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HOTHOUSE EARTH. OCTOBER 2011
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Uitwegen voor de moeilijke situatie van NL (industriële) WKK

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Driebergen, Dinsdag 3 juni 2014

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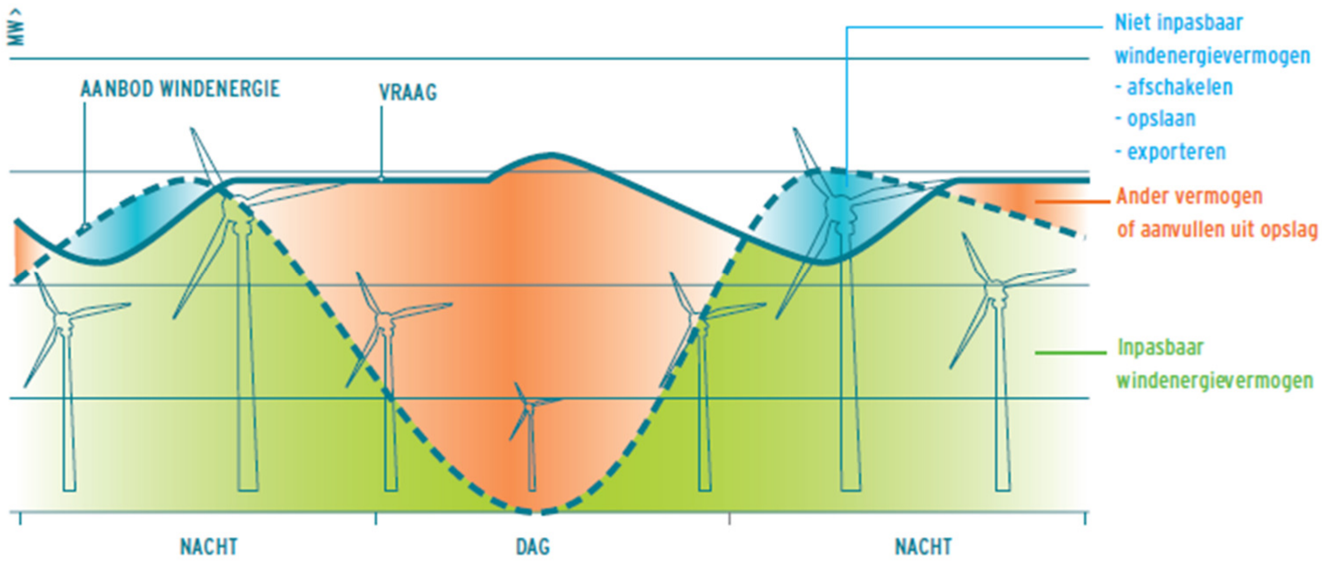
Renewables genereren alle stroom

(in Nederland in 2023 1500-2500 uur per jaar)

VB: Nederland



RegieOrgaan Energietransitie Nederland: Duurzame energie in een nieuwe economische orde; 14 november 2008

De wisselingen zullen groot en snel zijn

(en komen in korte tijdsblokjes)

VB: Spanje

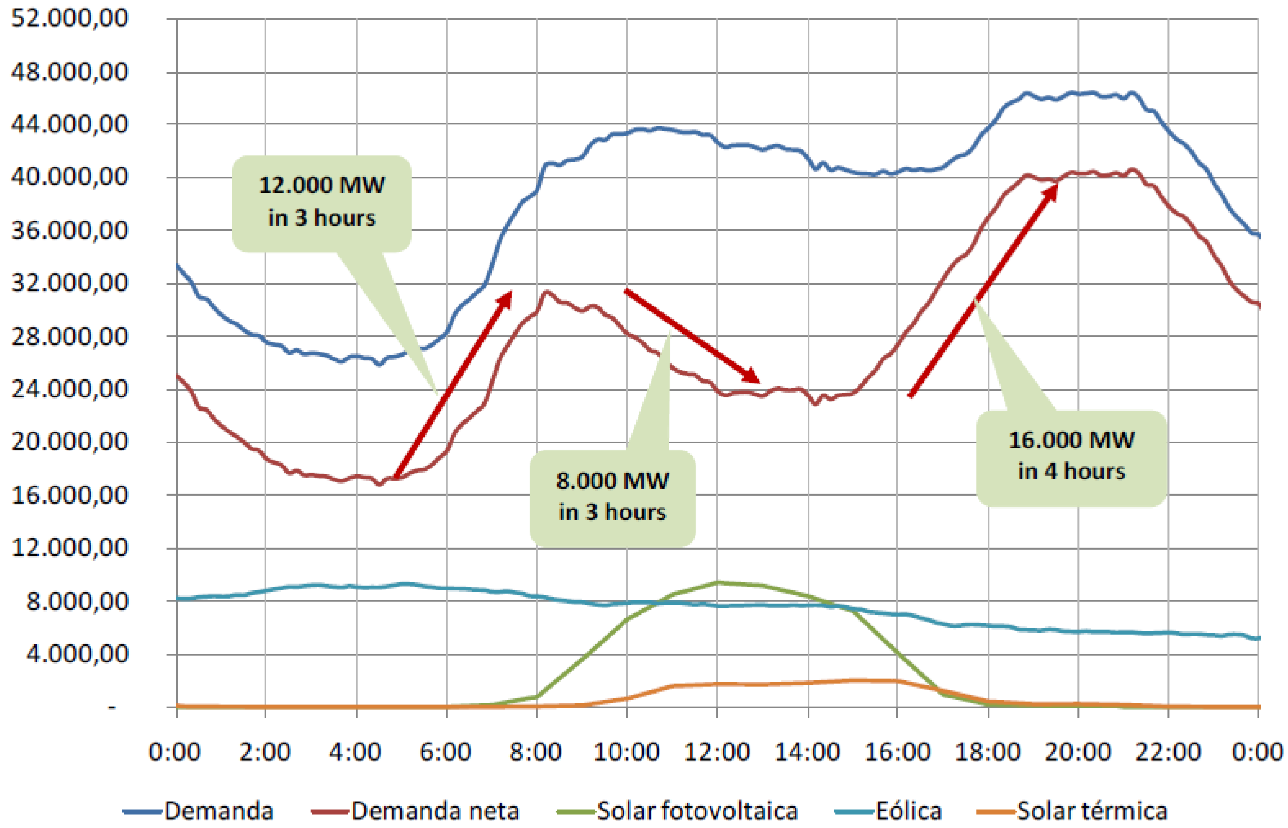


Figure 9 – Impact on electricity system of projected wind and solar load profiles in Spain in 2020 (Source UNESA)

Eurelectric: Flexible gas markets for variable renewable generation. May 2014

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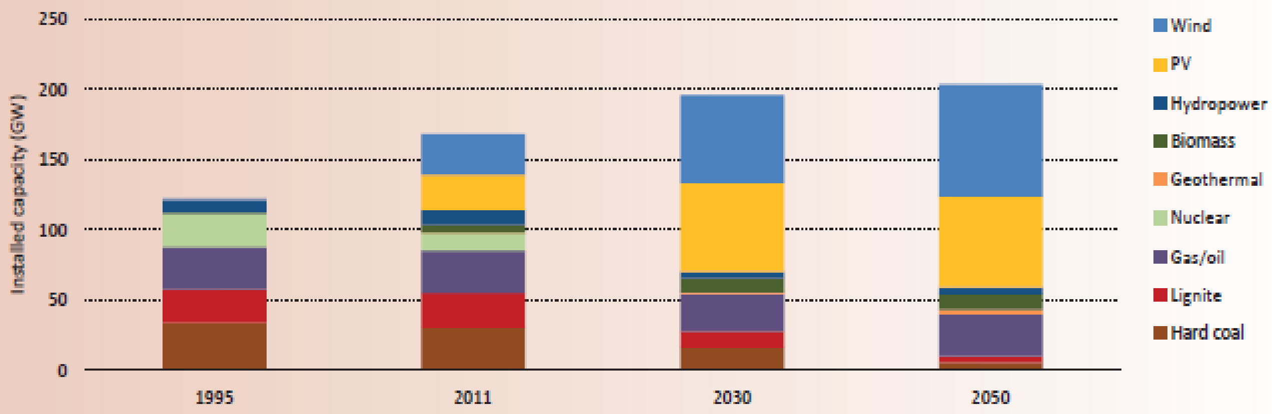
En we zijn er nog lang niet

(Duitsland plant 80% RES power in 2050)

VB: Duitsland

Figure 13: Installed capacity and electricity generation in Germany: 1995, 2011, 2030, and 2050



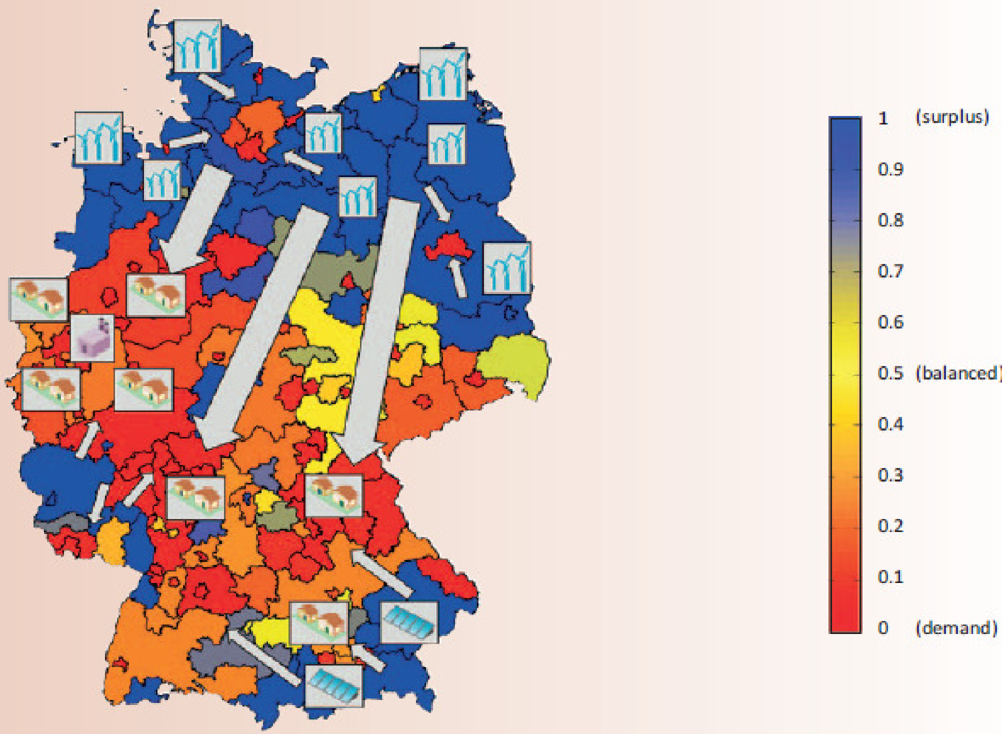
Source: Eurelectric (2009), "Statistics and prospects for the European electricity sector (1980-2000, 2004, 2005, 2006, 2010-30)", *EURPROG 2008*, Eurelectric, Brussels, Belgium and *BMWI (2013) and* BMU (Federal Ministry for the Environement, Nature Conservation and Nuclear Safety) (2012), "Langfristszenarien und trategien fur den Ausbau der erneuerbaren Energien in Deutschland bei Berucksichtigung der Entwicklung in Europa und global", BMU, Berlin.

IEA: Energy Storage Technology Roadmap; 2014

Met grote regionale verschillen

VB: Duitsland

Figure 14: Challenges faced by the electricity sector in Germany



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Note: figure based on results of research project ‚Bedarfsanalyse Energiespeicher' realized by Fraunhofer UMSICHT, supported by the German Federal Ministry of Economics and Technology.

Source: Beier, P. and P. Bretschneider (2013), "Modellbasierte, regional aufgelöste Analyse des Bedarfs an netzgekoppelten elektrischen Energiespeichern zum Ausgleich fluktuierender Energien", final report, Bedarfsanalyse Energiespeicher, Frauenhofer Institute, Munich, Germany, http://www.iosb.fraunhofer.de/servlet/is/37913/04_IOSB_Jahresbericht-2012-2013_Standorte2.pdf.

IEA: Energy Storage Technology Roadmap; 2014

WKK (Met HS en P2H) integreert

Box 2: Potential use of thermal storage in CHP plants to support the integration of renewable energy resources

Thermal energy storage can increase operational flexibility in CHP plants by enabling the decoupling of the heat demand of a connected district heating system and the requirements of the electricity system. Furthermore, the increased flexibility afforded by both thermal and electricity storage in CHP facilities could enable higher levels of participation in balancing power markets.

Thermal storage, in the context of district heating, stores heat in the form of hot water in tanks. In atmospheric storage systems, the water temperature lies just below the boiling point at around 95°C to 98°C. Pressurised tanks typically store water at temperatures of between 120°C and 130°C. The size of such storage tanks can range from 100 cubic metres (m^3) up to 50 000 m^3 in volume, which corresponds to heat storage capacities from approximately 10 megawatt hours (MWh) to 2 gigawatt hours (GWh) per load cycle.

Storage facilities that store energy at atmospheric pressure have comparatively lower investment costs than pressurised ones. However, the pressurised storage technologies show a 30% to 40% higher specific storage capacity per volume.

Today's thermal storage facilities focus on reducing the operation of peak load boilers and avoiding costly restarting processes. Furthermore, in the presence of district heating networks, heat price can have a significant impact on the choice of the CHP plant's business model. In the case of rapidly increasing use of renewable energy resources, CHP is poised to operate primarily in one of two strategies.

(.../...)

IEA: Energy Storage Technology Roadmap; 2014

Flexibele WKK: Low Carbon power source and sink, dankzij warmte

Box 2: Potential use of thermal storage in CHP plants to support the integration of renewable energy resources (continued)

Case A High electricity prices	Case B Low electricity prices
*High residual load**	*Low or negative residual load*
Focus placed primarily on electricity production with residual heat being directed to district heating networks as it is available. The balance of the heat demand is met using previously charged thermal storage systems or other heat-only facilities.	*In this case, the electricity price is lower than the electricity production costs of the CHP plant. As a result, the CHP is either shut down or operated at the minimum level needed to prevent shutdown and any heat demand is served by previously charged thermal storage.*
However, in many CHP facilities, heat and electricity production are coupled in a rigid manner. As a result, medium or low heat demand results in decreased levels of electricity production. In this case, thermal storage can serve as the heat sink to allow for increased electricity production at times of low heat demand (and vice versa).	*In these cases, CHP facilities could alternatively integrate auxiliary electric heating systems (power-to-heat) if no higher-value application exists for the electricity. The combination of CHP plants, thermal storage and power-to-heat systems allows for the direct integration of excess electricity from renewable energy sources into district heating networks.*

* Residual load is defined as the electricity demand minus the amount supplied by renewable energy.

IEA: Energy Storage Technology Roadmap; 2014

Met name in de korte termijn markten

Table 8: Options for various energy system applications in Germany

Service provided	Current options	Future storage options
Temporal imbalances (hours to days)	• Curtailment of variable renewables • Electricity storage • Gas turbines • Other fossil power plants • Centralised CHP • Thermal storage	• Batteries (lithium-ion and lead-acid batteries) in households with roof-mounted PV systems • Thermal and electricity storage in decentralised CHP • Thermal storage • Fuel cells • Electricity storage
Regional imbalances	• Electricity exports in Northern Germany to Netherlands and Poland • Imports in Southern Germany from France and Czech Republic • Transmission grid enhancement	• Large-scale batteries (MW scale) at the distribution grid • CAES systems (10s to 100s MW scale) linked to transmission grid • Thermal storage
Long-term storage needs (weeks to months)	• Thermal storage	• Hydrogen storage • Thermal storage • Power-to-gas

IEA: Energy Storage Technology Roadmap; 2014

Gas omzetting (ook WKK) kan snel op/af

Results from an EU study (ELEP) on local generation

Table 3: Dynamic properties of different generators [3]

	Ramp rate	Start time to synchronisation
	%/minute	minute
Gas-fired steam	3	120
Coal fired steam	3	150
Aero derivative gas turbine	20	5
Gas turbine combined cycle	5	8
Diesel engine	100	0.5
Gas engine	30	0.5
Hydro	40	0.2

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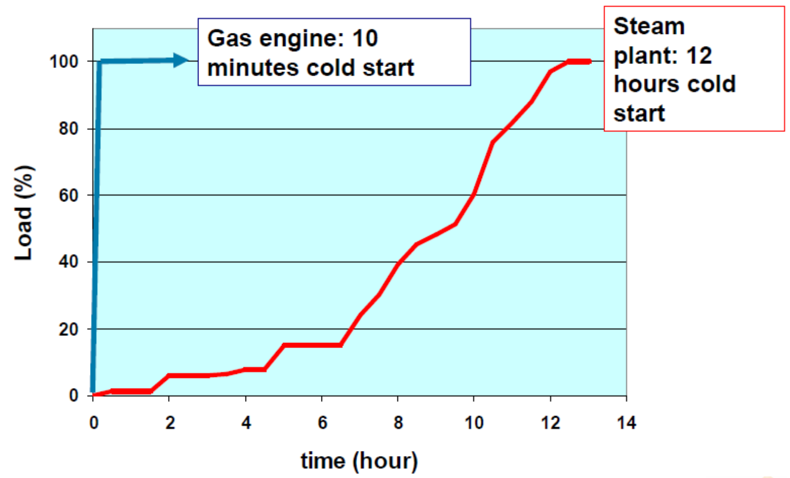
Cold Start 330 MW gas-fuelled power plant



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Wartsila Power Systems.

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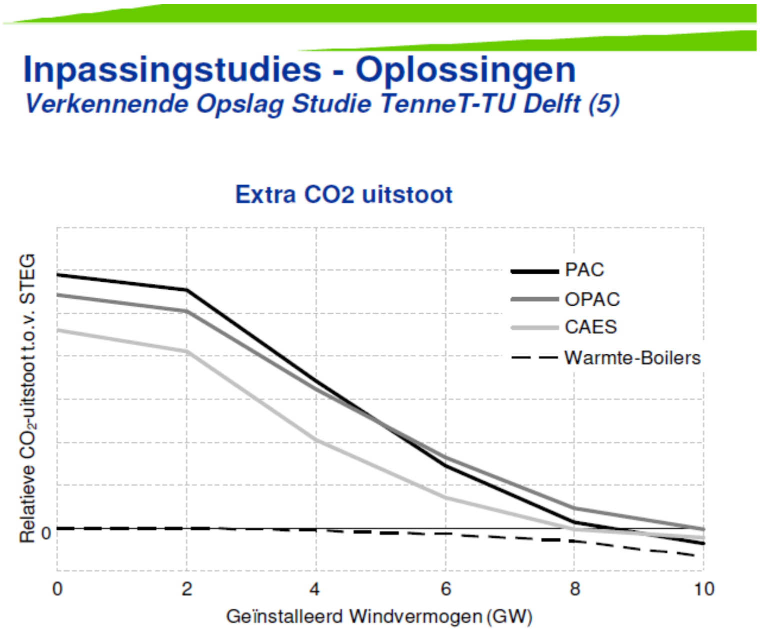
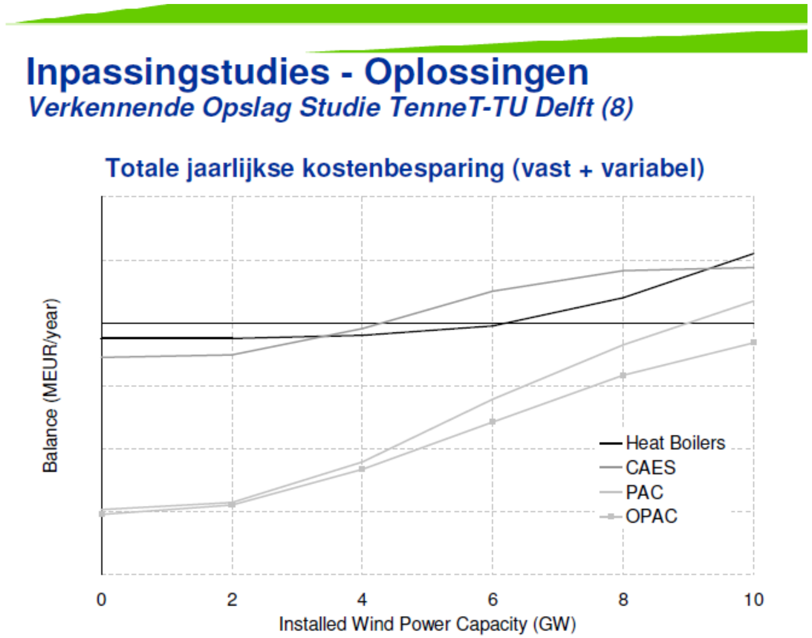
Gas WKK+HS+HB levert goedkoopste NL integratie van veel wind en zon





TenneT: Integratie van grootschalig windvermogen in het Nederlands elektriciteit systeem; Pelgrum; 9 november 2007; www.cogen.nl

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Juist Nederland heel geschikt voor uitbouw WKK met HB, HS en P2H

4.6 Summary and Conclusions

An interesting result is that energy storage is shown to increase overall emissions of CO_2 for the system as a whole at lower wind power penetrations. This can be explained by the use of energy storage for substituting clean, peak-load gas generation for base-load coal generation and the conversion losses inherent to operating storage. Heat boilers always provide CO_2 emission savings with increasing amounts with wind power installed capacity. The cost benefit analysis performed here shows that neither PAC nor UPAC are likely to have a positive balance, even at very high wind power penetrations, which is mainly due to the very large investment costs associated with these options. CAES may be an option for higher wind power penetrations, although its benefits for wind power integration are limited. NN2 has the largest potential for wind power integration and for operational cost savings due to its very large reservoir size and low conversion losses. Considering this alternative for wind power integration only however results in a negative balance. <u>For the Dutch power system, the use of heat boilers at CHP locations and the development of additional interconnection capacity with Norway seem to have the highest potential for efficiently creating additional technical space for wind power integration.</u> Possibilities for international exchange should be regarded as a promising alternative for the development of energy storage in the Netherlands.

Maar ook in Duitsland en Denemarken speelt flexibele WKK centrale rol

There are technologies that can be used to relax each of these constraints: CHP plants can be supplemented with heat storages or electrical boilers to be dispatched more flexibly. Batteries, consumer appliances, or power electronics could help to supply ancillary services. Both measures imply that thermal plants can be turned down more easily in times of high VRE supply. In general, new plant designs and retrofit investments allow steeper ramps and quicker start-ups.

The mid-term value factors indicate that the impact of adding flexibility to the system is large (Fig. 28). As expected, adding flexibility increases the market value of wind. What might be surprising is the size of the effect: making CHP plants flexible alone increases the value factor by more than ten percentage points at high penetration levels. All flexibility measures together increase the market value of wind by an impressive 40%. At high wind penetration, the amount of hours where prices drop below the variable costs of hard coal is reduced from more than 50% to around 20% (Fig. 29).

These findings lead to a number of conclusions. Firstly, there are a number of integration options that help mitigating the value drop of VRE: transmission investments, relaxed constraints on thermal generators, and a change in wind turbine design could be important measures. Especially increasing CHP flexibility seems to be highly effective. Increasing wind turbine rotor diameters and hub heights reduce output variability and could help to stabilize wind's market value. Secondly, variable renewables need mid and peak load generators as complementary

Lion Hirth (Vattenfall Germany): The market value of variable renewables.
In Energy Economics 38, 2013. Pages 218-236

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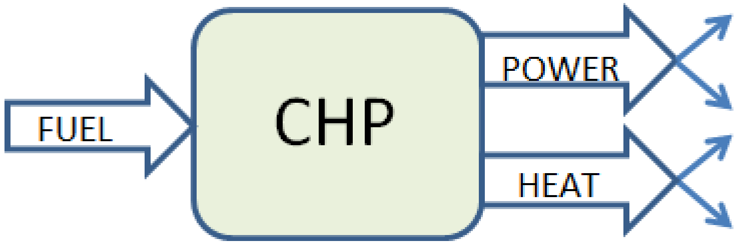
Opties om WKK te flexibiliseren

Flexibele E WKK….



A. POWER TO POWER GRID

B. POWER FOR OWN USE

C. HEAT TO HEAT GRID

D. HEAT FOR OWN USE

…kent verschillende stappen van flexibiliteit…..

1. Reducing/stopping power to the grid delivery, as market prices make his supply lossmaking
2. Reducing/stopping power for own use generation, as it is then cheaper to purchase power
3. Reducing/stopping heat delivery to third parties, if low prices prevail and flexibility allows
4. Reducing/stopping heat generation for own use, at prolonged periods of low power prices.

….flexibiliteit die nog toeneemt door (systeem) integratie met

1. Heat storage (HS), using thermal inertia of processes, buildings, etc. or special heat storage facilities (above- or underground) to temporally store heat as to time-shift power generation.
2. Power to Heat (P2H), using (oversupply of) power to generate low/medium/high temperature heat. P2H can be both applied in domestic spatial heating, as well as in industrial applications
3. Power to Pressure (P2P). using (oversupply of) power to recompress low pressure steam to high pressure steam. P2P has large scale application potential in (petro) chemical industry.

Alle flexibele WKK opties vragen structureel ander marktontwerp.

Voor Discussie

- Huidig markten belonen verspilling/vervuiling
- WKK besparingen niet financieel beloond
- Flexibilisering kost capex, opex, bij minder vollast uren > maakt WKK economie slechter
- Maar flex WKK wel qua kosten goedkoopste low carbon wind en zon integratie.
- Marktontwerp dient sustainable energy system te stimuleren en carbon intensiteit/ capaciteit/productie/flexibiliteit te belonen.

“slechts een kwestie van tijd”

EnergieActueel, 6 mei 2014