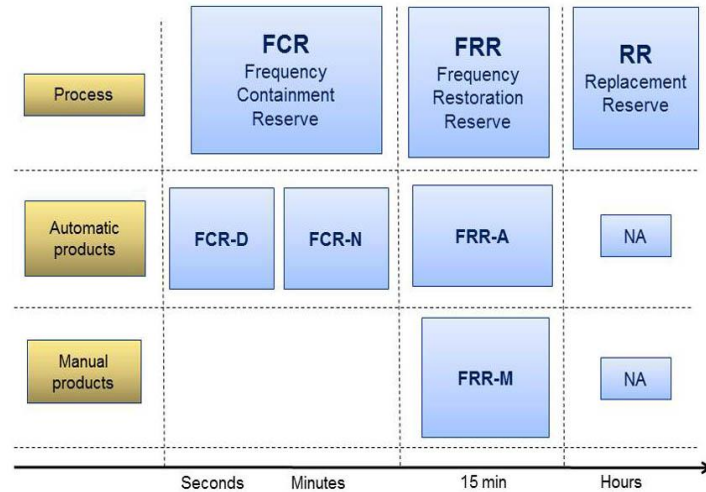
Traditional markets

Electricity markets

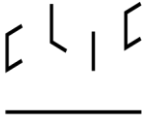
- Day-ahead market Elspot (13:00, 1 MW)
- Intraday market (one hour before delivery, 1 MW)
- Reserve markets
 - FCR-N (Frequency containment reserve - normal), (hourly market 18:00) up and down regulation (0.1 MW)
 - FCR-D (Frequency containment reserve - disturbance), (hourly market 18:00) up and down regulation (1 MW)
 - FRR-A (Frequency restoration reserve - automatic), (hourly market 18:00) up and down regulation (5 MW)
 - FRR-M (Frequency restoration reserve - manual), (hourly market 18:00) up and down regulation (5 MW)

Capacity market

Business: Reserve markets



Source: Fingrid

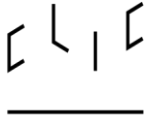


Role of CHP in future power system



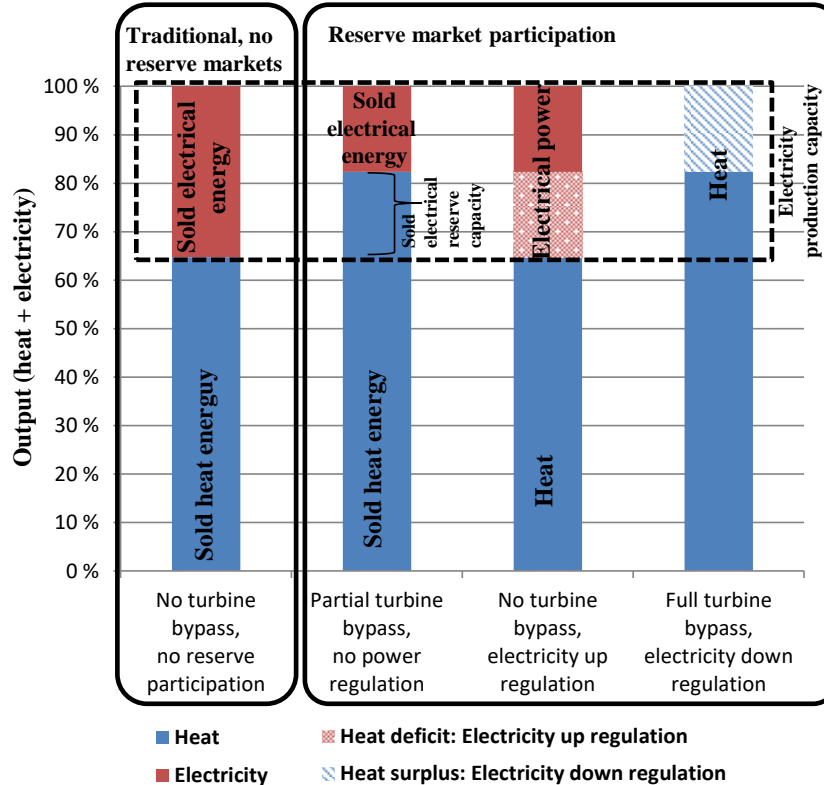
- CHP has capability to respond fast in power regulation demand
- Electricity prices in spot markets are relatively low → profitability to operate is poor → New business
- Finnish power production capacity 16.4 GW (2016)
- Now CHP 7 GW (bio CHP 2 GW)

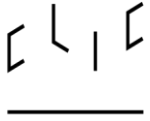




Regulation of CHP plant output power

Example

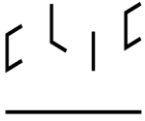




Case example



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Case study: simulation of actual CHP power plant

Participation in new energy market sectors

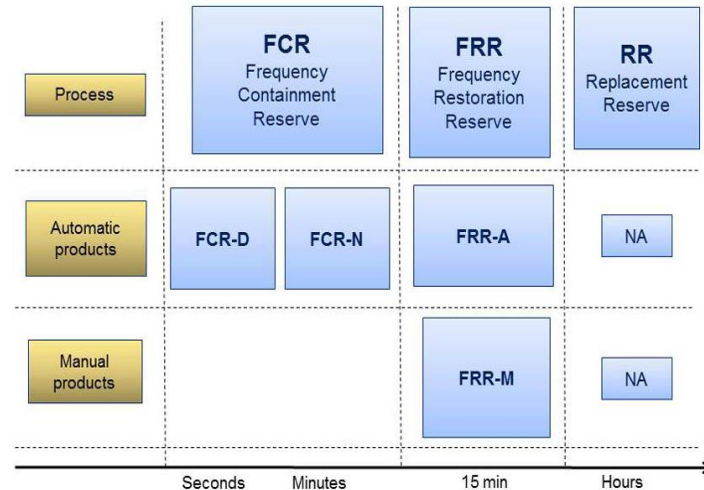
Heat market

Studied markets

Electricity markets

- **Day-ahead market Elspot** (13:00, 1 MW)
- **Intraday market** (one hour before delivery, 1 MW)
- **Reserve markets**
 - FCR-N (Frequency containment reserve - normal), (hourly market 18:00) up and down regulation (0.1 MW)
 - FCR-D (Frequency containment reserve - disturbance), (hourly market 18:00) up regulation (1 MW)

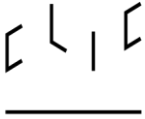
Data of electricity markets available 2009-2016



Source: Fingrid

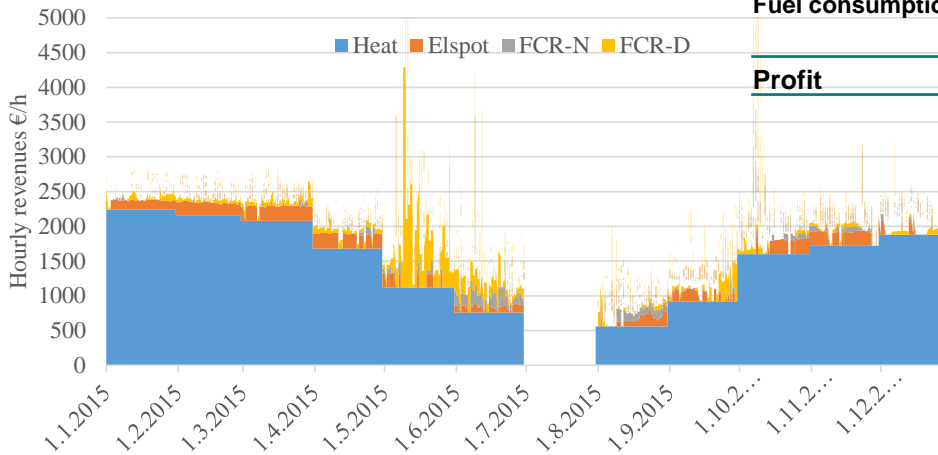


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Profitability of participation in reserve markets: Case Järvenpää Fortum

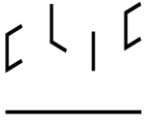
Comparison of two cases:
Flexibility markets would have a significant effect on operational profit



	Year 2015	
	Reserve market	Without reserve market
Revenue total	15 802 000 €	14 877 000 €
Heat	12 162 000 €	12 162 000 €
Elspot	1 892 000 €	2 628 000 €
Elbas	120 000 €	87 000 €
FCR-N	645 000 €	0 €
FCR-D	983 000 €	0 €
Costs	7 990 000 €	8 366 000 €
Fuel consumption	7 990 000 €	8 366 000 €
Profit	7 812 000 €	6 511 000 €

**2015:
+ 20% profit**

**Year 2014:
+ 15% profit**



Conclusions

1. Energy system faces wide challenges in future
 - New ways to operate energy system
 - New business opportunities
2. CHP power plants are interesting player in energy system
 - Technology is already there
3. Study indicates feasibility for CHP plant participation in reserve markets
 - + 15% - 20% annual profit





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THANK YOU!

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