Moderation of variable generation from renewable energy sources

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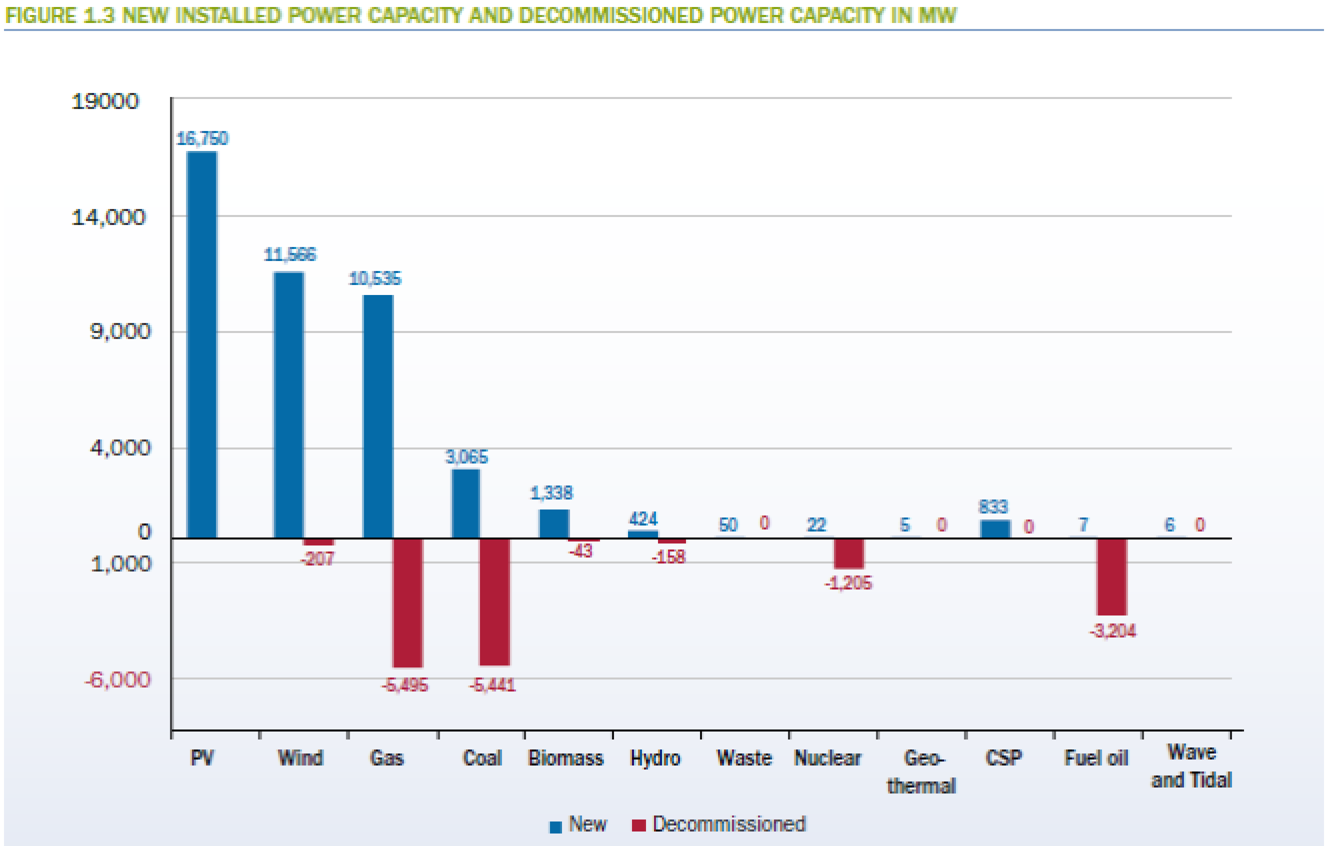
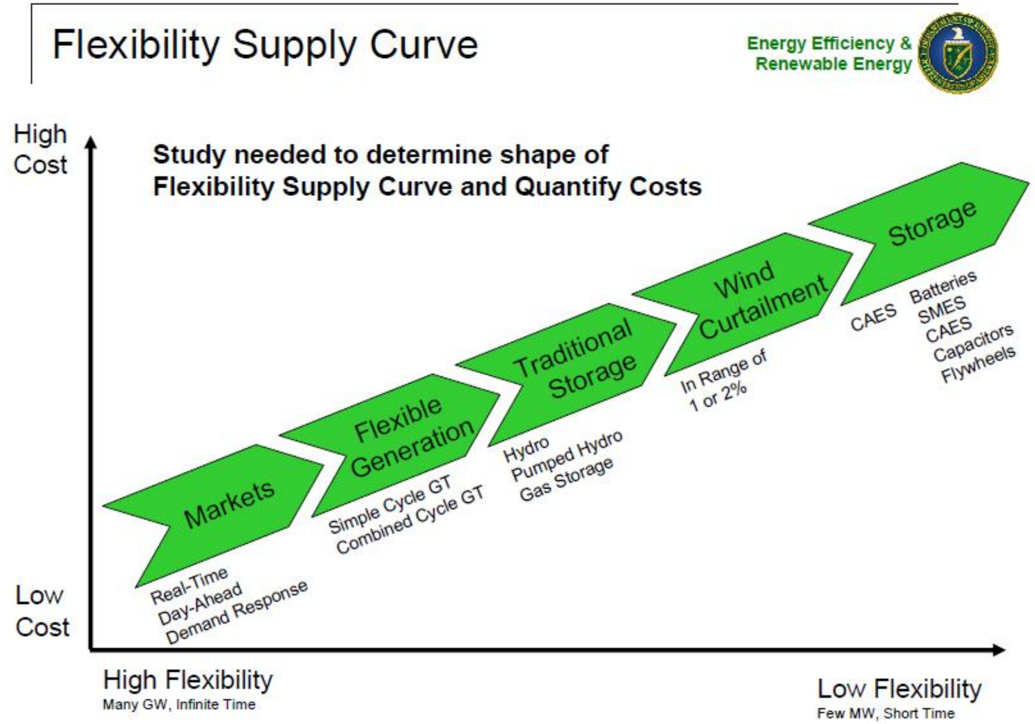
Renewables are coming…



Source: EWEA 2012

What we can do?
Energy Imbalance Options

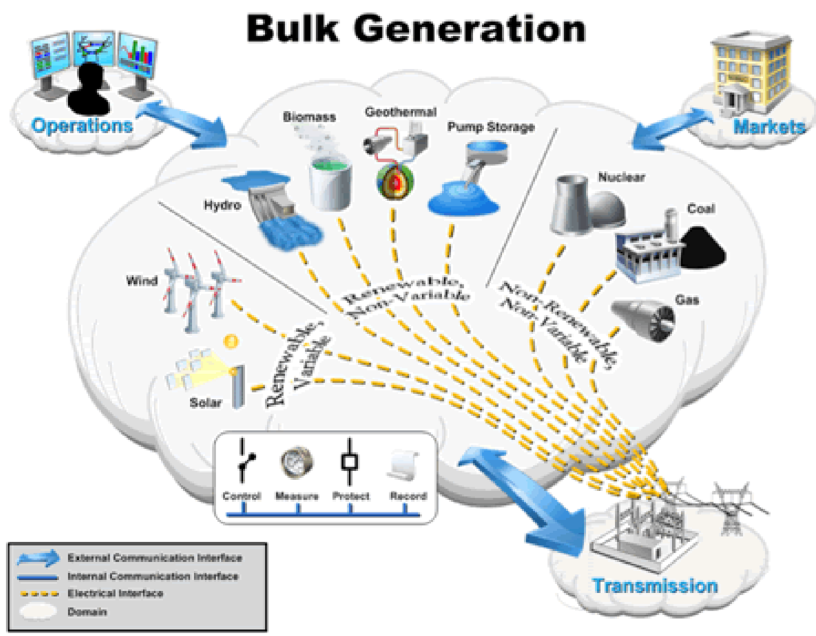
- Energy storage
- Regional market dispatch – interconnection imbalance
- Transmission upgrades
- Consumer load flexibility
- Wind production curtailment
- Increased flexibility from traditional generators
  - Reduced minimum loads
  - On / off cycling time reduction
  - Up / down load ramp increase



Nickell, B.M. (2008). “Wind Dispatchability and Storage Interconnected Grid Perspective.”

Mike D, Bob M, Baillie A. Transitioning from Traditional to Renewable Infrastructure. 2010. Available at: ww.aegislink.com

What existing power plants can do?
Flexibility of power plants – need for storage



NIST Smart Grid Conceptual Model

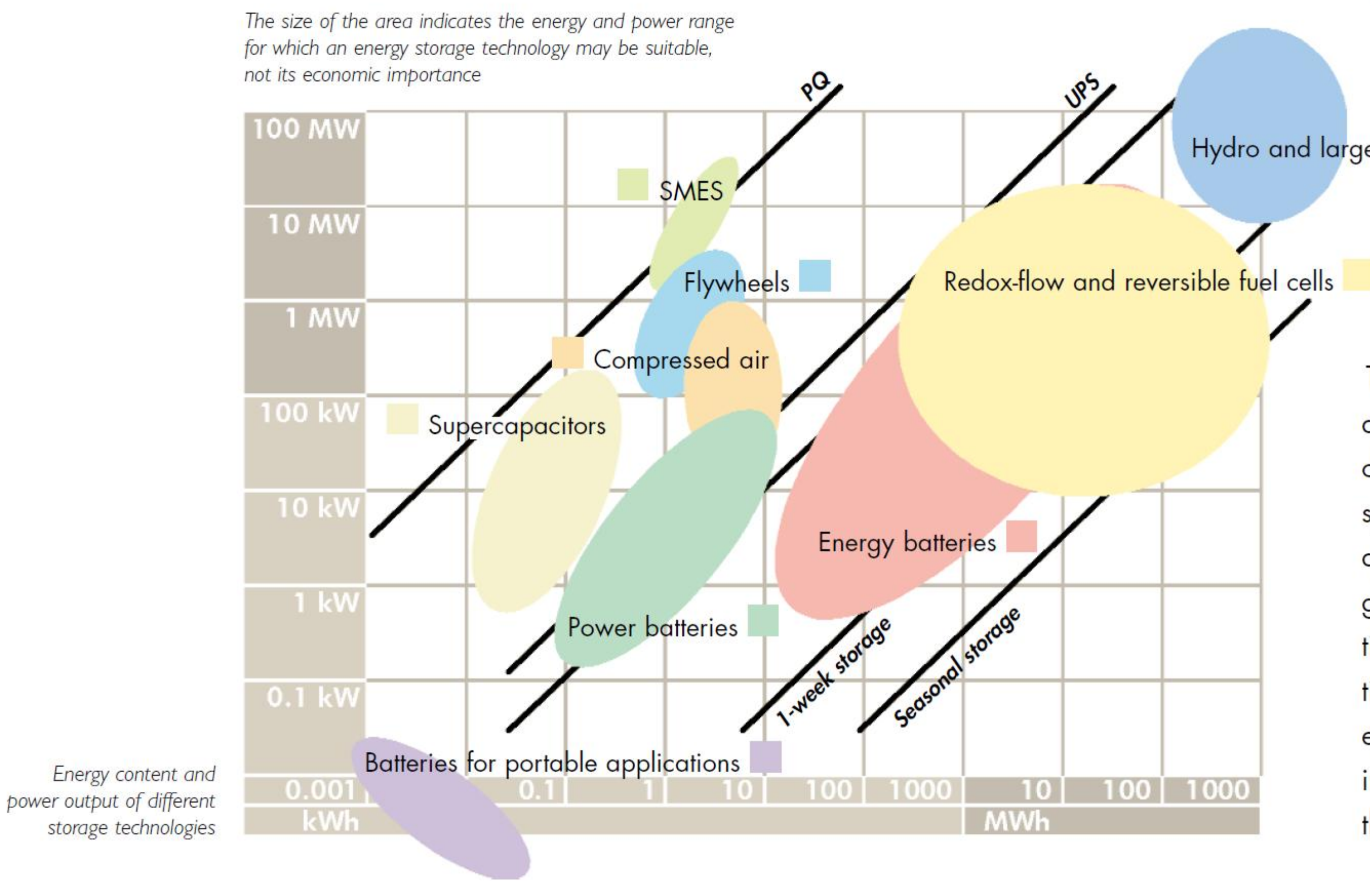
Technology	Flexibility parameter
Load	−0.1
Wind	−0.08
Solar PV	−0.05
Geothermal	0
Nuclear	0
Coal	0.15
Biopower	0.3
Gas-CC	0.5
Hydropower	0.5
H_2 Electrolysis	0.5
Oil/gas steam	1
Gas-CT	1
Electricity storage	1

P. Sullivan, V. Krey, and K. Riahi, "Impacts of considering electric sector variability and reliability in the MESSAGE model," *Energy Strategy Reviews*.

- NIST:
  - Non Renewable, Non Variable
  - Renewable, Non Variable
  - Renewable, Variable
- each generating technology is assigned a coefficient between 1 and 1 representing:
  - (if positive) the fraction of generation from that technology that is considered to be flexible
  - (if negative) the additional flexible generation required for each unit of generation from that technology.
- Non renewable is not variable but it could be not flexible.

What storage could do?
Storage technologies

expectations and overall costs.

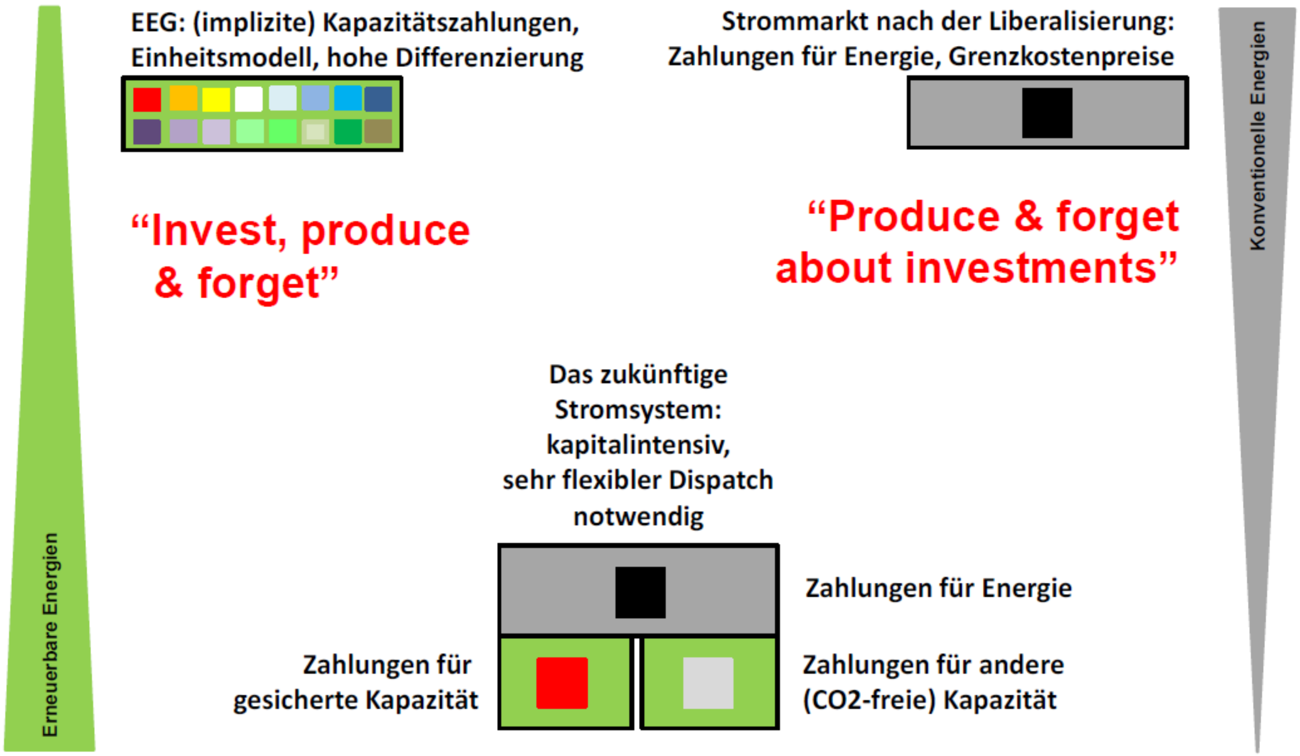


The power output and energy content of energy storage systems is typical for a storage technologies and application. Particular attention to these differences will be paid to in the description on the left.

Energy Storage A key technology for decentralised power, power quality and clean transport, Energy, environment and sustainable development, European Commission, 2011

Who want to invest?

New generation investment drivers



Welcher Weg dorthin?

„From vision to transition“

Vision und Augenmaß. Zur Reform des Flankierungsrahmens für die Stromerzeugung aus erneuerbaren Energien Fachgespräch von Agora Energiewende „Die Zukunft des EEG – Evolution oder Systemwechsel?“ Dr. Felix Chr. Matthes

Процена потребне висине накнаде до 2020. године

Godina	Neto energija GWh	Cena za kupce €/MWh	Cena energije €/MWh	Cena balansir. €/MWh	Snaga povlašć. MW	Energija povlašć. GWh	Troškovi za podsticajne cene miliona €	Troškovi za balansiranje miliona €	Prihod od cene energije miliona €	Potreban prihod od naknade miliona €	Visina naknade €/MWh	Visina naknade din/kWh	Uticaj na cenu za kupce %	Mesecni troskovi prosečnog domaćin. dinara
2011	28607	59.35	37.39	3.74										
2012	29036	54.19	34.14	3.41										
2013	29472	54.19	34.14	3.41	33	164.45	16.36	0.56	5.61	11.31	0.38	0.044	0.71	22
2014	29914	58.04	36.56	3.66	87	350.35	35.48	1.28	12.81	23.95	0.80	0.092	1.38	46
2015	30362	62.16	39.16	3.92	359	1176.75	116.03	4.61	46.08	74.56	2.46	0.282	3.95	141
2016	30818	66.57	41.94	4.19	429	1541.7	155.66	6.47	64.66	97.46	3.16	0.364	4.75	182
2017	31280	71.30	44.92	4.49	534	2081.1	213.79	9.35	93.48	129.66	4.15	0.477	5.81	238
2018	31749	76.36	48.11	4.81	677	2684.5	280.69	12.91	129.14	164.47	5.18	0.596	6.78	298
2019	32226	81.78	51.52	5.15	858	3390.5	360.05	17.47	174.68	202.83	6.29	0.724	7.70	362
2020	32709	87.59	55.18	5.52	1045	4134.5	446.93	22.81	228.14	241.60	7.39	0.849	8.43	425

- Претпостављени раст потрошње 1.5% годишње
- Претпостављени реални раст цене 5% годишње од 2014. године
- Претпостављени курс 115 динара за евро

ПОЛИТИКА РЕПУБЛИКЕ СРБИЈЕ У ОБЛАСТИ ОБНОВЉИВИХ ИЗВОРА ЕНЕРГИЈЕ, ПРОФ. ДР ЗОРАНА МИХАЈЛОВИЋ, МИНИСТАР , Привредна комора Србије, Београд, 10. децембар 2012

Where MoEDaEPoRoS would like to invest?
Priority storage projects.

PSHPP "Bistrica", 60 GWh, 680MW, 600M€

PSHPP "Djerdap III", 460 GWh, 1800MW, 400M€ (1st phase, 600MW)

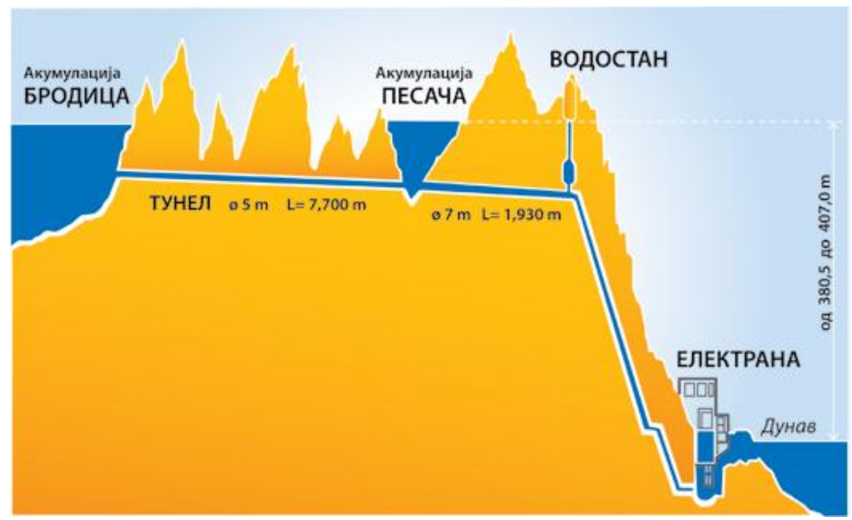
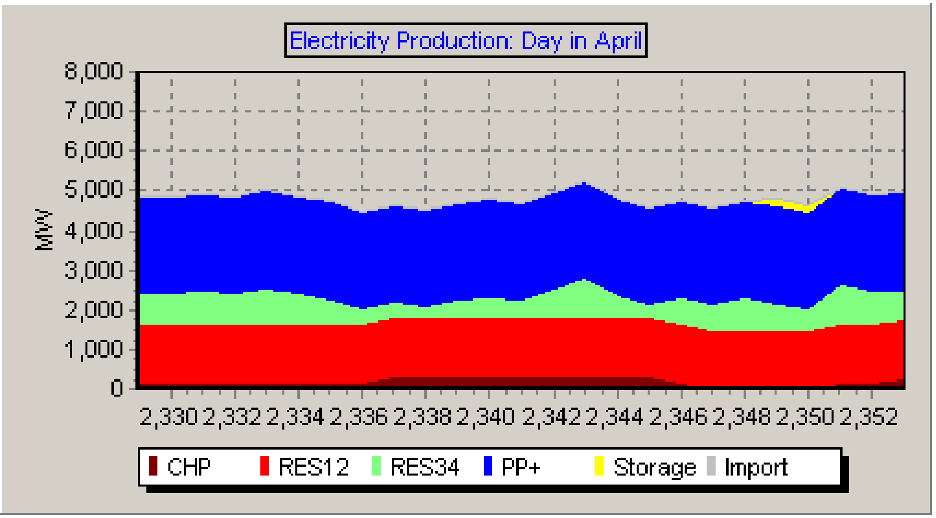
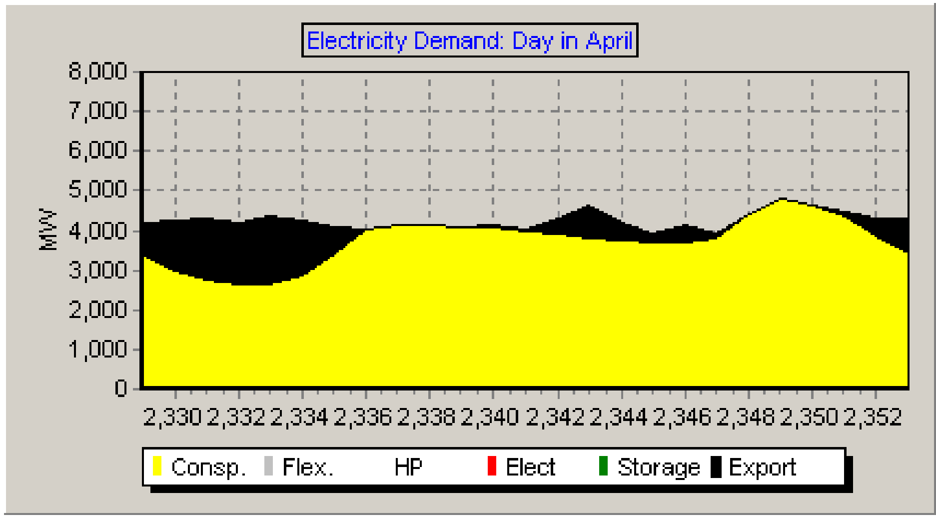


Photo: Strateski i razvojni projekti Elektroprivrede Srbije, Elektroprivreda Srbije (Beograd), 2011

What if there is no investment in storage?
Critical Excess Electrity Production

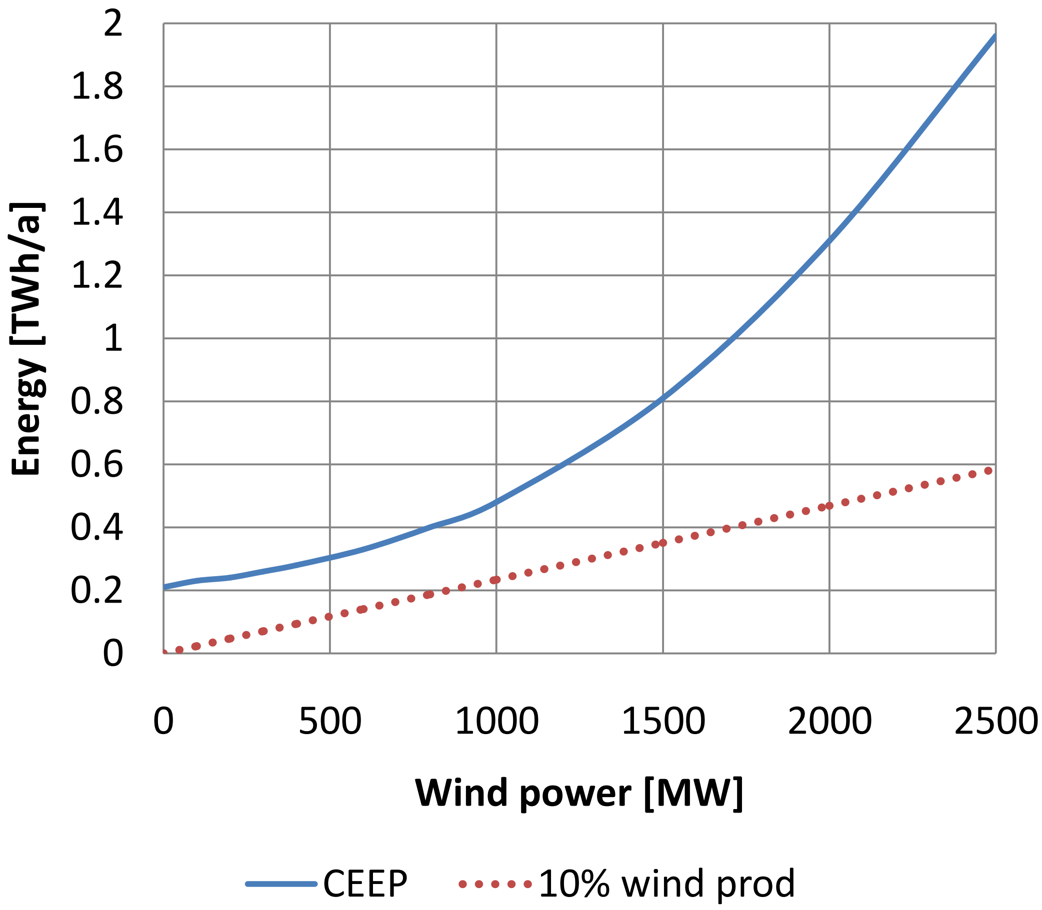
- Scenario with 2000MW of wind integrated, day in April.
- Flexibility of existing hydro and TPP is limited and fully exploited.
- Critical productions must be exported or curtailed.





CEEP in Serbia, scenarios up to 2500MW of wind

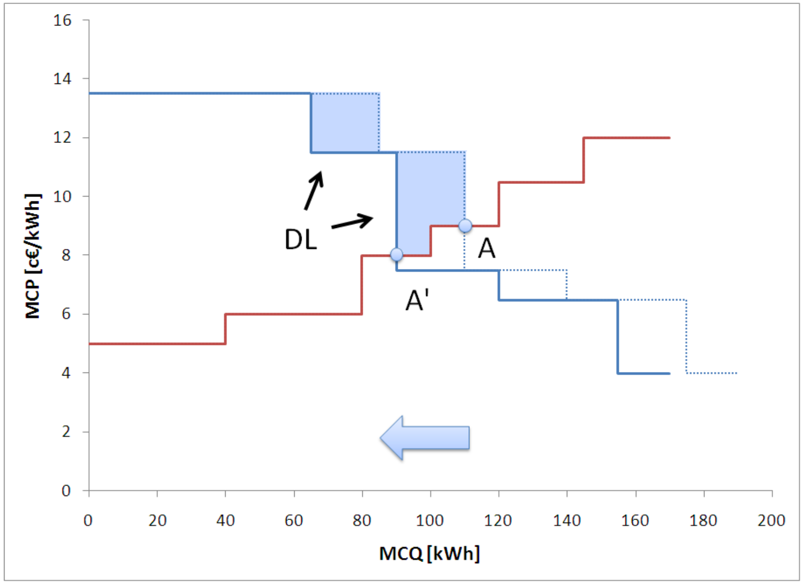
- Who will pay for moderation costs of variable renewable energy sources?
- What is Critical Excess Electricity Production in Serbia for case of 2500MW of wind power?
- It is exportable but should be not exported without a plan.



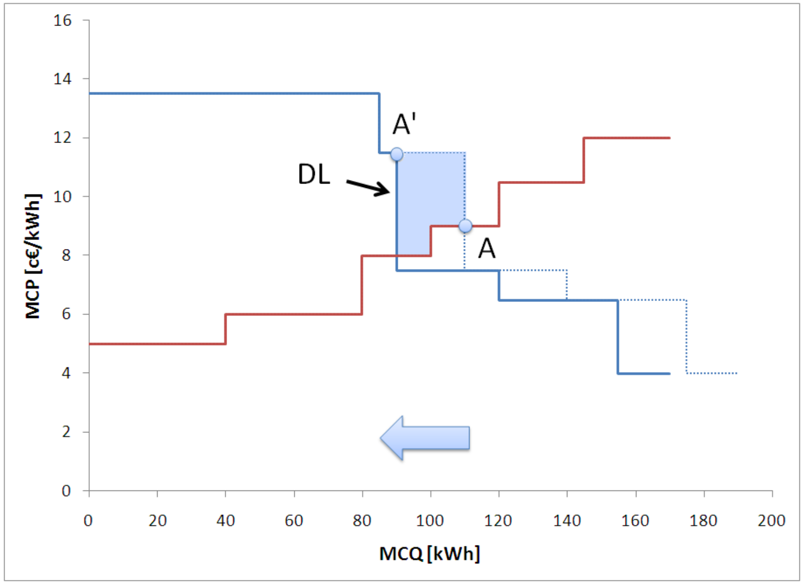
I. B. Bjelić, N. Rajaković, B. Ćosić, and N. Duić, "Optimal wind power generation in existing Serbian power system,"

What if transmission is not sufficient? *Congestion...*

...at supply side



...at demand side.



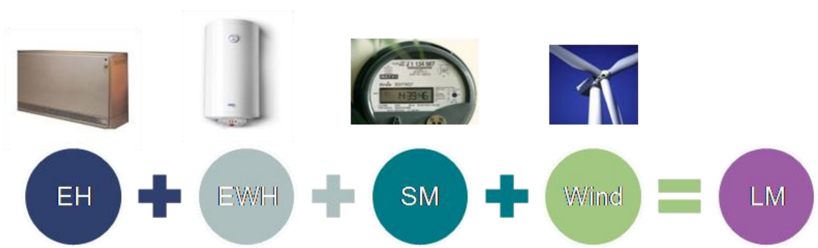
I. B. Bjelić and I. Škokljev, "Deregulated Serbian Electricity Market Optimal Dispatch with Congestion Constraints," *Journal of Electrical Engineering, vol. 8, pp. 325-331, 2011.*

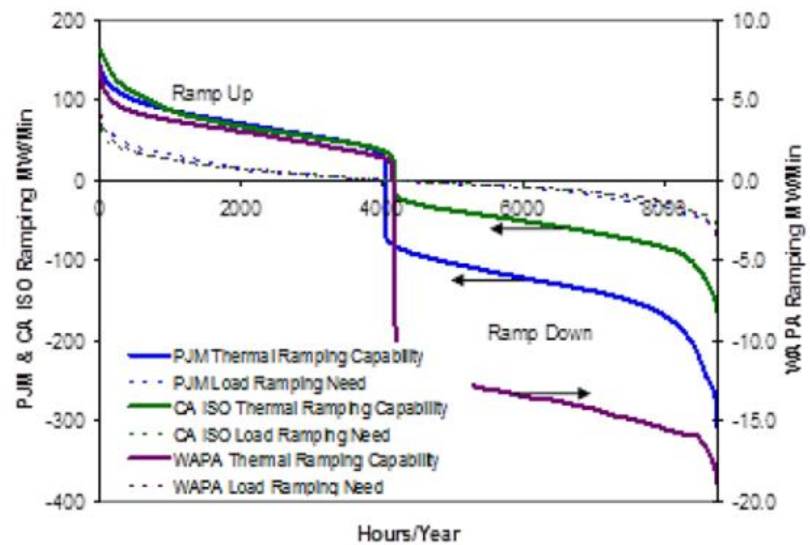
Flexibility of production and consumption: options to be considered

Demand Response: Discretionary Demand	Low to Medium	Low to Medium	Short to Medium
Demand Response: Interruptible Demand	Low to Medium	Low to Medium	Short to Medium
Demand Response: Distributed Energy Storage Appliances	Low to Medium	Low to Medium	Short to Medium
Flexibility of Existing Plants—Minor Retrofits	Low to Medium	Low to Medium	Short to Medium
Flexibility of Existing Plants—Major Retrofits	Medium to High	Medium to High	Medium to Long
Flexibility for New Generating Plants	Low to High	Medium to High	Medium to Long

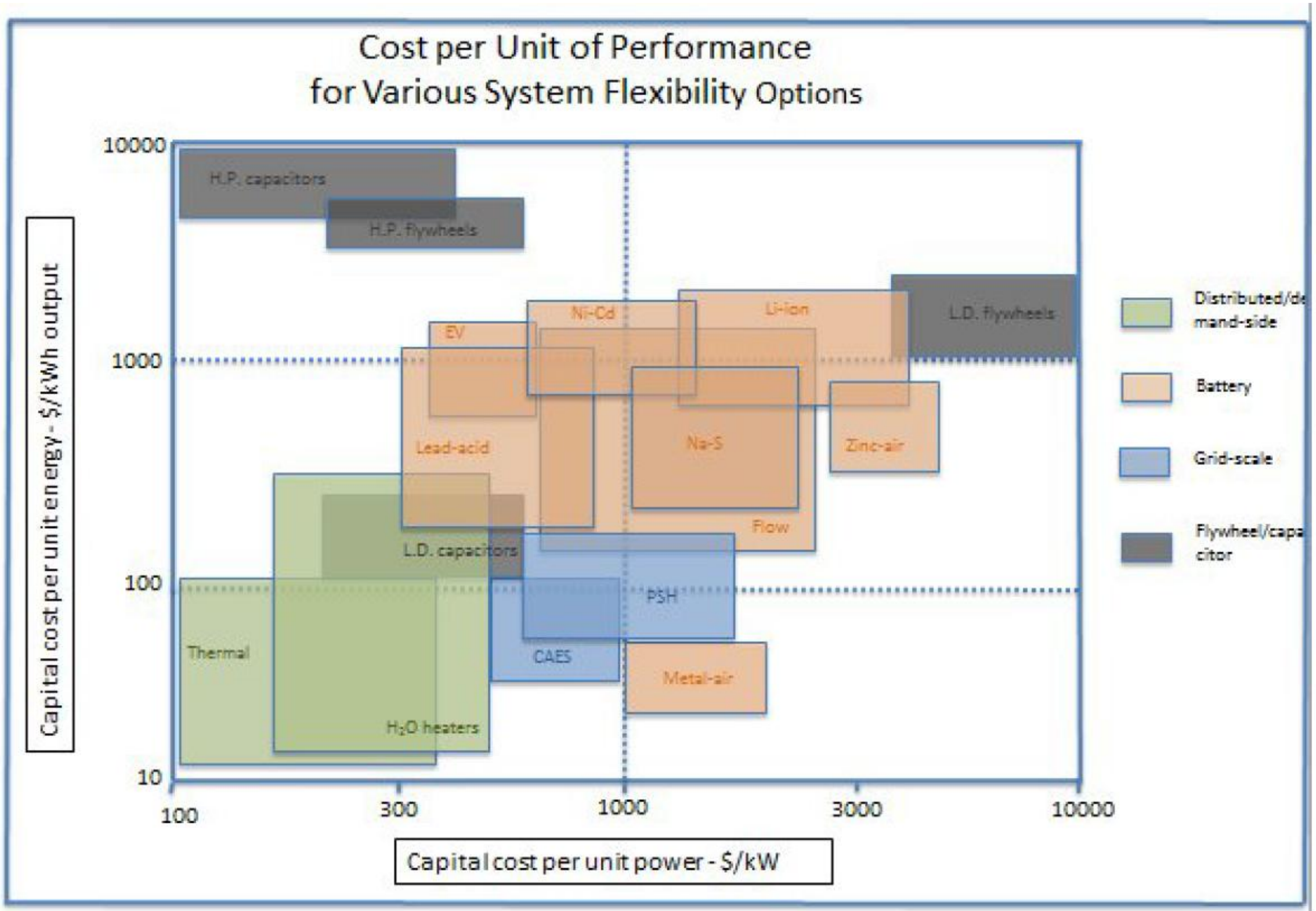
"Meeting Renewable Energy Targets in the West at Least Cost: The Integration Challenge" NREL/SR-550-47434

- Retool Demand Response to Complement Variable Generation
- Access Greater Flexibility in the Dispatch of Existing Generating Plants





Cheap consumer side flexibility options (virtual storage options)



"Meeting Renewable Energy Targets in the West at Least Cost: The Integration Challenge" NREL/SR-550-47434

Virtual Power Plant- concept

Virtual power station

A conventional power station generates electricity in one location, using one type of generating technology and is owned by one legal entity. A virtual power station is a multi-fuel, multi-location and multi-ownership power station, which generates electricity in many locations in the grid. Both supply energy reliably at the predetermined time. In today's electricity market this means making a supply contract for each hour of the next day. Some power stations, both conventional and virtual stations, must also be capable of changing their power output quickly and sell this capability as ancillary services to grid operators.

Energypark at Clausthal, Germany

For a grid operator or energy trader, purchasing energy or ancillary services from a virtual power station will be equivalent to purchasing from a conventional power station.
The concept of a virtual power station is not a new technology but a method of organising decentralised generation and storage in a way that maximises the value of the generated electricity to the utility. Virtual power stations using distributed and renewable energy generation and energy storage have the potential to replace conventional power stations step by step until a sustainable energy mix has developed.

Further reading

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- I. B. Bjelić, N. Rajaković, B. Ćosić, and N. Duić, “Optimal wind power generation in existing Serbian power system .,” in 7th CONFERENCE ON SUSTAINABLE DEVELOPMENT OF ENERGY, WATER AND ENVIRONMENT SYSTEMS, 2012.
- Milan Ivanović, Saša Minić, Miloš Kostić, "Techno - Economic Analysis of Connecting Cogeneration Plant to the Distributive Network", Power Plants 2012, E2012-075, Zlatibor, Serbia, 2012, pp. 886-900
- Saša Berberski, Željko Đurišić, Short-Mid-Term Power Prediction of Photovoltaic Array Based on Clouds Tracking in Real Time, 27th European Photovoltaic Solar Energy Conference (EU PVSEC), Frankfut, Germany, 24-28. September 2012
- Škokljev, D. Šošić, “Available Transmission Capacity Assessment”, Serbian Journal of Electrical Engineering, Vol. 9, No. 2, June 2012,pp. 201-216.
- G. Dobrić, Ž. Đurišić, Z. Stojković, Fotonaponski sistem na krovu zgrade tehničkih fakulteta u Beogradu povezan na distributivnu mrežu, INFOTEH-JAHORINA 2012, Vol. 11, Ref. ENS-3-4, Mart 2012, p.181-186.

Thank you for your kind attention

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