BMWi-Project
Smart Grids for the power supply of the future

Biogas storage as an approach to level load peaks of decentralized feed-in from renewable energy

Dortmund, 25th, Sep. 2012 – Dipl. Wirt.-Ing. Dirk Sattur

Gefördert durch:

Bundesministerium für Wirtschaft und Technologie

aufgrund eines Beschlusses des Deutschen Bundestages

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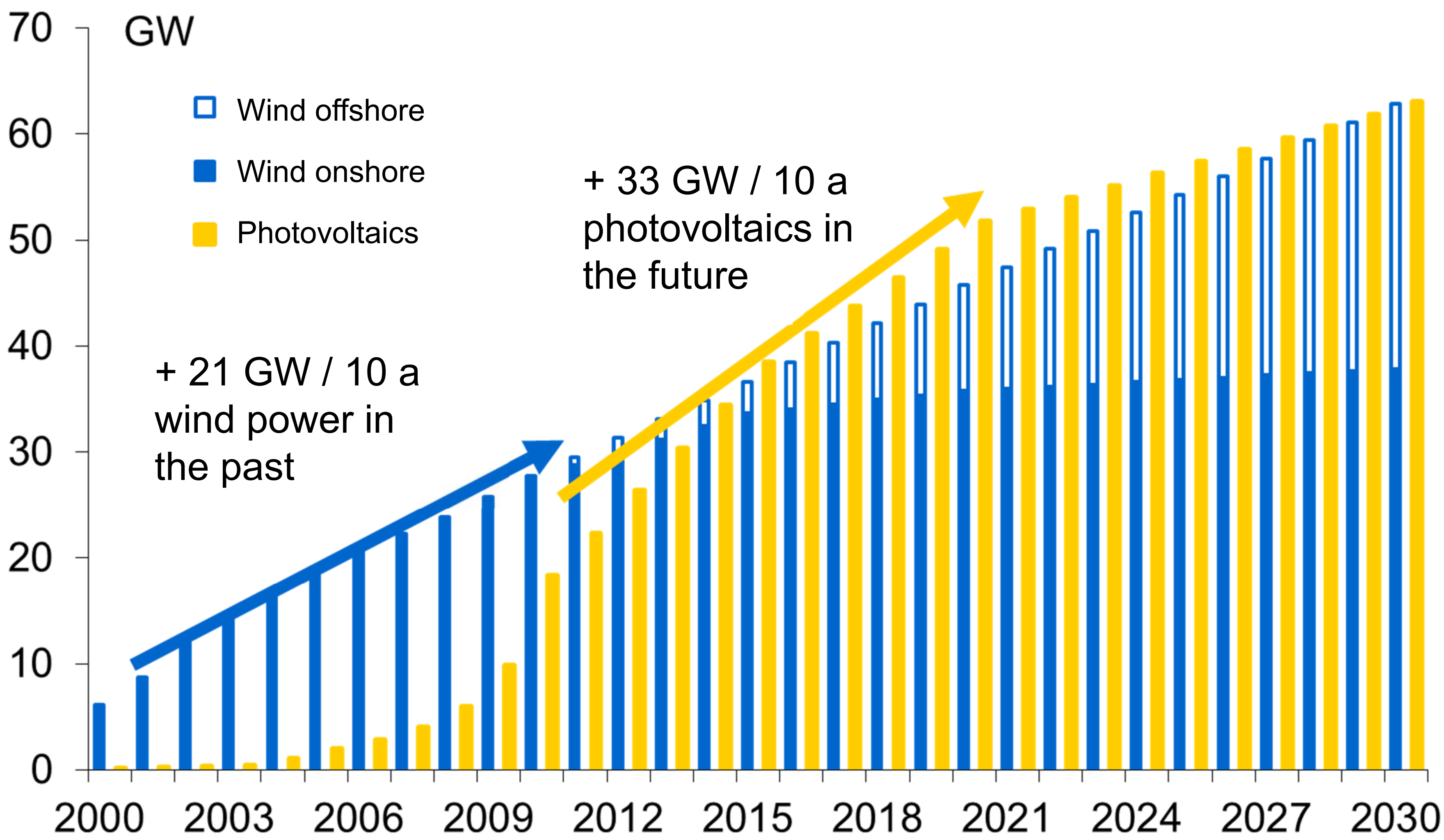
Netze für die Stromversorgung der Zukunft

Grids for the power supply of the future is a joined project sponsored by the BMWi (Fed. ministry of economy and technology)

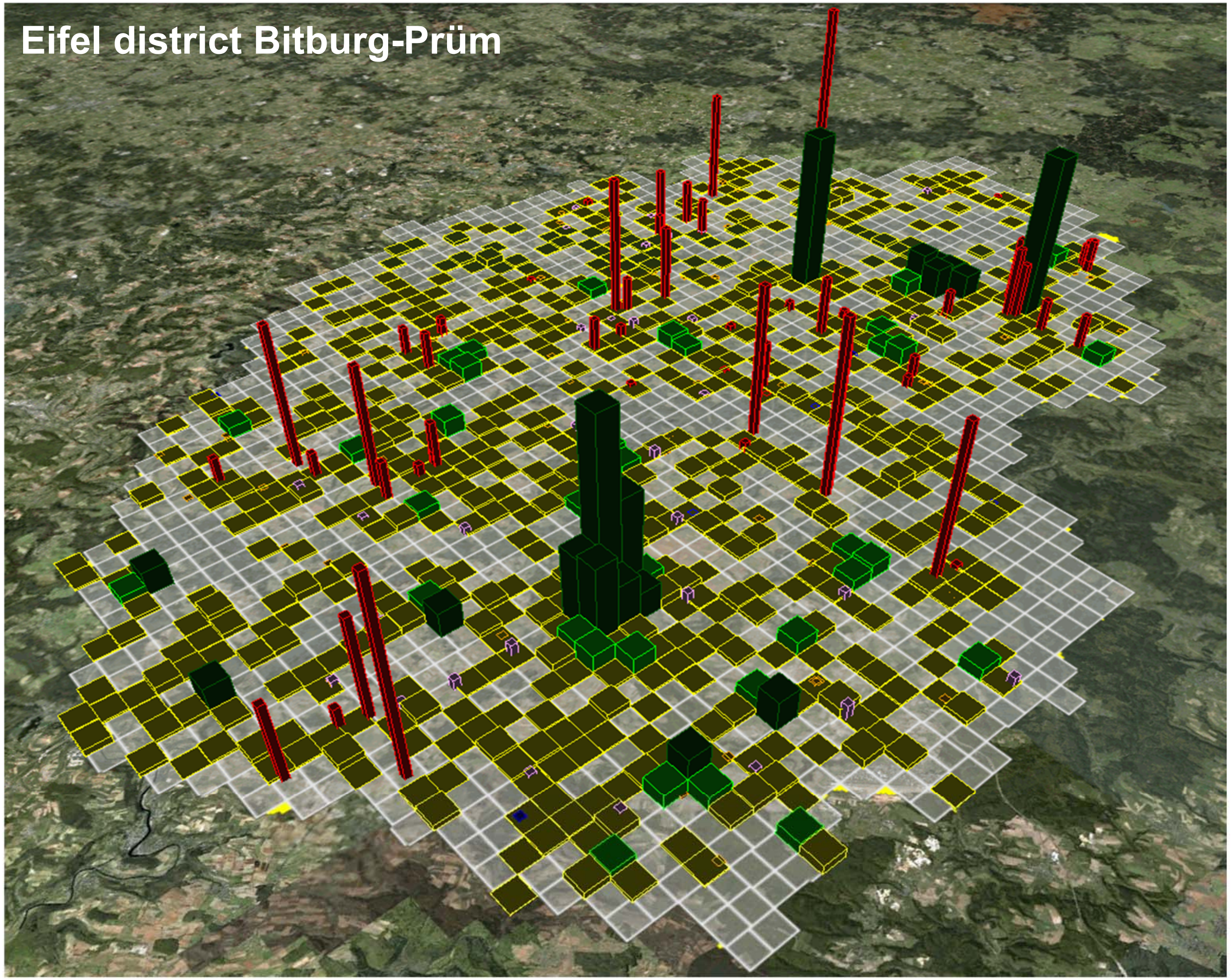
Consortium manager	**RWE Deutschland AG**
Aims Gefördert durch: Bundesministerium für Wirtschaft und Technologie aufgrund eines Beschlusses des Deutschen Bundestages	> Identification of smart distribution grid concepts (depending on the supply task) > Further development of valuation methods > Development of tools and utilities > Demonstration of results at a demo grid
Duration	**July 2009 – September 2011**
Demonstration-Smart-Grid Test of advanced technology in the following fields:	> Use of information and communication technology (ICT) > Storage to avoid grid reinforcement > Customer-oriented regulation of voltage quality > Wide range regulation > Trunk line with break switch

Expansion of photovoltaics has more impact on the lower grid levels than the expansion of wind power



Source: BMU (Fed. Environment Ministry) pilot study

Inhomogeneity of supply responsibilities – local disparities of power demand and generation are cost-pushing



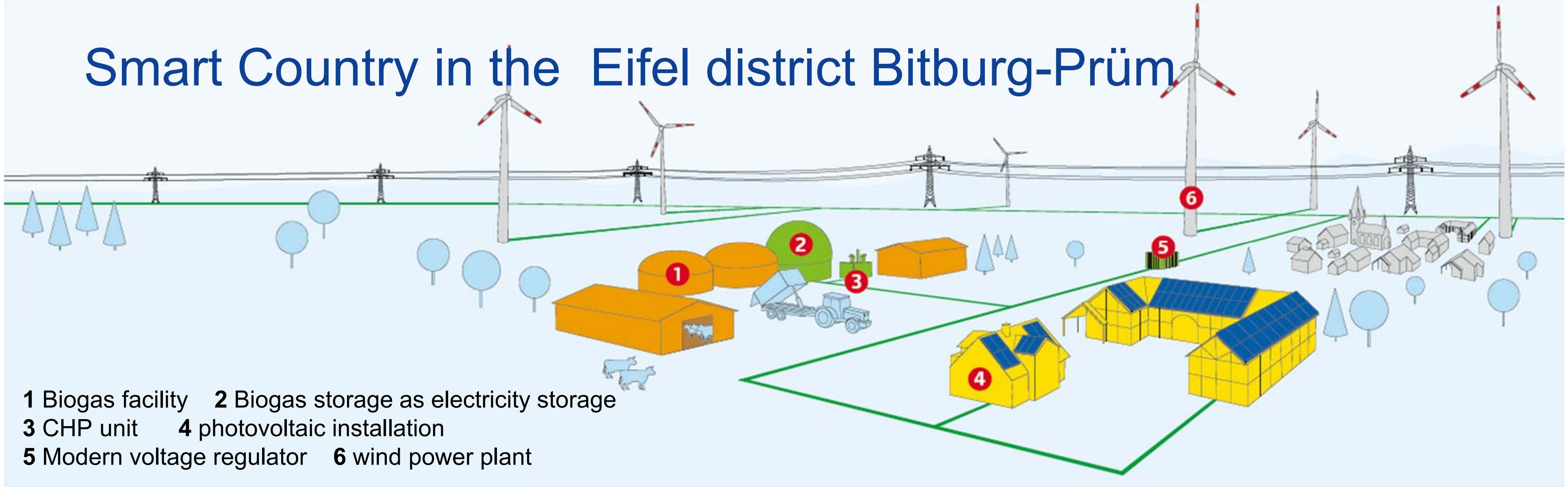
Load distribution:

- Urban areas
- Rural areas (single farmsteads)
- Not supplied area (Lakes, forests)

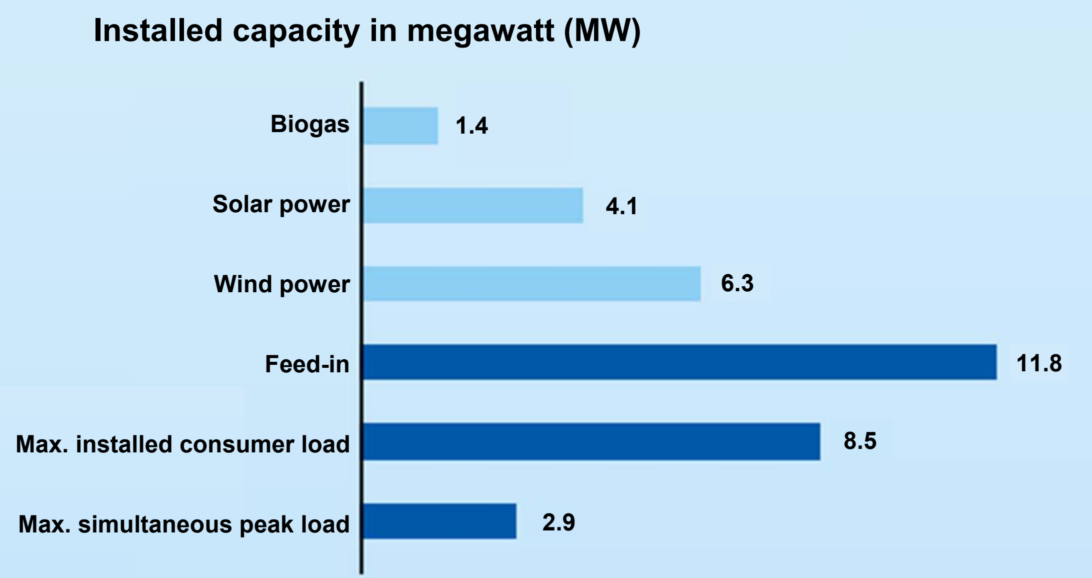
Generation distribution:

- Wind power
- Photovoltaics
- Hydropower
- Biomass

Smart Country in the Eifel district Bitburg-Prüm

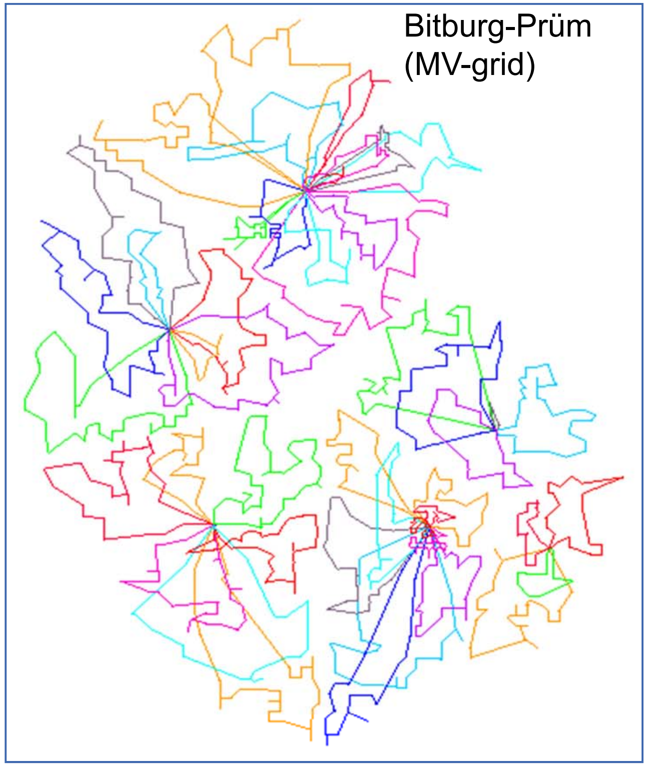


1 Biogas facility **2** Biogas storage as electricity storage
3 CHP unit **4** photovoltaic installation
5 Modern voltage regulator **6** wind power plant



Changing supply task results in significant restructuring effort when using conventional grid expansion

Reference grid 2010



Grid load: 135 MW
Generation: 110 MW
Grid length: 2.438 km

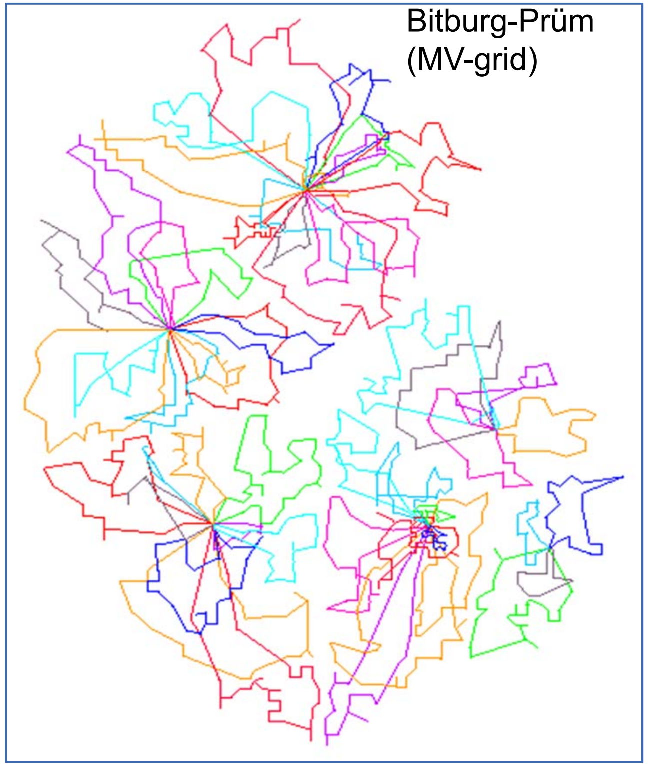
Continuously used lines: 2.126 km

Additional lines: 973 km

Obsolete lines: 312 km

40% additional grid

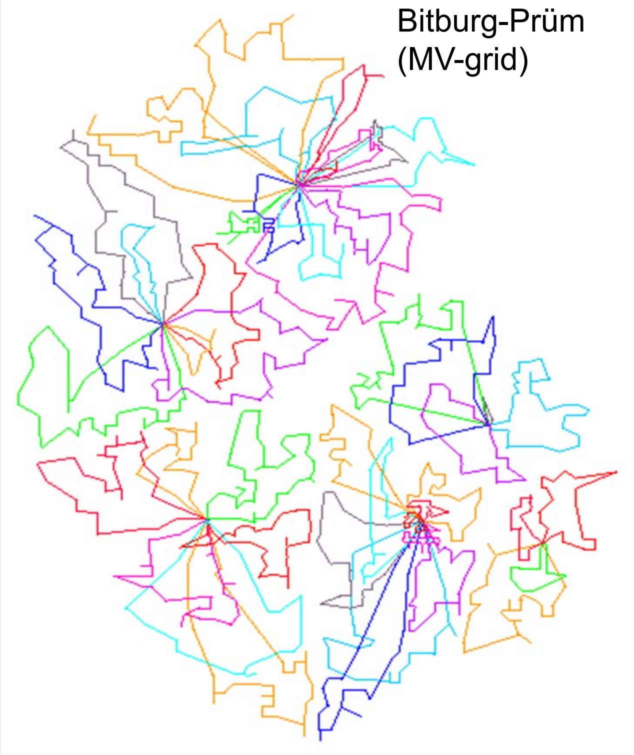
Reference grid 2030



Grid load: 120 MW
Generation: 210 MW
Grid length: 3.099 km

Restructuring effort can be reduced depending on the area using different innovative grid concepts

Reference grid 2010



Grid load: 135 MW
Generation: 110 MW
Grid length: 2.438 km

Continuously used lines: 2.151 km

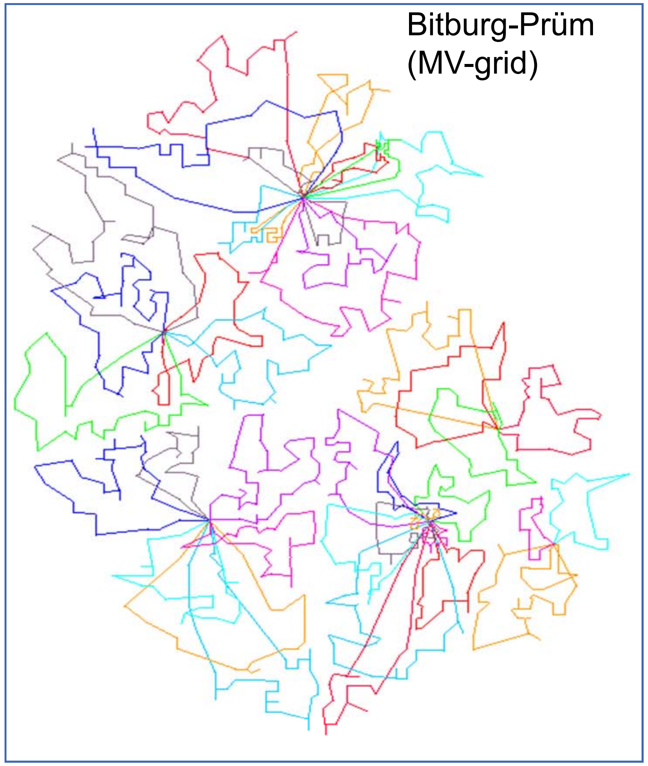
Additional lines: 568 km

Obsolete lines: 309 km

Controllable distribution substations: 15 % of DS

23% additional grid*

Reference grid 2030

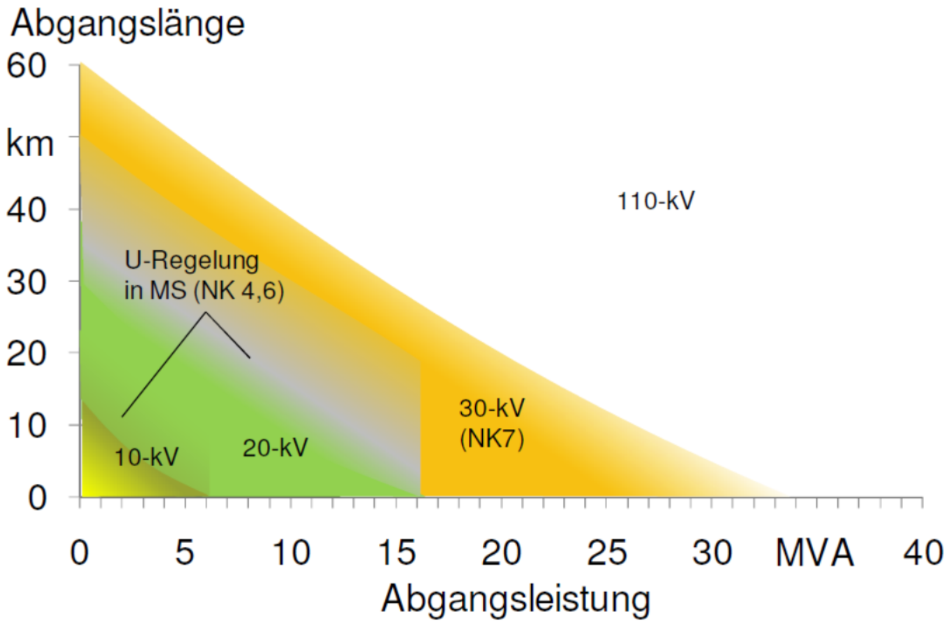


Grid load: 120 MW
Generation: 210 MW
Grid length: 2.697 km

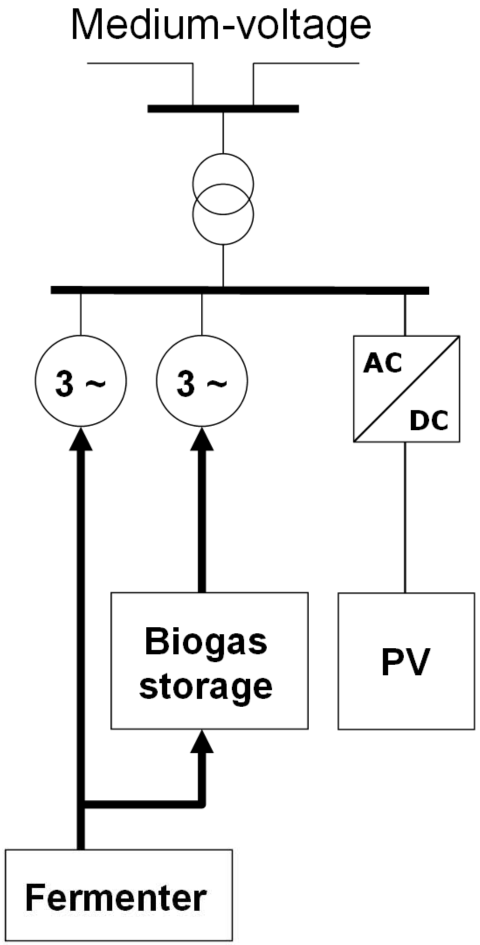
*) geregelte Ortsnetzstationen (ONS) berücksichtigt

Fazit

- Durch den Einsatz von IKT kann eine bessere Netzbeobachtbarkeit, eine schnellere Störungsmeldung sowie eine optimierte Zustandsmeldung des Netzes erreicht werden, zudem kann eine aktive Optimierung dieser Netze an der Belastungsgrenze durchgeführt werden
- Konventionelle, ländliche Stromverteilnetze stoßen an die zulässigen Grenzen der Spannungshaltung, normative Spannungsqualität fungiert als maßgeblicher Kostentreiber
- Bisher bekannte Netzverstärkungsmaßnahmen sind zukünftig wirtschaftlich mit intelligenten Netzlösungen zu vergleichen
- Insbesondere die intelligenten Netzkonzepte sind wirtschaftlich, die zu einer Reduzierung von Spannungsbandrestriktionen führen (z.B. geregelte ONS)
- **Netzausbaumaßnahmen sind unwirtschaftlich, wenn Ihre Durchführung durch den Bau von Energiespeichern verringert oder vermieden werden kann.**
- Grundsätzlich lässt sich nach Abgangslänge und Abgangsleistung ein Bereich identifizieren, bei dem eine Vergleichrechnung intelligenter Konzepte zum Erfolg führen kann



Electricity storage in the form of biogas



> **Aim:**
– Priority feed-in of PV power
– Raising the capacity for decentralized feed-in of the medium-voltage grid

> **Method:**
– Avoiding biogas conversion into electricity in times of high PV power feed-in functions like a storage in the power grid.

> **Result:**
– Biogas facilites with storage do not need to be taken into accout when dimensioning the grid.

Data and specifications of the existing facility

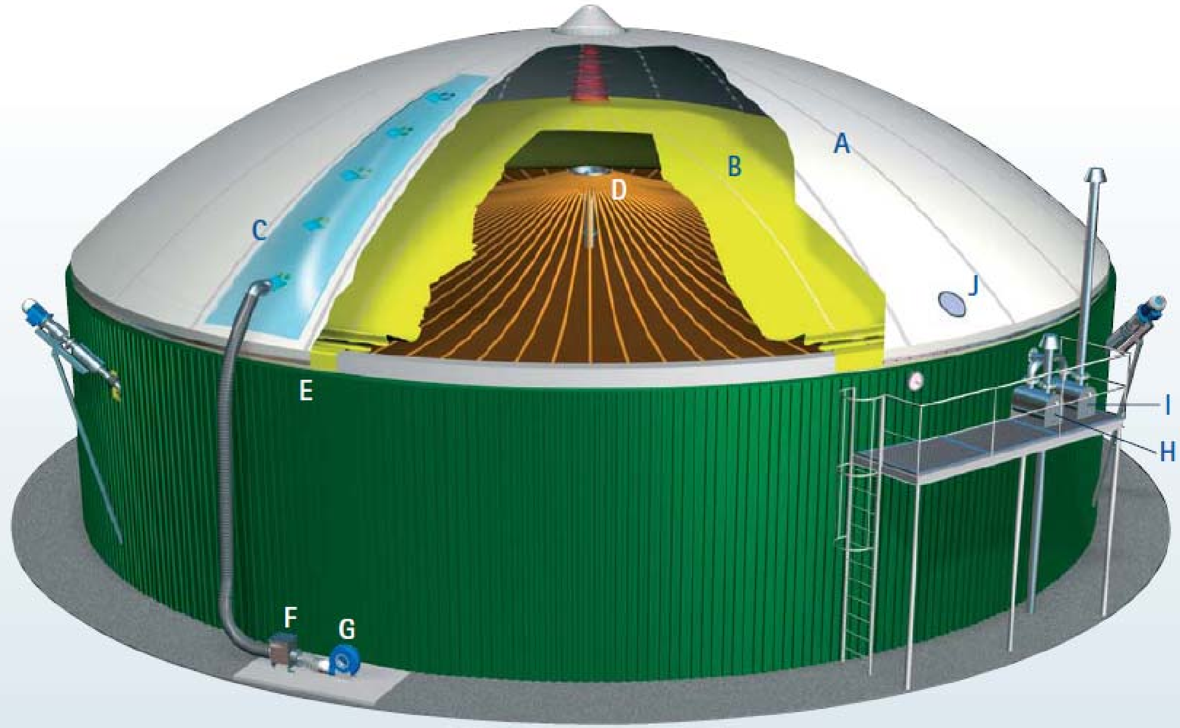
- Biogas facility with an electrical output of 300 kW
  - CHP-Station 1: Otto engine from 2005 with an output of 190 kW_{el}
  - CHP-Station 2: Igniting-beam CHP-unit from 2000 with an output of 110 kW_{el}

- Raw biogas production: ca. 160 m^3/h
- Two fermenters, one storage for the fermented substrate (Diameter approx. 26 m)
- Electricity feed-in in 2009 of about 8610 hours.
- Approval under building law
- Conversion into electricity without formaldehyde- and technology bonus
- Additional feed-in of approx. 60 kW_{el} photovoltaic electricity

Requirements for the planned storage

- Installation of an efficient gas storage with a maximum capacity for running six hours in storage-mode (1.600 m³ WGV) by covering a already existing storage for the fermented substrate
- Pressure handling and operation of the storage in low-pressure mode, hence feed-in of secondary energy. (Compression from 3 to 10 mbar)
- Setup of flexible CHP capacities, to ensure economic operation while running at partial load. Increase of capacity to 140 % of prior output (approx. 410 kW_{el})
- Refitting of the gas engines start-stop operation and operation at partial load
- Installation of an intelligent local control system to gather data about the grid status and to automatically run the decentralized storage unit

Pilot project Bitburg-Prüm
Realization as double membrane storage unit

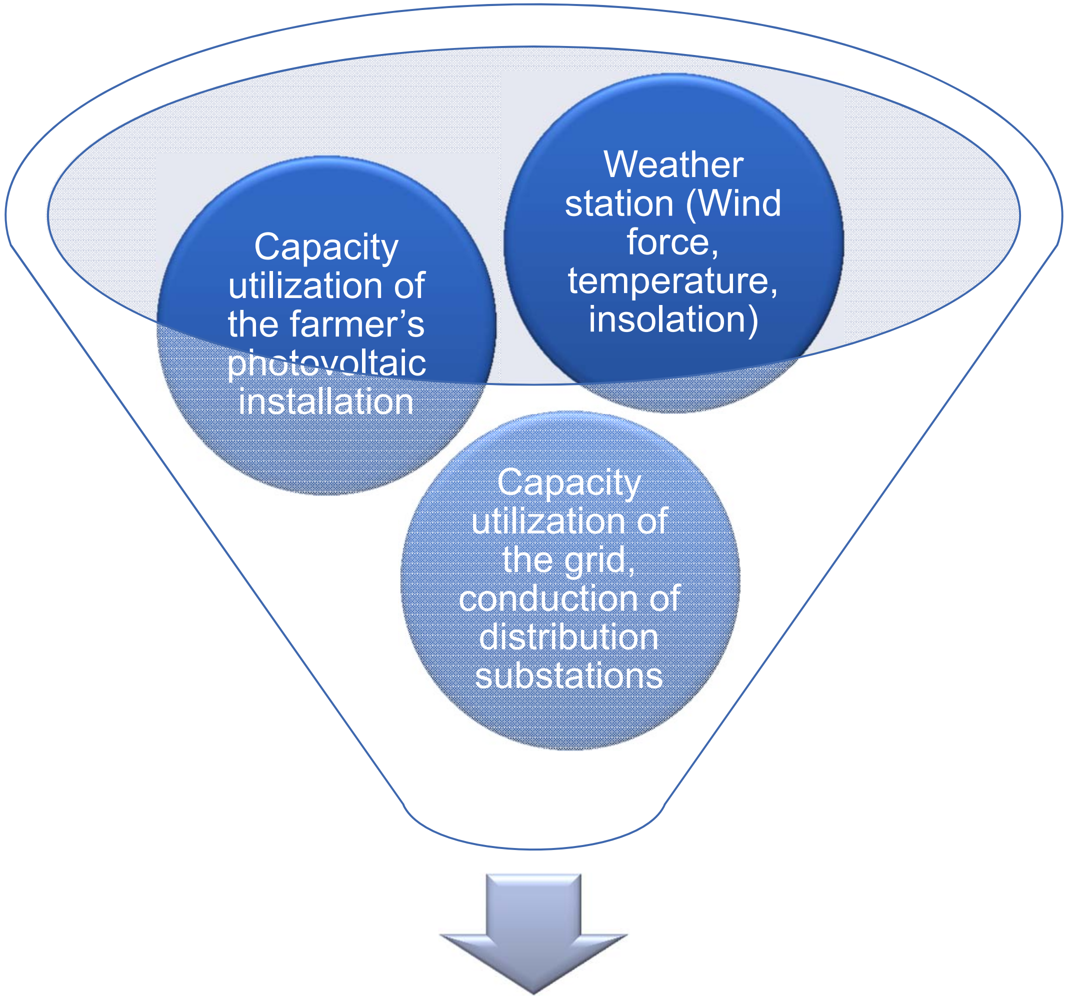


A Outer membrane
B Inner membrane
C Air flow system
D Harness system
E Anchoring ring
F Air valve
G Fan
H Vacuum valve
I Blow-off valve
J Sight glass

Source: Ceno-Tec GmbH

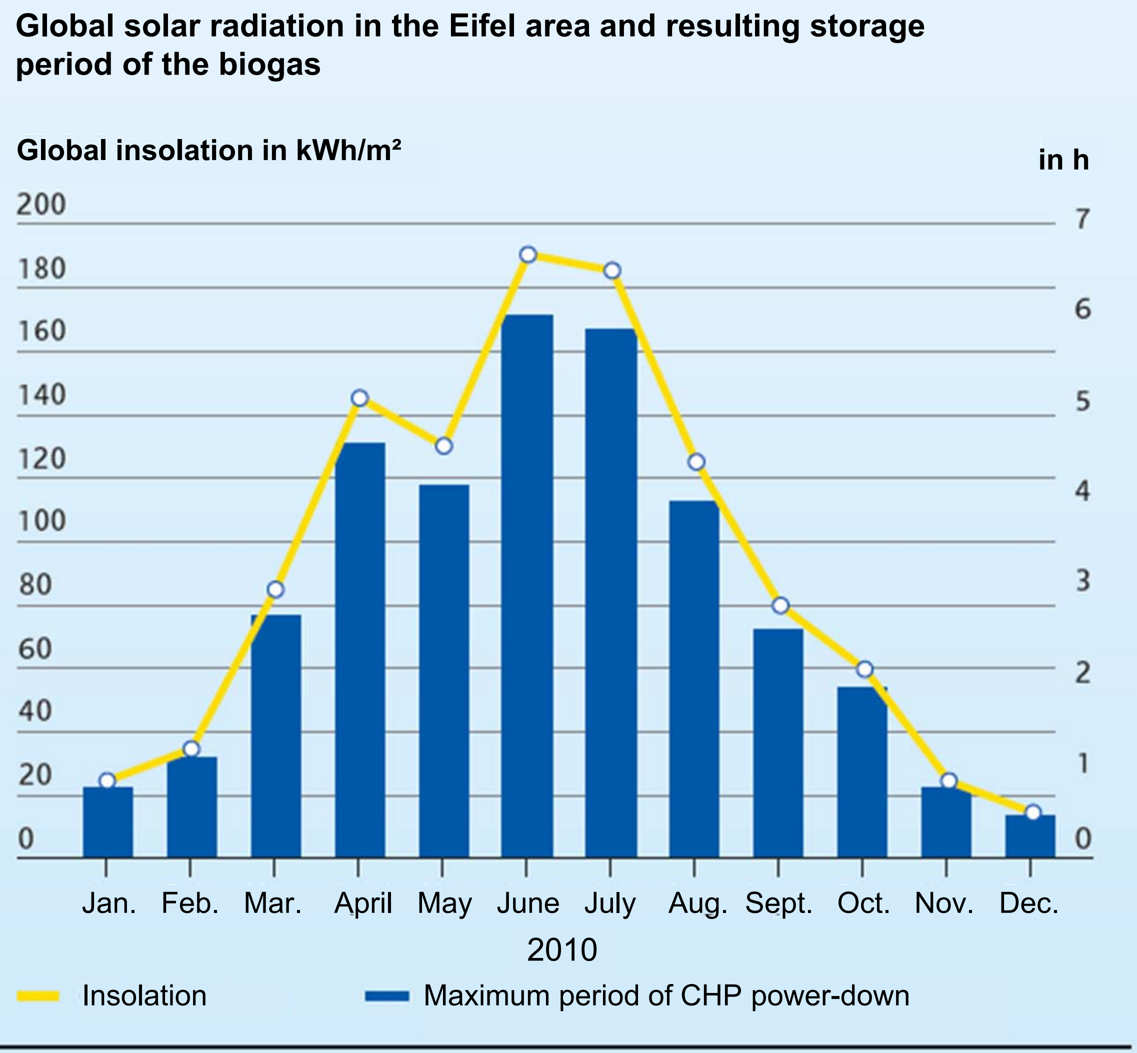
- Low investment costs
- Suitable for high snow and wind loads
- Energy-efficient
- Short construction period
- High operating safety
- Exact level measurement
- No corrosion of the membrane
- No fine-desulphurization necessary
- Very low amount of maintenance required
- Gain in gas output when digestate storage unit is covered

Installation of a “smart” control system



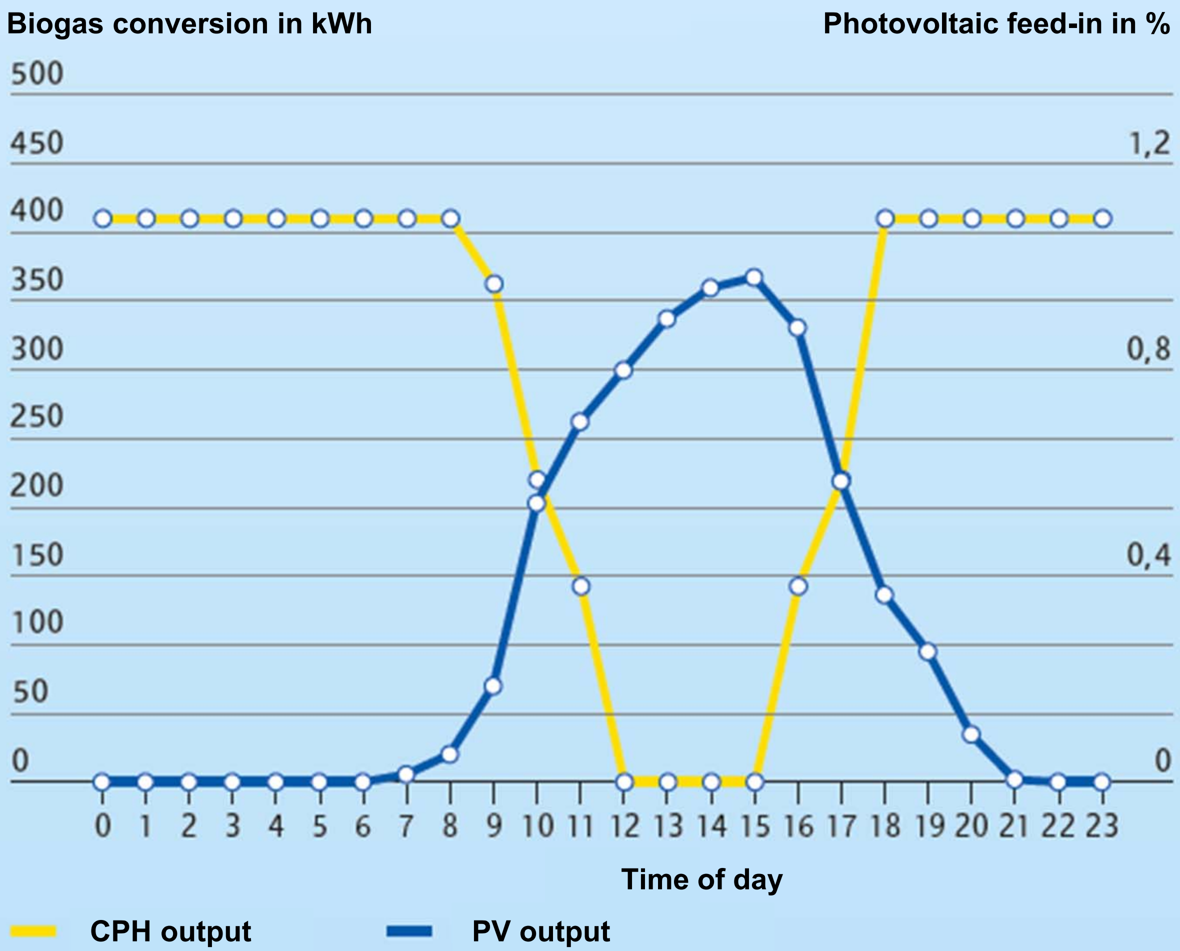
Installation of a smart control system for the biogas storage unit aiming towards self-sufficient operation

Global insolation plotted as a function of the time of the year and the corresponding storage period of the biogas



CHP output as a function of the photovoltaic feed-in

Photovoltaic vs. converted biogas feed-in
- Typical hydrograph for PV and converted biogas feed-in



Practical experience from realization of projects

- Modernization of the existing biogas facility necessary for TÜV-certification
- In order not to loose privileging of the biogas facility it is necessary to consider the total amount of storage volume for biogas farm plants
  (Fermenters incl. biogas storage < 3 t approx. 2.300 m³)
- Total storage capacity for biogas thus mainly restricted by certification
  (> 3 t biogas BImSchG [Federal Immission Control Act] certification for the plant as a whole required)
- Approved feed-in quantities for the entire year are not to be exceeded
- Substrate management by use of an automatized substrate pump and permanently installed pipes connecting fermenters, biogas storage and final depots required
- Power grid operator of the biogas facility as cooperation partner and on-site operator of the biogas storage.

Benefits for the argriculturist due to installed biogas storage

- Up to 10% higher methane production by covering the digestate storage
- Upgrading obligation under EEG 2012 (Renewable Energy Sources Act) for digestate storage fulfilled (as of 2014 for existing facilities)
- Increasing efficiency factor of 40.6% due to installation of additional CHP capacities
- Formaldehyde-bonus granted because of new CHP units
- Modernization of existing biogas facility
- No additional space required since no separate biogas storage has to be build
- Increased flexibility of biogas production
- Possible withdrawal from Renewable Energy Sources Act (EEG) and self-marketing of electricity with marketing and flexibility premium as outlined in EEG 2012

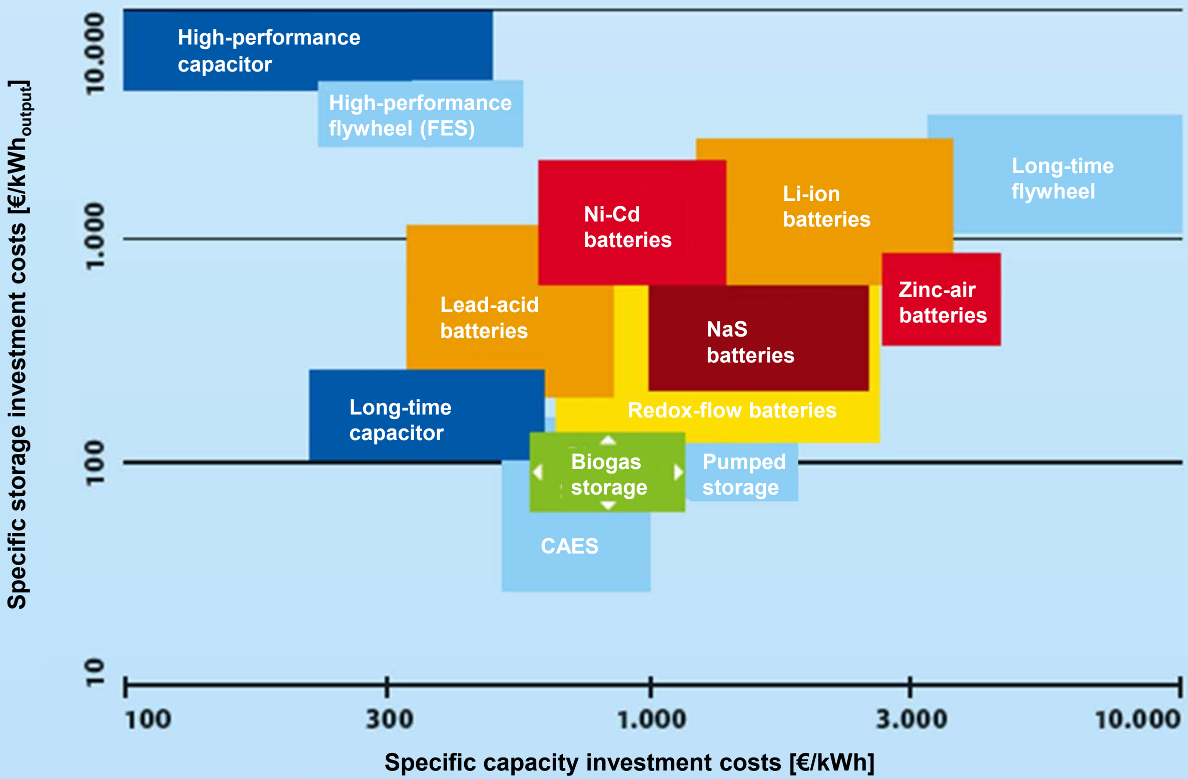
Biogas storage (Fermenter and storage unit)

Biogas storage (CHP unit and gas conditioning)

Biogas storage and container for pumps (substrate)

Overview - Technologies for storing electricity

Comparison between specific storage investment- and capacity costs as well as a yet to be validated classification of biogas storages



Source: Farret, F.A., 2006: Integration of Alternative Sources of Energy

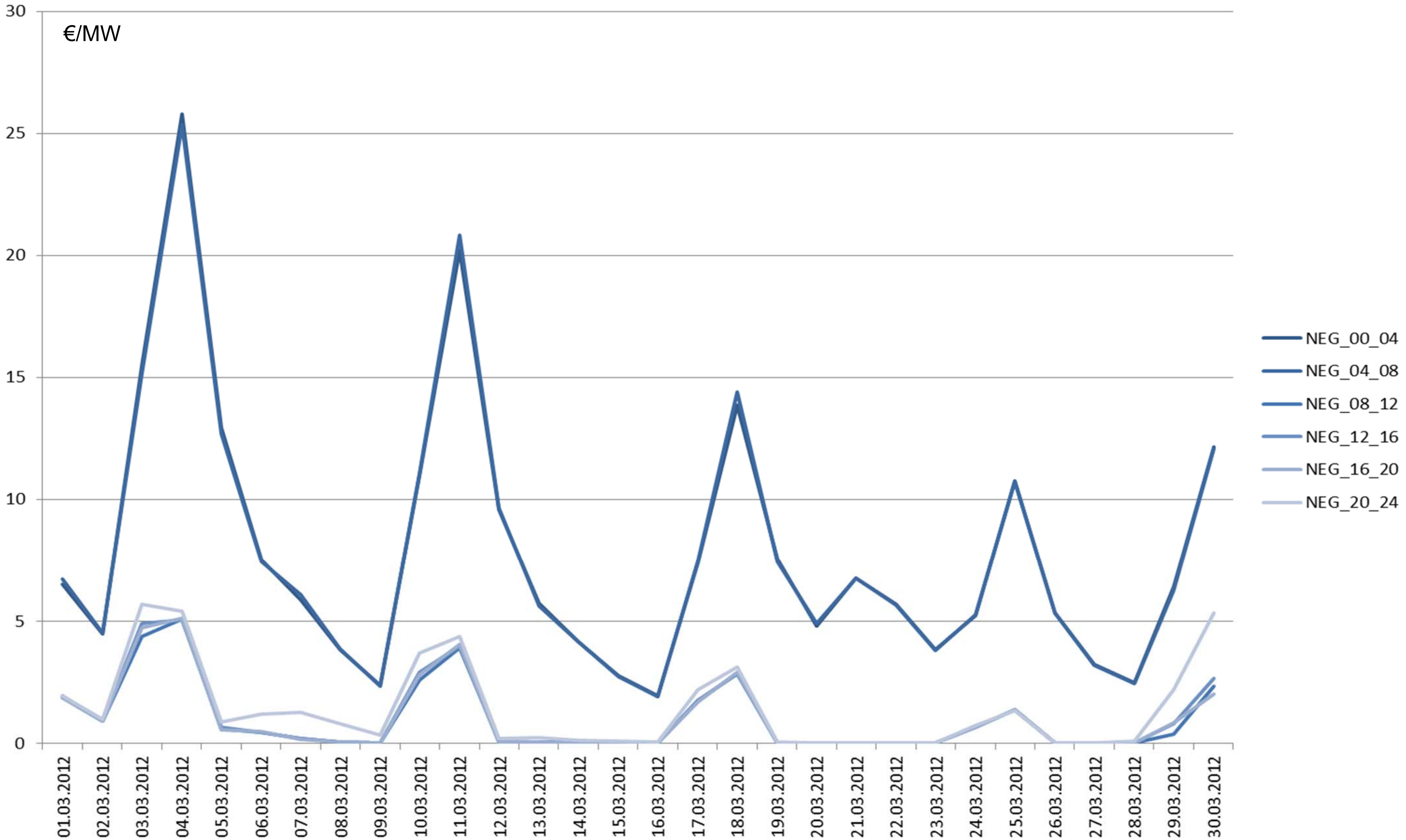
Project Smart Country vs. direct marketing EEG 2012

> Does the approach of leveling load peaks in the grid of „Smart Country“ counteract with the direct marketing in accordance with EEG 2012?
> Basically no, since the incentive to convert biogas into electricity in line with demand according to EEG 2012 is based on the marketing of control energy (usually negative control energy, minute reserve) and the most lucrative time slices are conducted via auction because of overload in the transport grid operator's control network

> Can biogas storages become a general solution for voltage fluctuations and overload in distribution grids with increasing decentralized feed-in?
> This questions cannot be answered definitely from today's point of view. However, studies show that an appropriate can by all means compete with pumped storage hydrogen power stations while having lower investment costs and a higher efficiency

> Are there legal or economic barriers to the extension of storage capacity?
> On the one hand investment costs (approx. 300K€ up to 800K€ depending on the size) are a factor, on the other hand the incentive to store energy is not sufficient. Legal restrictions for the gas storage capacity are basically what prevents higher storage volumes. This may result in a costly transition to the Major Accidents Ordinance (German StFV).

Demand rates for negative tertiary control reserve as of 03/2012 in time slices



Bundesministerium für Wirtschaft und Technologie
VORWEG GEHEN
technische universität dortmund
Consulting für Energiewirtschaft und -technik GmbH

Conclusion

> Interesting approach partially using already existing infrastructure next to decentralized electricity generation to operate an also decentralized and efficient energy storage in direct vicinity .

> Biogas as a primary energy carrier, which can be used flexibly and demand-oriented for conversion into electricity (unlike pumped storage hydro power stations, batteries, etc.)

> Comparatively low costs for energy storage as well as easily manageable technology

> Efficiency increases with the number of storage units and unified control network to utilize the positive and negative regulating power most effectively.

Impressions

Impressions

Thank you for your attention.
„Smart Country“

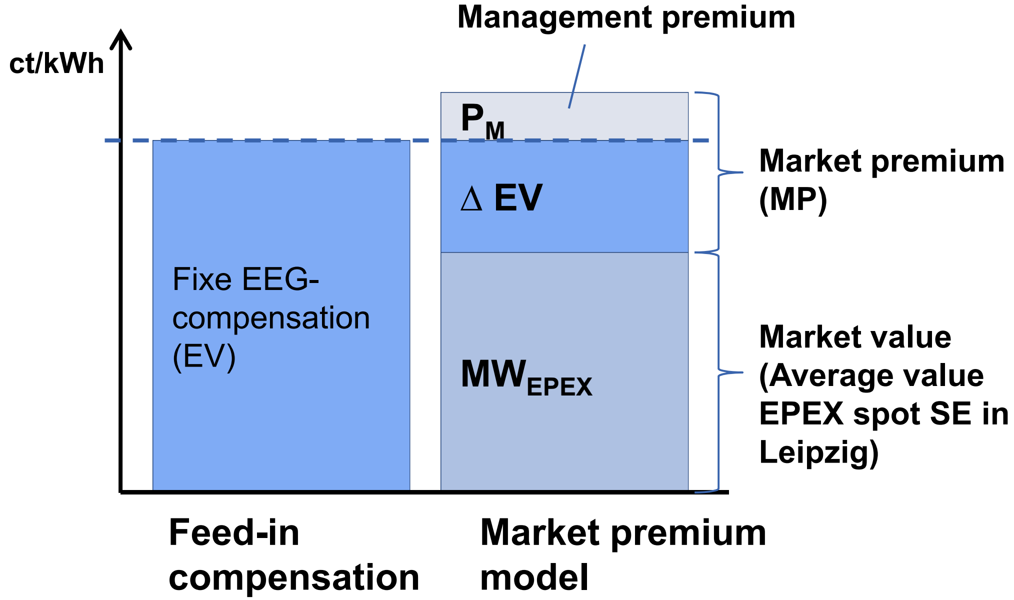
BACK-UP

Market premium as outlined in § 33g EEG

Composition of the market premium

Essential characteristics:

- Market premium is monthly and retroactive determined for each investment
- Market value is calculated ex-post and specifically for each energy carrier based on spot market listings and published by the TSO
- Average specific market value plus market premium equals feed-in compensation
- Management premium to compensate costs for listing on the electricity market, trading connections etc. as well as for deviations from projections due to fluctuating generation



$P_{M(Controlable)}$
2012: 0.3 ct/kWh
2013: 0.275 ct/kWh
2014: 0.25 ct/kWh
as of 2015: 0.225 ct/kWh

$P_{M(Wind\ and\ PV)}$
2012: 1.2 ct/kWh
2013: 1.0 ct/kWh
2014: 0.85 ct/kWh
as of 2015: 0.7 ct/kWh

Flexibility premium as outlined in § 33i EEG

Requirements

Policy of comprehensive marketing	**The total amount of electricity generated by the facility has to be directly marketed according to § 33b number 1 or 3 (more specific § 33f).**
Entitlement for compensation in accordance with § 16	**An entitlement for compensation is required and not to be diminished by § 17**
Reporting obligation	**Location, total capacity and utilization of the flexibility premium have to be reported to the BNetzA (Federal Network Agency FNA)**
Minimal rated capacity	**Rated capacity has to be a minimum of 0.2 times the value of the installed capacity.**
Certification environmental consultant	**Technical suitability of the facility for a demand-oriented electricity feed-in**

Flexibility premium as outlined in § 33i EEG