SIEMENS

Virtual Power Plants in Competitive Wholesale Electricity Markets

Experience with RWE Virtual Power Plant in Germany

How new business models can enable Virtual Power Plants through new energy market opportunities in US

Prashanth Duvoor
Siemens Smart Grid Division

Key Challenges Drive Implementation of Demand Response Programs & Virtual Power Plants

SIEMENS

Challenges

Generation & network bottlenecks

Increasing peak load prices

Increasing distributed & renewable generation

Rising consumption

Trends

New market opportunities for distributed energy resources and demand response

April 18, 2013   Infrastructure & Cities Sector – Smart Grid Division

Short Overview of German Electricity Markets – before we look at the RWE VPP Example

European Energy Exchange EEX

- Standard products traded at the EEX are hourly day-ahead contracts as well as bundled base and peak contracts.
- Operates an intra-day market based on the same hourly contracts traded in the day-ahead market.

Transmission System Operator (TSO)

- TSOs is responsible to maintain the transmission system stability and reliability in supply (Primary, Secondary and tertiary reserve)
- Primary reserve satisfy a TSOs' demand for up/down regulation Activation time: 30 sec, and Availability time: up to 15 mins
- Secondary reserve - satisfy a TSOs' demand for up/down regulation Activation time: 5 mins, and Availability time: 15 mins to 1 hr
- Tertiary reserve satisfy a TSOs' demand for up/down regulation Activation time: min. 15 mins, and Availability time: 15 mins to few hrs

Virtual Power Plant (VPP) – RWE ProVipp –
Siemens Experience with Virtual Power Plant in Germany

SIEMENS

Challenge

- Integration of multiple renewable energy resources
- Defining various operation strategies
- Implementation of an optimal operation strategy for renewable and distributed energy resources

Solution

- Build up a virtual power plant integrating small hydro power plants, combined heat and power units, and emergency generators based on DEMS®
- DER*-Controller for innovative communication with DEMS®

Benefits

- Allows market access for renewable and distributed energy resources
- Increases the economical benefit of distributed energy resources
- Provides regulating energy to reserve markets

System Operator / Markets (EEX)

Purchase of electricity — Aggregation & sale of flexibility — Sale of ancillary services to the grid

Aggregator (RWE)
DEMS**

Resale of electricity — Sale of overage power

DER* Controllers

Customers' Generation Units

* **D**istributed **E**nergy **R**esources   ** **D**ecentralized **E**nergy **M**anagement **S**ystem

Project partner:
RWE

Country: Germany

*DER = Distributed Energy Resource
DEMS = Decentralized Energy Management System
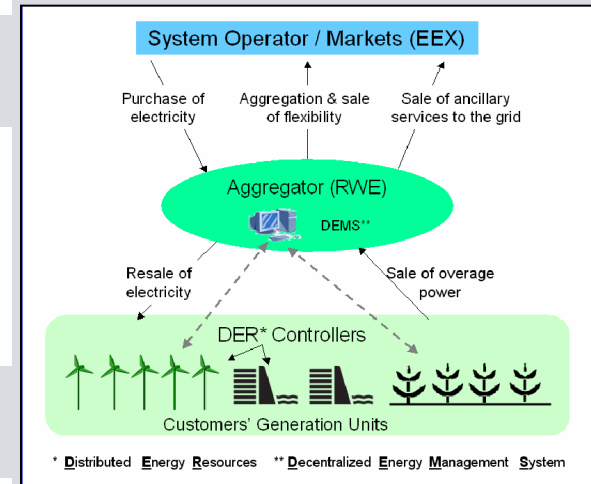
Started as a Pilot Project in Oct 2008 –
demonstrated the technical and economic deployment maturity of VPP and gained insights into further application options

VPP - Siemens DEMS – Decentralized Energy Management System Solution

9 Small hydro units (8.6 MW).

Project Focus: Development of a marketable Virtual Power Plant

• Definition of business models in different energy markets

• Definition and implementation of optimal operation strategies for distributed generation

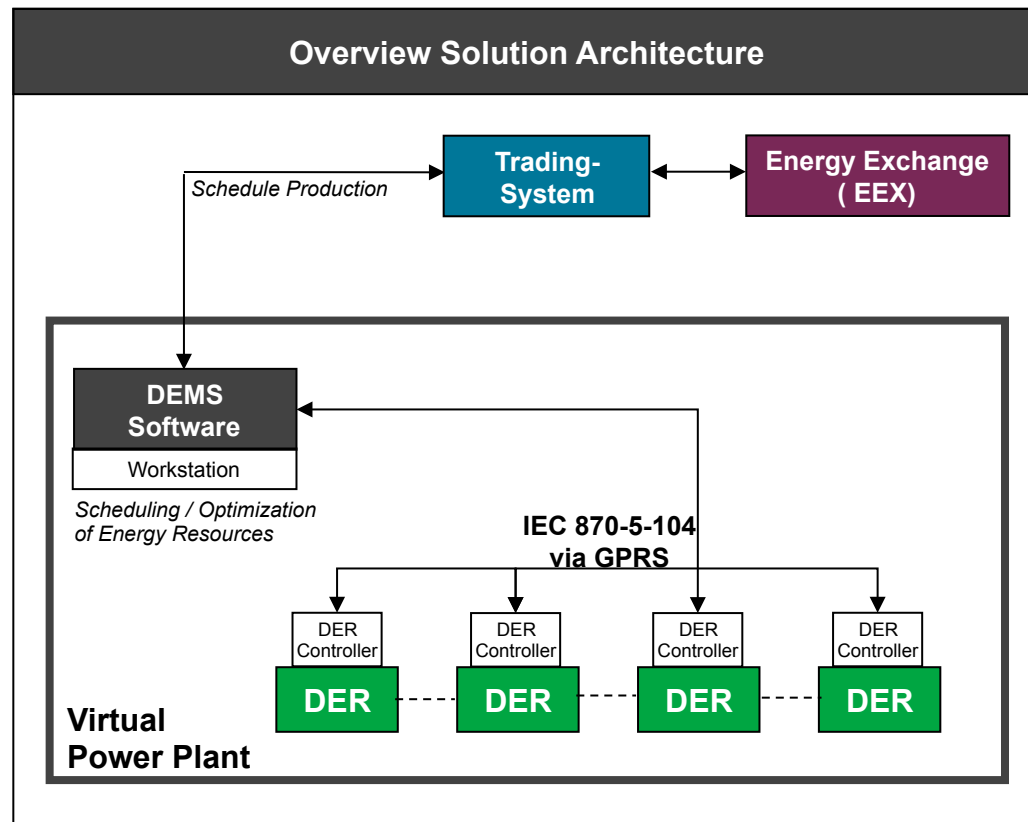• Implementation of innovative communication concepts between distributed generation and DEMS

Project partner:
RWE

Country: Germany

RWE VPP Solution Overview –
the Central Control System, and communication to DER units plays a key role in VPP implementation

SIEMENS

Siemens' Distributed Energy Management System (DEMS) is the central feature of the virtual power plant, and DER Controller, locally installed at the generation unit site, which allows bidirectional communication with DEMS

Overview Solution Architecture

Schedule Production

| Trading-System | ↔ | Energy Exchange (EEX) |

DEMS Software
Workstation

Scheduling / Optimization of Energy Resources

IEC 870-5-104 via GPRS

DER Controller | DER Controller | DER Controller | DER Controller

DER - - - **DER** - - - **DER** - - - **DER**
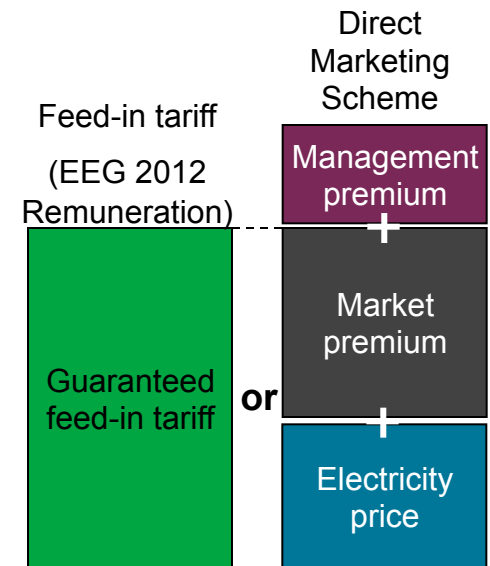
Virtual Power Plant

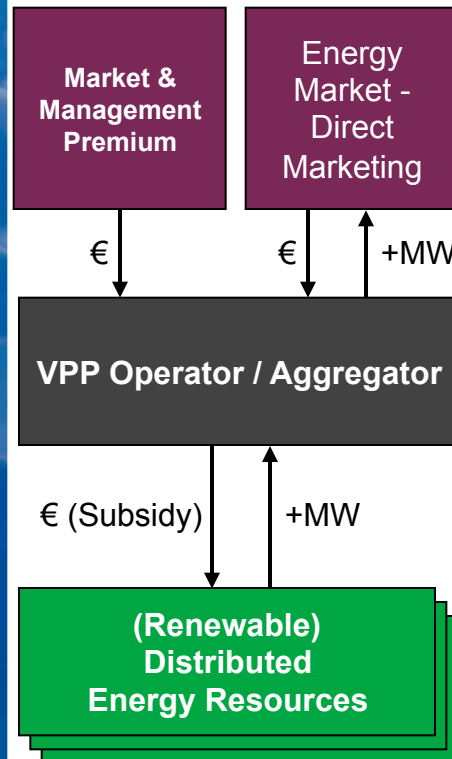**Project partner**:
RWE

Country: Germany

Planned Expansion of the RWE VPP (200 MW by 2015) – Triggered by the change in Legislation in Renewable Energy Sources Act (EEG)

- After the amendment in the **Renewable Energy Sources Act (EEG)**, RWE is planning aggregating a number of distributed energy sources into a virtual power plant and the marketing of the pooled power outputs into EEX

- The market premium model laid down in this legislation since January 2012, provides an incentive to sell electricity from EEG plants directly in the European Energy Exchange (EEX).

- The merging of approx. 20 megawatts (MW) of electrical generating capacity to the pilot project capacity - is planned for the first year of operation in 2012, which is to grow to about **200 MW by the year 2015.**

- The objective is to integrate different distributed energy sources such as biomass plants, biogas block heating plants, wind turbines, and hydroelectric plants throughout the whole of Germany.
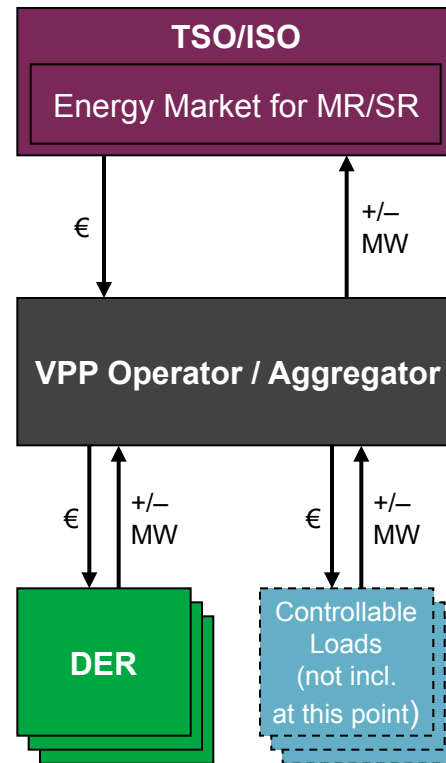
Feed-in tariff (EEG 2012 Remuneration)

Guaranteed feed-in tariff

or

Direct Marketing Scheme

Management premium

+

Market premium

+

Electricity price

Source: www.gtai.com

Highly Attractive Business Model for RWE VPP – enabled by Direct Marketing of Power with Market and Management Premium

Market & Management Premium	Energy Market - Direct Marketing

€ ↓   € ↓   +MW ↑

VPP Operator / Aggregator

€ (Subsidy) ↓   +MW ↑

(Renewable) Distributed Energy Resources

- Revenue from direct marketing eg. at EEX (energy exchange)

- Market premium for compensation of difference between the EEG feed-in tariff and monthly average spot market energy price

- Management premium covers the costs for admission to energy exchange, connection to trading system, market clearing, etc. (2012 fixed at 1.2 ct/kWh)

- Aggregation and marketing of distributed renewable generators (previously uncontrolled in-feed)

  - Market operation (energy marketing, administration of contracts with plant operators etc.)

  - Operation of distributed generators, contracts with generation operators

  - VPP System incl. SW, HW & Integration

Expanding the RWE VPP Business Model – to sell Tertiary/Minute Reserve in the TSO Reserve Market

TSO/ISO

Energy Market for MR/SR

€

+/– MW

VPP Operator / Aggregator

€   +/– MW   €   +/– MW

**DER**

Controllable Loads (not incl. at this point)

- Revenue from providing capacity to Minute Reserve or Secondary Reserve
- Revenue for making capacity available
  - Price for providing energy after call
  - Positive and negative reserve power

SIEMENS

- Aggregation of demand
- Demand Response segment
- Large segment in US energy markets

- Aggregation of distributed generation
- Distributed Resources segment
- Large segment in Europe

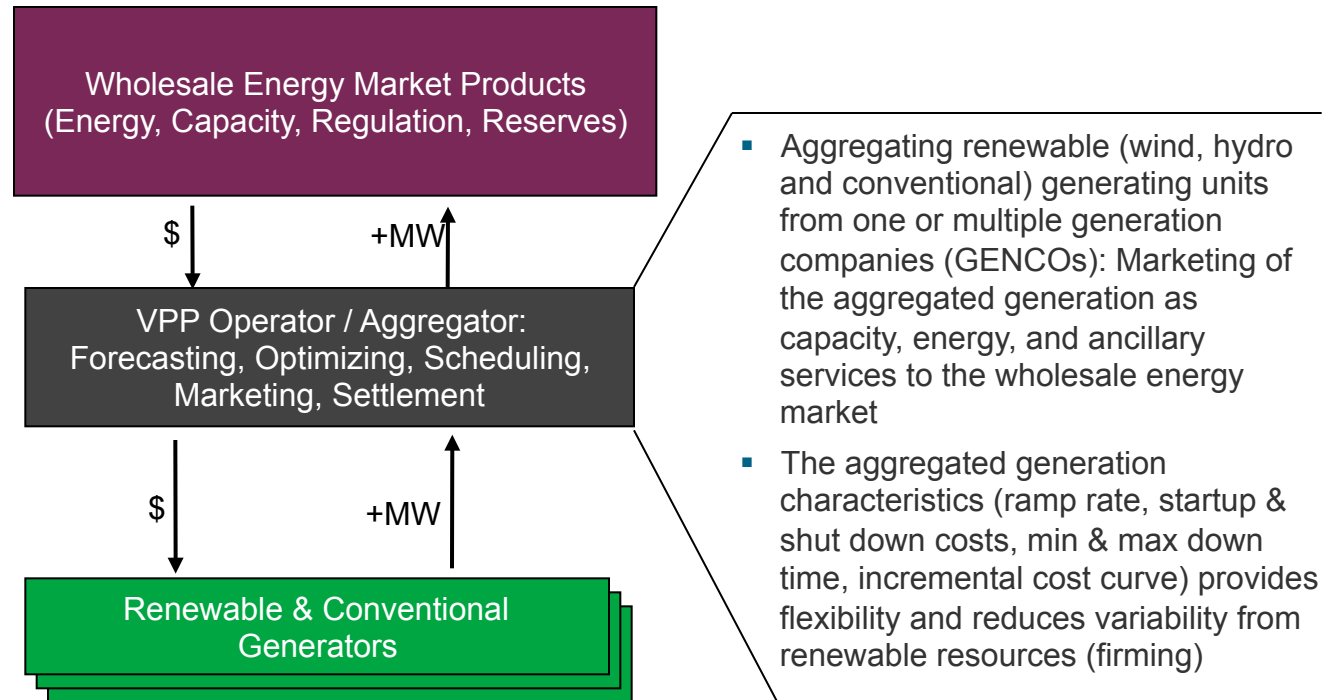**DEMAND-SIDE**　　**MIXED-ASSET**　　**SUPPLY-SIDE**
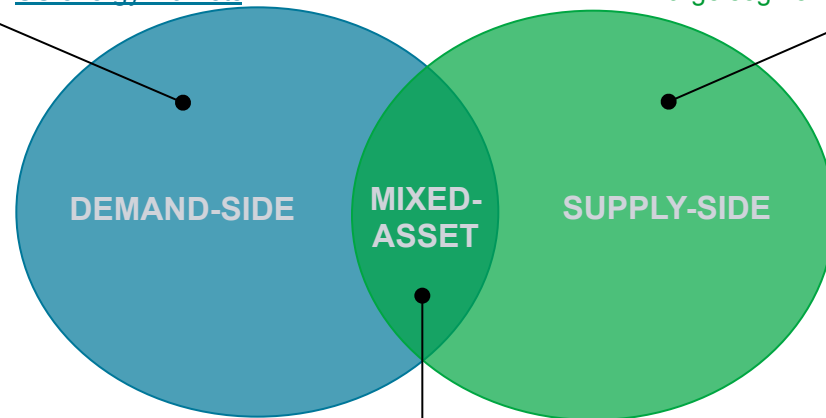
- Combined DER and DR
- Ultimate goal of the VPP concept and expected to flourish longer-term
- The integrated operation of multiple integrated renewable resources, energy storage, demand response are largely uncharted

Source: Pike Research

VPP Business Model – for VPP Operator, GENCOs to better manage Variable Energy Resources

Challenge

- Variable Energy Resource intermittency and need for additional ancillary services

Wholesale Energy Market Products (Energy, Capacity, Regulation, Reserves)

$ ↓   +MW ↑

VPP Operator / Aggregator: Forecasting, Optimizing, Scheduling, Marketing, Settlement

$ ↓   +MW ↑

Renewable & Conventional Generators

- Aggregating renewable (wind, hydro and conventional) generating units from one or multiple generation companies (GENCOs): Marketing of the aggregated generation as capacity, energy, and ancillary services to the wholesale energy market

- The aggregated generation characteristics (ramp rate, startup & shut down costs, min & max down time, incremental cost curve) provides flexibility and reduces variability from renewable resources (firming)
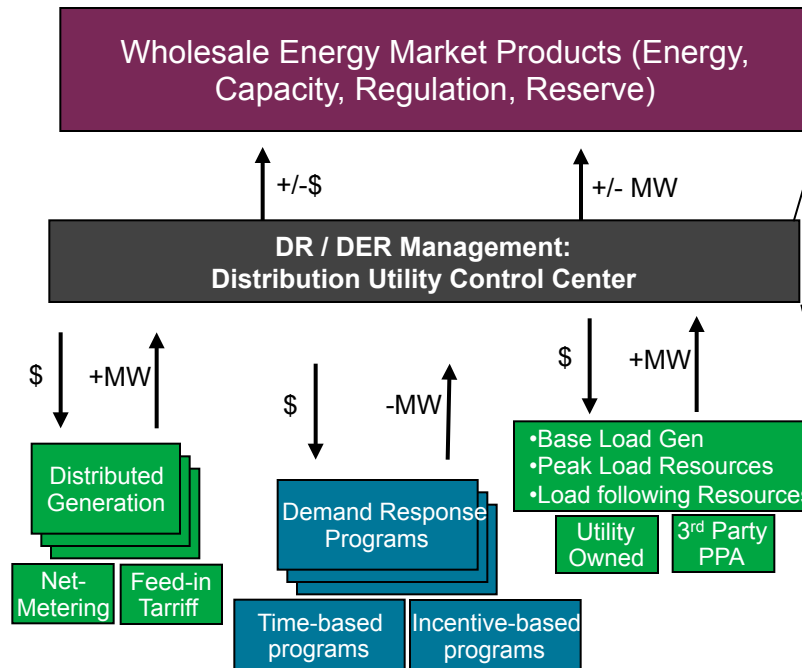
VPP Business Model – for Distribution Utilities to maximize benefit from energy market participation

Challenge

- Managing DR/DER, generation, and load: to bid energy, capacity and ancillary services into wholesale energy market

Wholesale Energy Market Products (Energy, Capacity, Regulation, Reserve)

+/-$ +/- MW

DR / DER Management: Distribution Utility Control Center

$ +MW $ -MW $ +MW

Distributed Generation

Demand Response Programs

- Base Load Gen
- Peak Load Resources
- Load following Resources

Utility Owned   3rd Party PPA

Net-Metering   Feed-in Tarriff
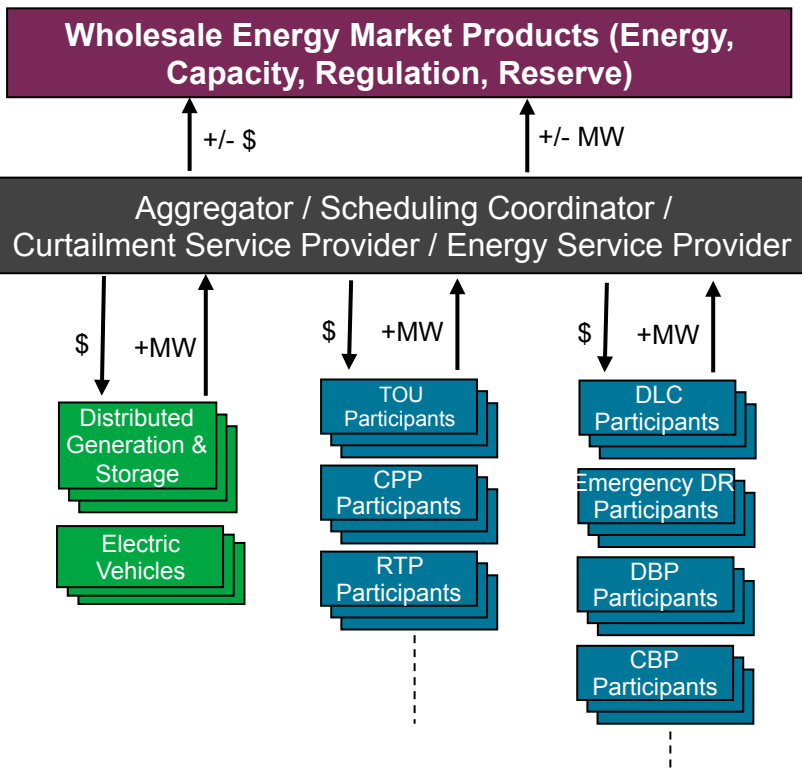
Time-based programs   Incentive-based programs

- (i) Coordinate power purchases from ISO, own generation and external PPA providers to maximize revenue satisfy demand;
- (ii) maximizing utility revenue via optimally managing demand and distributed generation by aggregating by utility level DR/DER programs, location, system constraints, etc
- Maximize the benefit: Cost of own generation and PPA (vs.) demand reduction & DG dispatch (vs.) purchasing from wholesale energy market
- Coordinate between participation in energy market and/or operating reserve market
- Demand management as per the available demand response programs

VPP Business Model – for Aggregators to maximize benefit from energy market participation

Challenge

- Managing DR/DER to bid energy, capacity and ancillary services into wholesale energy market

Wholesale Energy Market Products (Energy, Capacity, Regulation, Reserve)

+/- $ +/- MW

Aggregator / Scheduling Coordinator / Curtailment Service Provider / Energy Service Provider

$ +MW $ +MW $ +MW

Distributed Generation & Storage

Electric Vehicles

TOU Participants

CPP Participants

RTP Participants

DLC Participants

Emergency DR Participants

DBP Participants

CBP Participants

- Manage multiple resources by aggregating DR and DER participants at the consumer end based on characteristics, geography, participating program, customer class, category, etc.
- Link retail level demand side resources to wholesale market products
- Aggregator has multiple options and flexibility to bid market products (energy, reserve, regulation, capacity) based on requirements of ramp rate, Pmax, Pmin, location, min/max up and down time, incremental cost curve, from the

SIEMENS

Thank you for your Attention

prashanth.duvoor@siemens.com
919 208 6221

April 18, 2013   Infrastructure & Cities Sector – Smart Grid Division