Combining a high share of variable energy with demand-side flexibility:

The WindNODE project

Dr. Boris Rigault
GJETC Outreach Event
Tokyo, September 24, 2019

SINTEG
SMART ENERGY SHOWCASES

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Content

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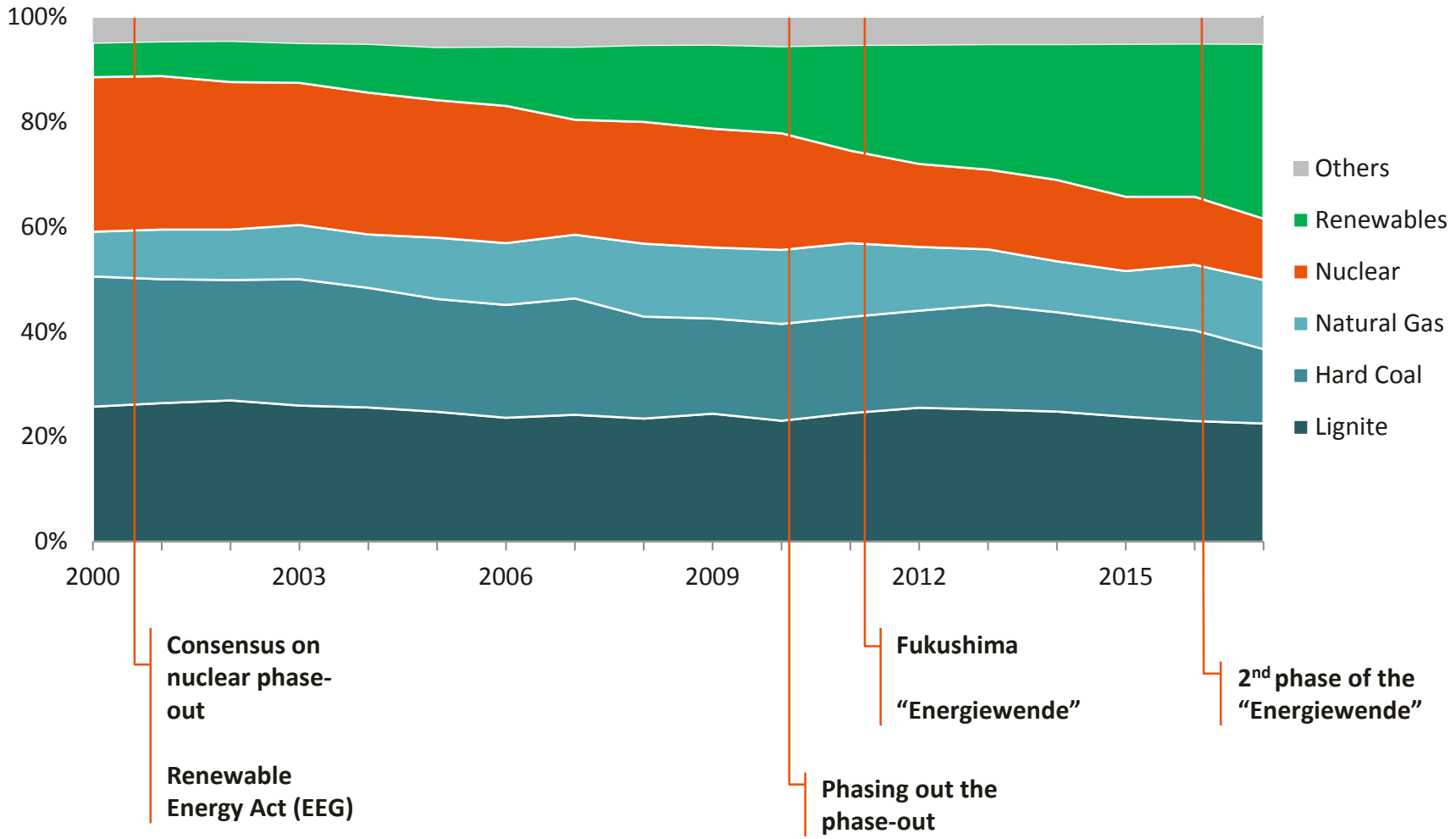
The German Energy Transition & the WindNODE Project

Enabling Demand Side Flexibility in Production

Outlook

Over 1/3 of German electricity mix comes from renewables

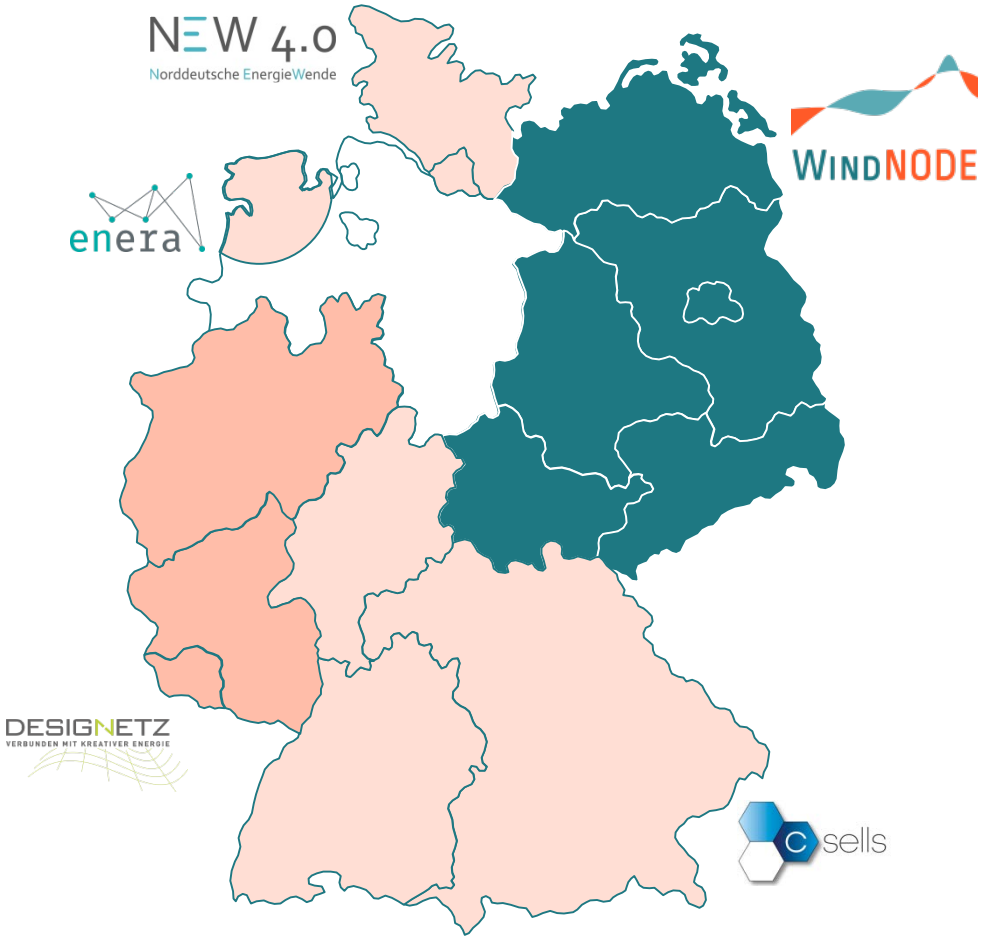
Gross electricity generation in Germany, percentage of total generation (2017)



Source: AG Energiebilanzen, 2018

SINTEG program:
Field tests for 2nd phase of energy transition

Overview of 5 smart energy showcases



Challenge & Targets

Scalable solutions for efficient, eco-friendly and safe integration of large amounts of renewables:

(1) Coping with intermittency

(2) Decarbonizing other sectors

(3) Defining "digitalization"

(4) Renewing energy transition narrative

Government Funding*, 2017-2020

230 mio. € for five consortia,
37 mio. € for WindNODE

WindNODE – entire East Germany

- 6 federal states, 16 mio. people
- 1 control area (50Hertz)
- Renewables frontrunner (> 56%)
- Energy transition challenges

* Funded by the German Federal Ministry for Economic Affairs and Energy (BMWi)

Source: BMWi, c/sells, designetz, enera, NEW 4.0, WindNODE

Utilizing flexibility to cope with intermittence

WindNODE

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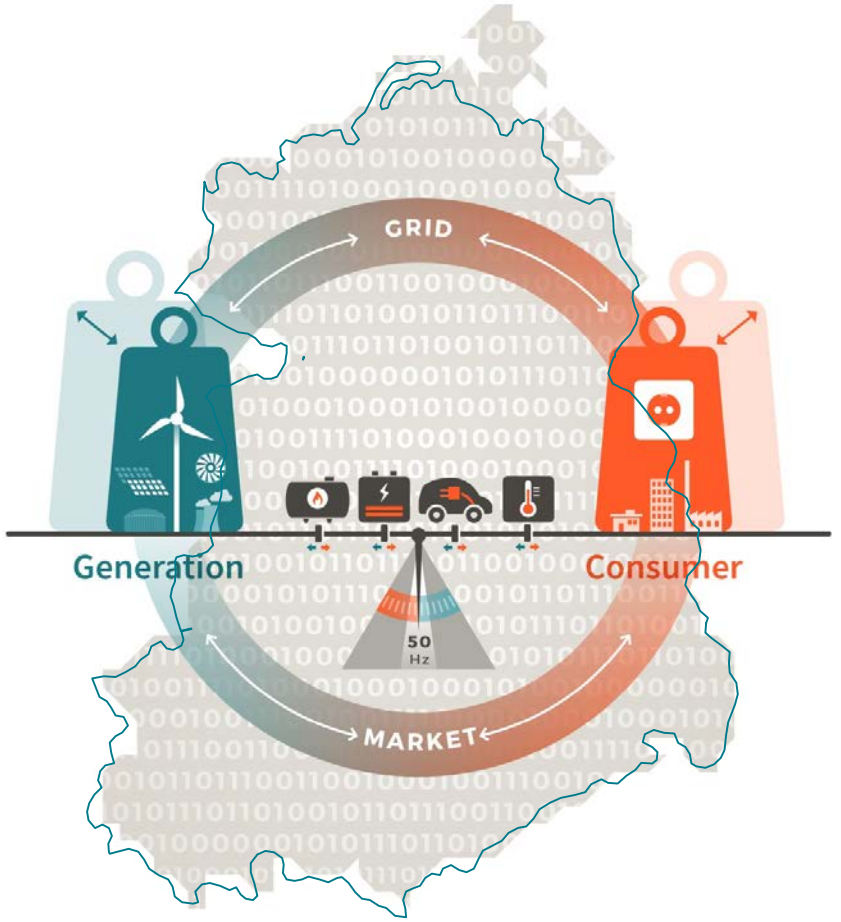
WindNODE approach

- ✓ **Identifying flexibility options**
  (technical potential)
- ✓ **Developing use cases for flexibility**
  (economic potential)
- ✓ **Creating value from energy data**
  (digitalisation in the energy space)
- ✓ **Field test**
  (blueprints, narrative, dissemination)



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Outlook

Demand Side Flexibility in Production

Partners in Workpackage 7.2

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Four Siemens facilities participate in demand side management effort

Siemens Dynamowerk Berlin
110 years of Innovation from Berlin

Siemens Measurement Equipment Plant Berlin
Intelligent Instrumentation for the Energy Transition

Siemens Targets

1) Learn what industrial load management can contribute to integrate renewables and reduce electricity costs

2) Understand how to consider thermal, mechanic and electrochemical production- and peripheral processes in different manufacturing sites.

3) Develop new functions for Siemens control products

Siemens Gas Turbine Plant Berlin
Power from Berlin.

Siemens Switchgear Plant Berlin
Competence Center for switchgear technology

Demand Side Flexibility in Production
Approach

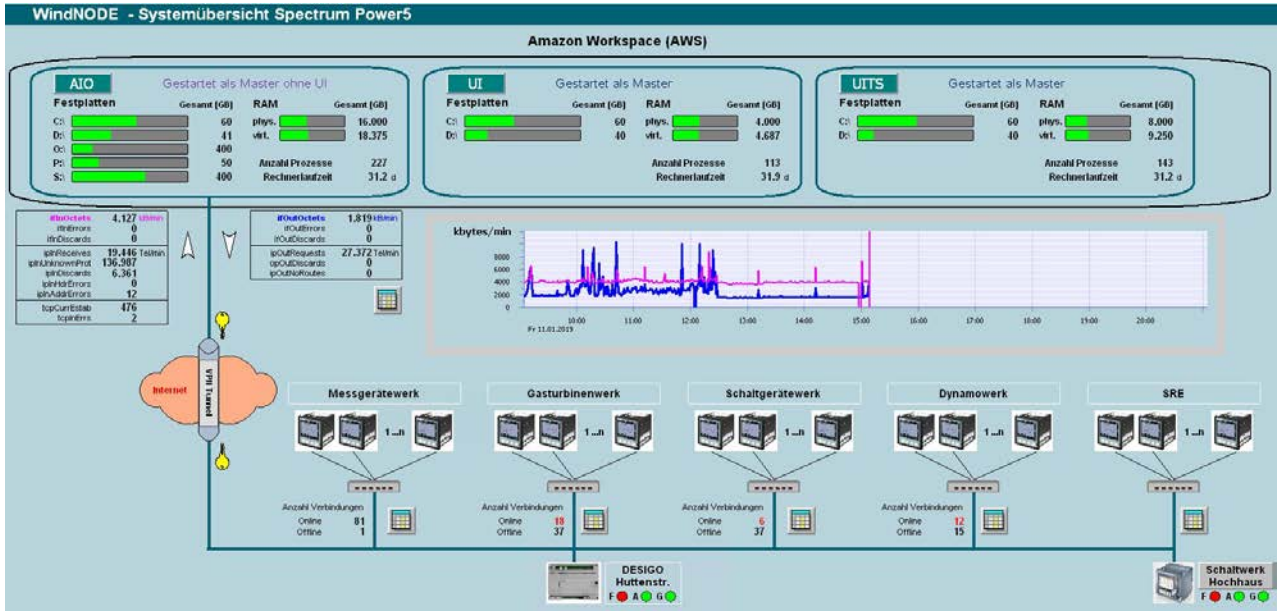
1 Installation of SICAM metering devices and energy data management system Spectrum Power 5

2 Analysis of processes with production experts

3 Apply load shifting concepts

a) *„fixed shifting“*
b) *„not projectable, but flexible“*
c) *„projectable & manually operated “*
d) *„projectable & fully automated“*

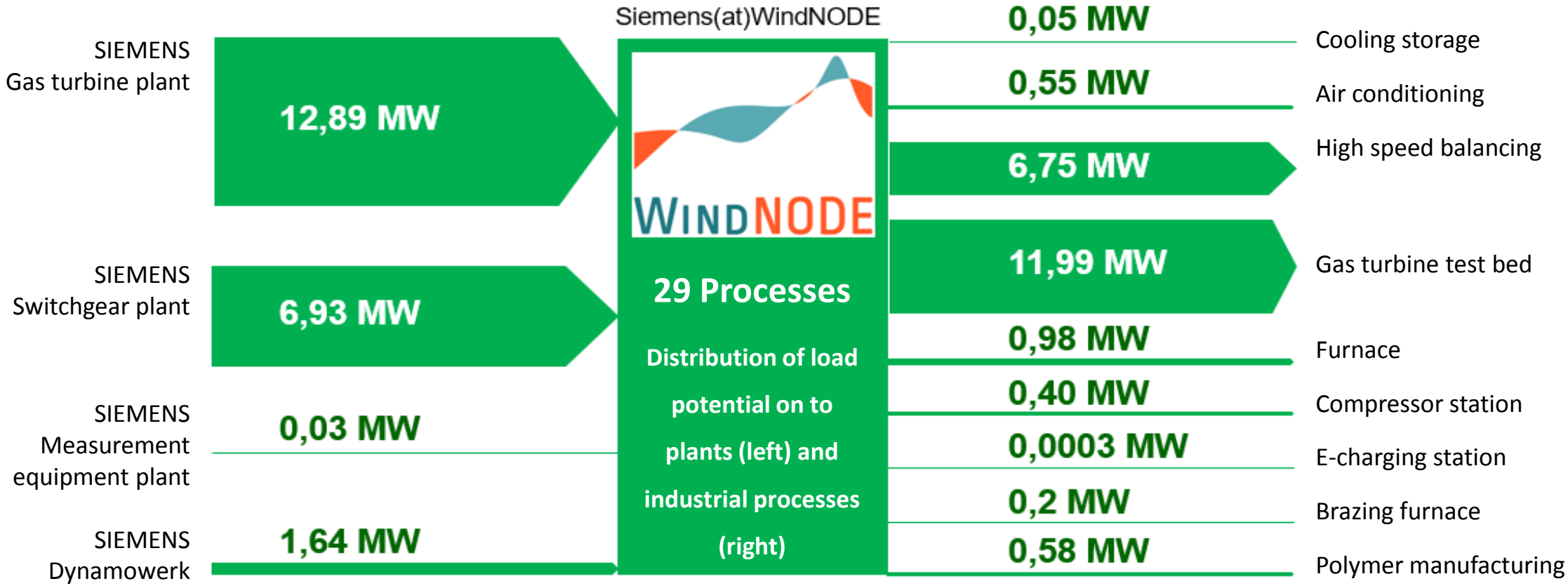
4 Load prognosis optimization for production planning



WindNODE system overview in Spectrum Power 5 (Certified Energy Management System acc. to DIN ISO 50001)

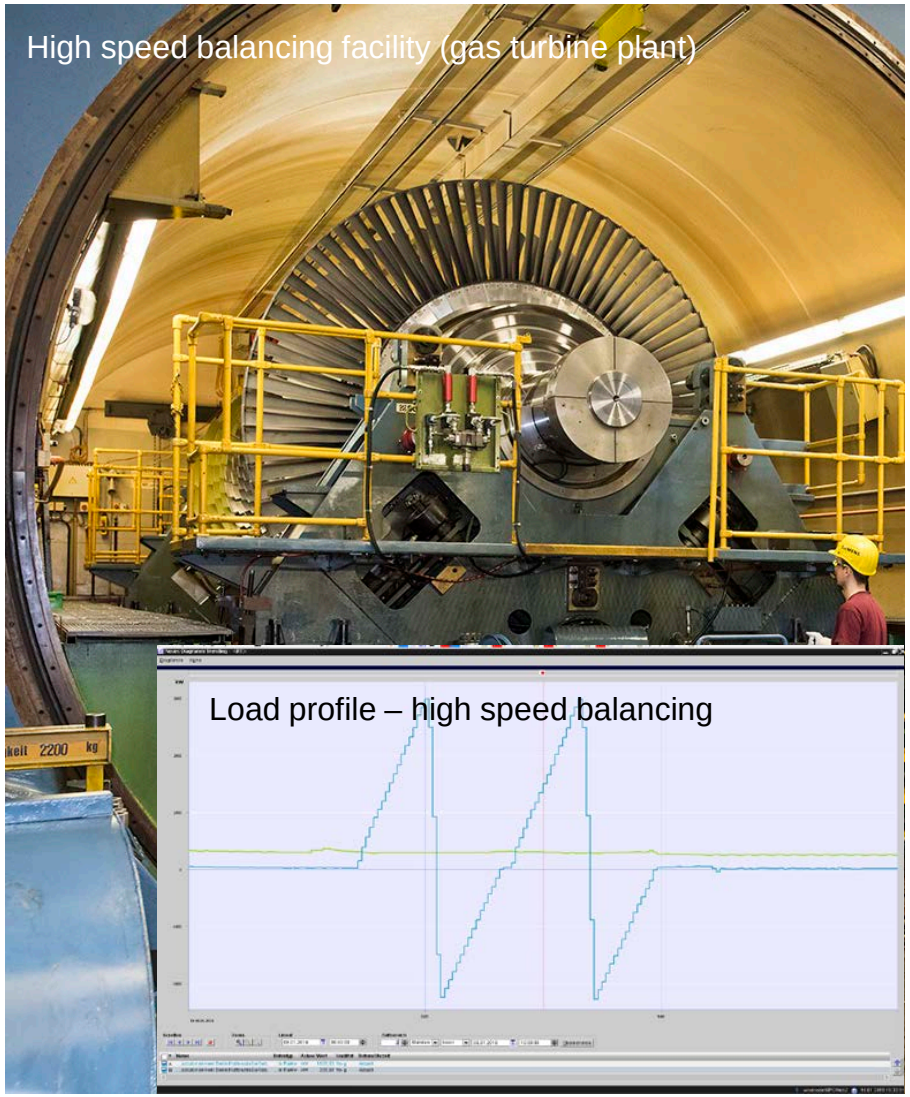
Demand Side Flexibility in Production

Identifying Flexible Processes



Demand Side Flexibility in Production

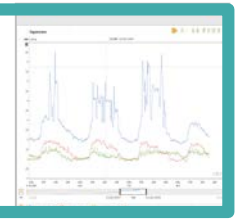
Understanding flexibility and means of control



Type of flexibility: **Example: Preferred control for balancing facility**

Include availability of renewable energy into production planning

→ **Time frame ~ 3 days**

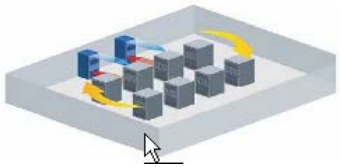


Show current energy availability at production machine in order to provide flexibility to operator

→ **Time frame ~ 3 hours**

Closed loop control of production equipment based on current renewable energy availability

→ **Time frame ~ < 1 min.**



Utilization of "Spectrum Power 5" (Certified Energy Management System) for the analysis of the internal energy demand according to DIN ISO 50001

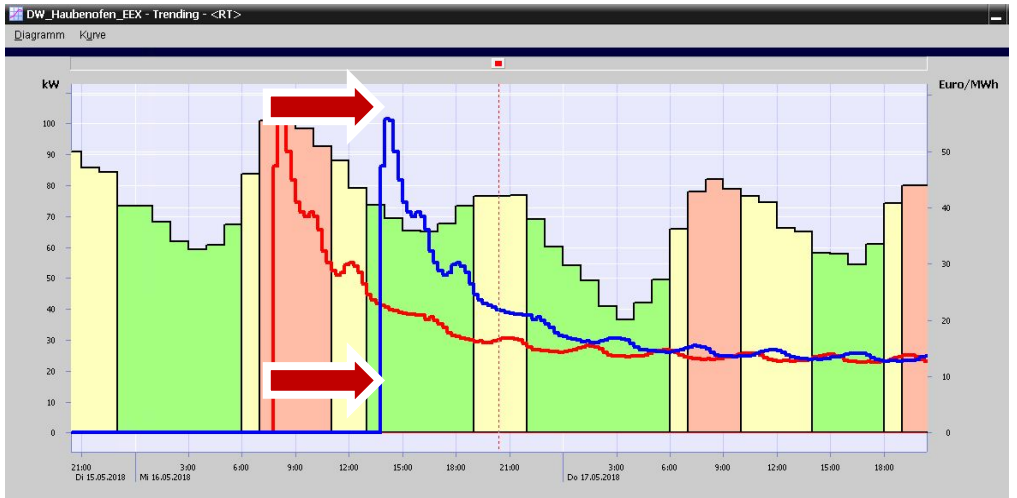
Demand Side Flexibility in Production

Optimization process

One optimization per grid connection

- **Input:** Price time series, flexibility time slots, opportunity costs
- **Minimize target function:** Total costs (power supply, network access, opportunity costs)
- **Degrees of freedom:** Load profile of flexible processes („typical“) can be shifted within the time slot. Max. power restrictions not to be exceeded.
- **Results:** Starting times of flexible processes and load forecast

Brazing furnace with 3 typical production related load profiles



Optimized furnace process with electricity price curve in the background

Demand Side Flexibility in Production

Commercialization of flexible loads by activation time

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Very short-term
(activation time: 5 s – 60 min)

→ **Reserve Power**

Short-term
(activation time: 45 min – 24 h)

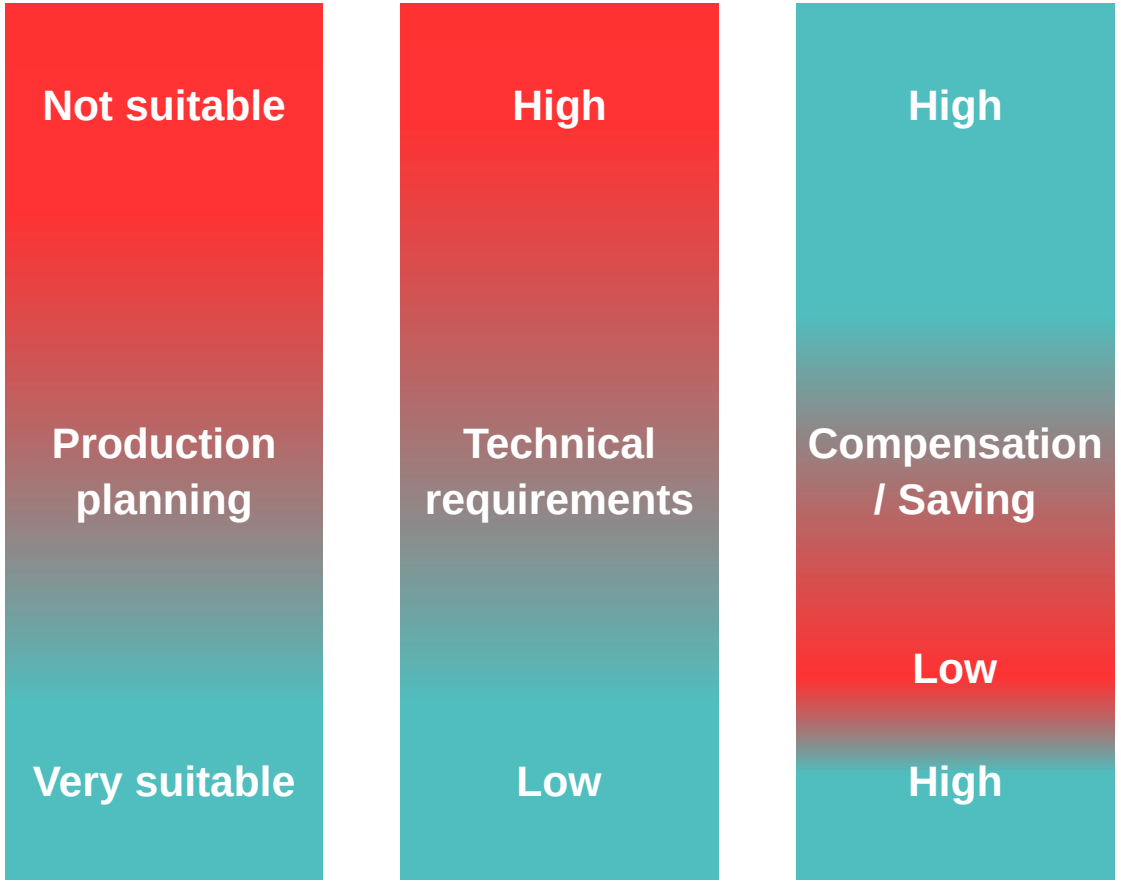
→ **Intraday Power Trading**

Medium-term
(activation time: 12 h – 36 h)

→ **Day-ahead Power Trading**

Static

→ **Peak load shaving, load profile optimization for long-term power purchase**



Flexible loads have been traded over WindNODE flexibility platform already

Source: Uni Leipzig, IKEM, TU Berlin, Siemens (2019) – WindNODE Working Paper

Content

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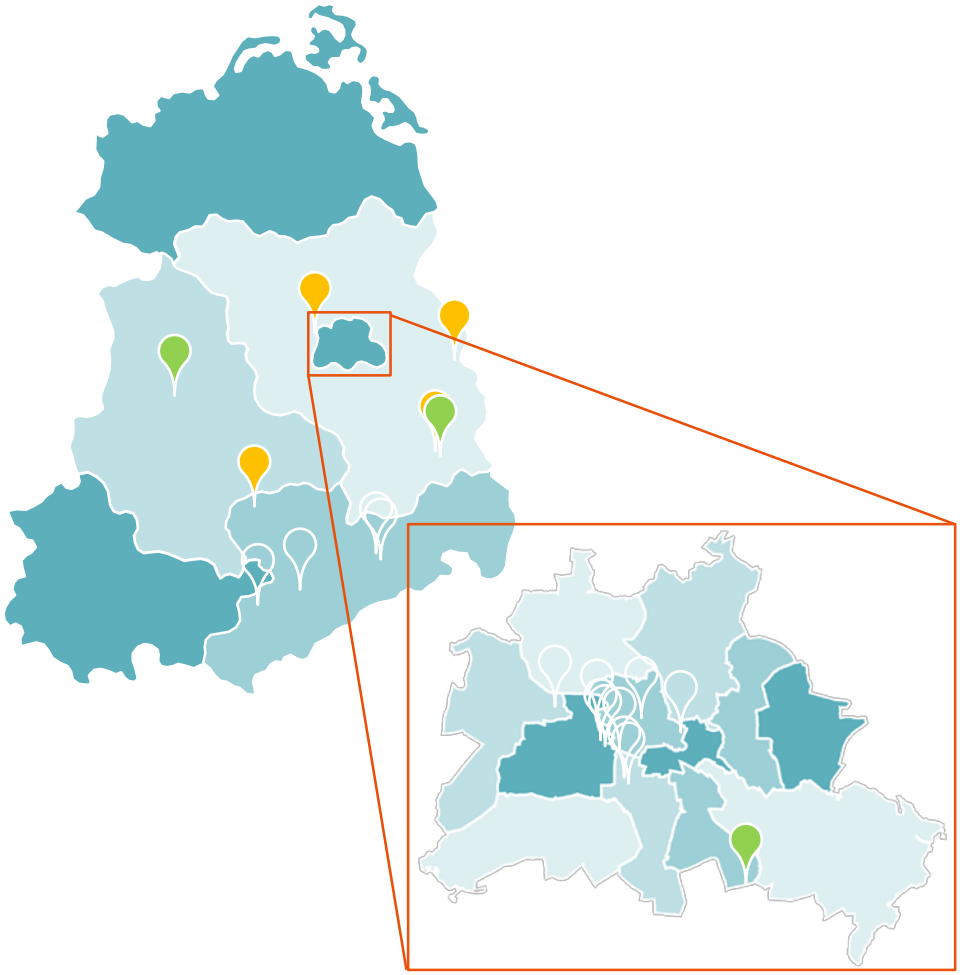
Outlook

More than 20 “visitor sites“ are planned

Overview of selected “visitor sites“, more are coming



Source: www.windnode.de/en/concept/showcase

Experience Demand Side Management
@ Siemens Showroom (Berlin, Nonnendammallee)

Combining Expertise in Renewables and Hydrogen

Outlook for a region with “energy & transition” expertise

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Examples for potential future projects in East Germany

Power-to-Gas. Government have recently launched their call for “Reallabor“ applications (“reality labs“ = showcases at a high Technology Readyness Level) with a focus on Power-to-Gas**. Up to EUR 100 mio. funding per year. Reference Plant Lausitz selected for realization.

Phasing out coal. Most likely, lignite will be phased out by 2038. Strong political attention for a major transformation effort. Currently, there is intensive discussion on perspectives for former coal regions. Hydrogen & sector coupling as promising approaches.

** Call by BMWi (Federal Ministry for Economic Affairs and Energy) is available online (only in German): www.energieforschung.de/antragsteller/foerderangebote /ideenwettbewerb_reallabore-der-energiewende

A joint effort by > 70 partners from industry and academia

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WindNODE partners

Steering Group

50hertz, Berlin Partner für Wirtschaft und Technologie, Fraunhofer FOKUS, energy saxony, SIEMENS, Stromnetz Berlin, WFBB Wirtschaftsförderung Brandenburg

Partners

ASEW, BELECTRIC, BSR, BVG, Berliner Wasserbetriebe, BMW GROUP, Borderstep Institut, BOSCH, b-tu, DECKEL MAHO, devolo, DIN, RIEDEL, Dresden, e2m, ENERTRAG, Fraunhofer IFF, Fraunhofer IWU, Fraunhofer IEE, GASAG SOLUTION+, Stadtwerke Cottbus Heizkraftwerksgesellschaft, IBAR, IKEM, ILK Dresden, KWD AUTOMOTIVE, ÖKOTEC, PUMACY, REINER LEMOINE INSTITUT, SCHWARZ, LIDL, Kaufland, SENERTEC Center Sachsen, SOLANDEO, stadtwerke Frankfurt (Oder), STADTWERKE HENNIGSDORF, TU berlin, UNIVERSITÄT LEIPZIG, Universität Rostock, VATTENFALL, WEMAG NETZ GmbH, Westsächsische Hochschule Zwickau, zev

Associated Partners

BES, Berlin Brandenburg Energy Network, degewo, e.dis, eMO, energiequelle, ENERSTORAGE, enso NETZ, enviaM, enviaTHERM, Zeit Ingenieure, Gewobag, Fernheizwerk Neukölln AG, FHW, HES, IBERDROLA, INFRALEUNA, InnoEnergy, LEAG, LUMENION, MITNETZ STROM, RADEBERGER GRUPPE, SPIE, stadtwerke energie jena-pößneck, SW FORST, SWT STAHLWERK THÜRINGEN, ThEGA, ubitricity, VHP READY, T-Systems, VSB, WEWOBAU, Zere

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Source: www.windnode.de/en/partners

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BACKUP

Reduction of CO_2 emissions is critical to limit global warming to below current commitments (considered unsustainable)

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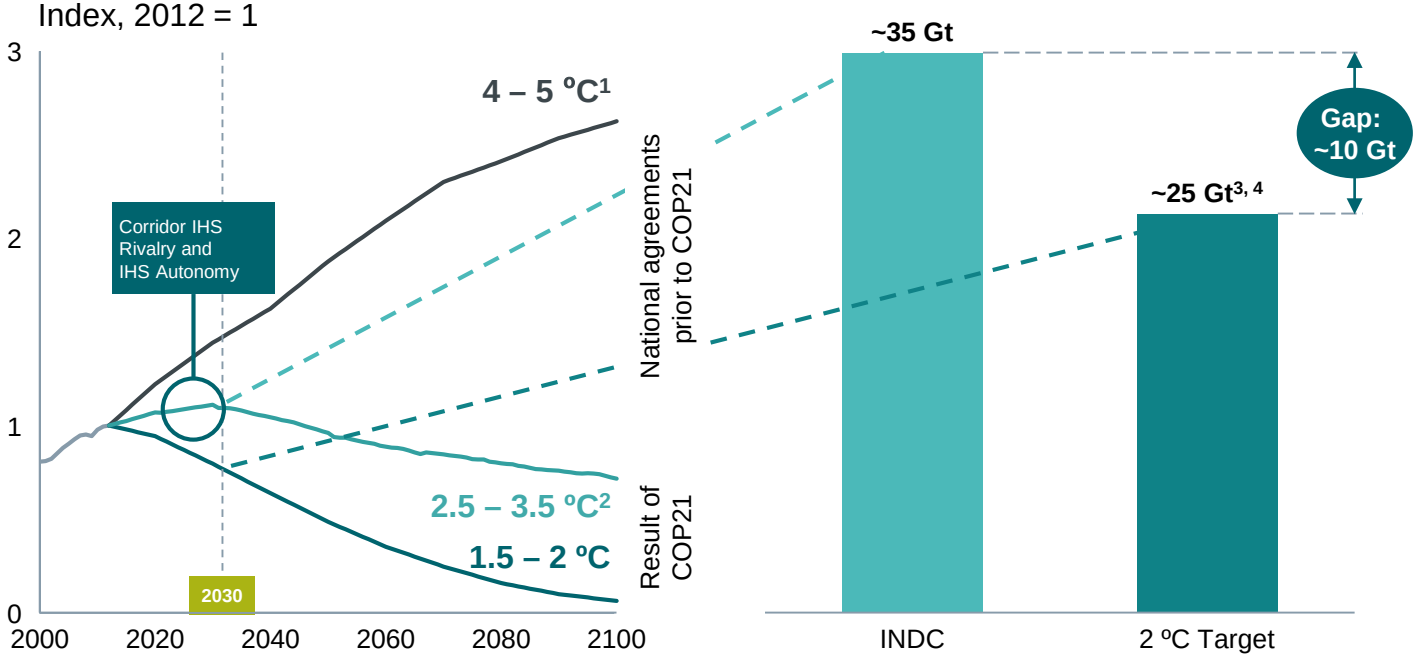
Increasingly ambitious targets from COP21 leave the world …

… with a significant CO_2 gap[3], already in 2030 …

… which needs to be closed to achieve 1.5 – 2 °C target

Global warming scenarios
Index, 2012 = 1



Transition of power generation mix
- Coal to natural gas (short term)
- Aggressive renewable growth
- Natural gas to sustainable hydrogen (long term)

Efficient energy management
- Electricity storage for intermittent renewables
- Smart grid technology for demand response

Improved energy efficiency
- Efficient use of energy
- Green electrification of transportation and heat (sector coupling)

1 Business as usual (BAU), without any emission reduction effort | **2** Intended Nationally Determined Contributions (pre-COP21 commitments) |
3 BAU & INDC data based on CO_2 equiv., whereas scenarios only provide CO_2 emissions which are ~33% lower than total CO_2 equiv |
4 Following Climate Action Tracker (~38 Gt CO_2 equiv. in 2030) | **Source:** CD ST SU, PV/Energy Mix Project Team, IEA

"Energiewende" was essentially an "electricity transition"

Energy concept 2050, decided in 2010 – Government's assessment report 2018*

	Base year	Status 2016	Assess-ment**	Target 2020	Target 2050
Greenhouse gas emissions	1990	- 27.3%	R	- 40%	≤ - 80%
Nuclear power phase-out				by 2022	
Renewables … share of gross final energy consumpt.		14.8%		18%	60%
… share of gross electricity consumption		31.6%		35%	≥ 80%
Energy efficiency … primary energy demand	2008	- 6.5%	R	- 20%	- 50%
… heat demand of building stock	2008	- 6.3%		- 20%	
… final energy consumption in transportation	2005	4.2%	R	- 10%	- 40%
Security of supply … transmission grid expansion			R		
… redispatch					
… system average interruption duration index (SAIDI)					
Prices					
Acceptance					

* Selected indicators in 7 major assessment dimensions

** Assessment by independent expert commission – qualitative assessment if no performance indicator is shown

Source: 6th Monitoring Report for the Energy Transition (Sechster Monitoring-Bericht zur Energiewende), 2018; Assessment Report of the Independent Expert Commission "Monitoring-Prozess Energie der Zukunft", 2018

WindNODE – showcase from the German capital region

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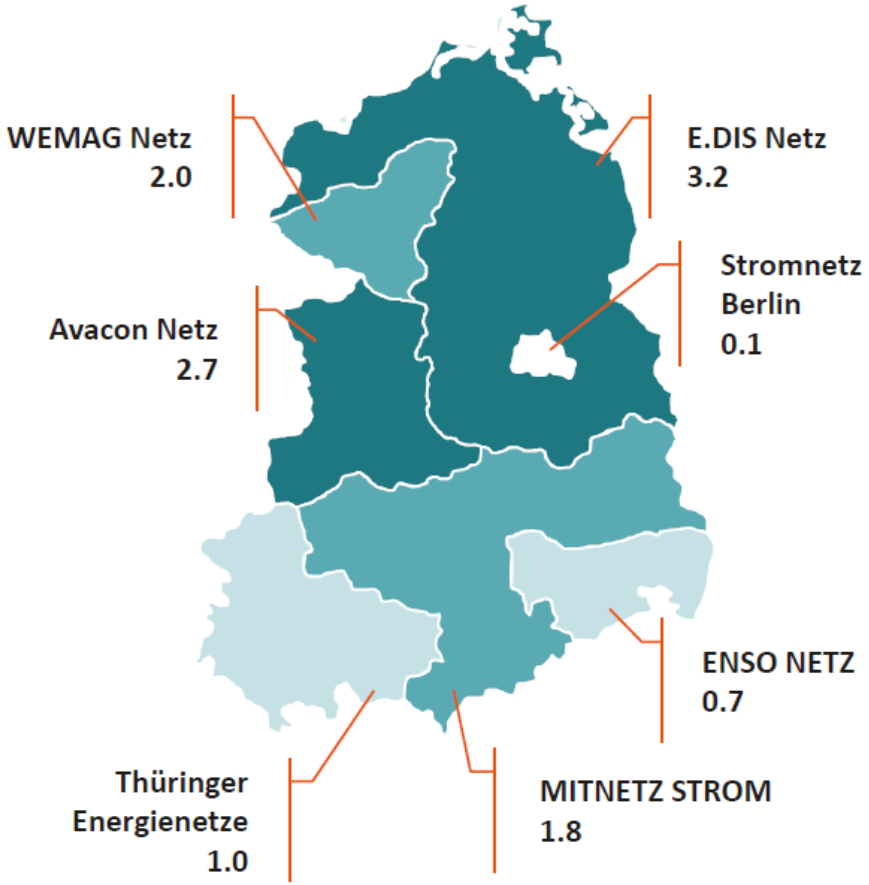
Installed renewable capacity per DSO* in our region

as a multiple of regional peak load (2014)



Our region's USPs (2017)

Entire East of Germany

- 6 federal states
- ca. 16 mio. people
- 1 control area (50Hertz)
- > 70 partner

Renewables frontrunner

- > 53% of the region's electricity is green

Energy transition challenges

- Grid congestion: Redispatch on 171 days, ~ 2% curtailment of renewables
- Large grid expansion projects
- Structural transformation in Lausitz region

* DSO = Distribution System Operator

Source: 50Hertz, GridLab, BMWi, Projektträger Jülich, WindNODE

Abundance of technical flexibility options

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Approach and intermediate results of selected partners

- ✓ **Identifying flexibility options** (technical potential)
- ✓ **Developing use cases for flexibility** (economic potential)
- ✓ **Creating value from energy data** (digitalisation in the energy space)
- ✓ **Field test** (blueprints, narrative, dissemination)

- Model supermarkets at Lidl & Kaufland
- PtH/PtC at GASAG Solution Plus
- BMW second life battery farm, Leipzig
- 4 Siemens factories, Berlin
- Germany‘s biggest PtH (120 MW) at Vattenfall
- High temperature heat storage (600 ° C) by Lumenion, GEWOBAG, Vattenfall
- Fluid ice storage unit, ILK Dresden
- Flexibility in water & sewage treatment, BWB
- …

BMW GROUP, ÖKOTEC ENERGIEMANAGEMENT GMBH, SCHWARZ, VATTENFALL, GASAG SOLUTION +, SIEMENS, LIDL, Kaufland, BSR, IKEM, Fraunhofer IFF, stadtwerke FRANKFURT (ODER), Fraunhofer IWU, Borderstep Institut, Stromnetz Berlin, Berliner Wasserbetriebe, Westsächsische Hochschule Zwickau University of Applied Sciences, zev

Flexibility platform for grid congestion management

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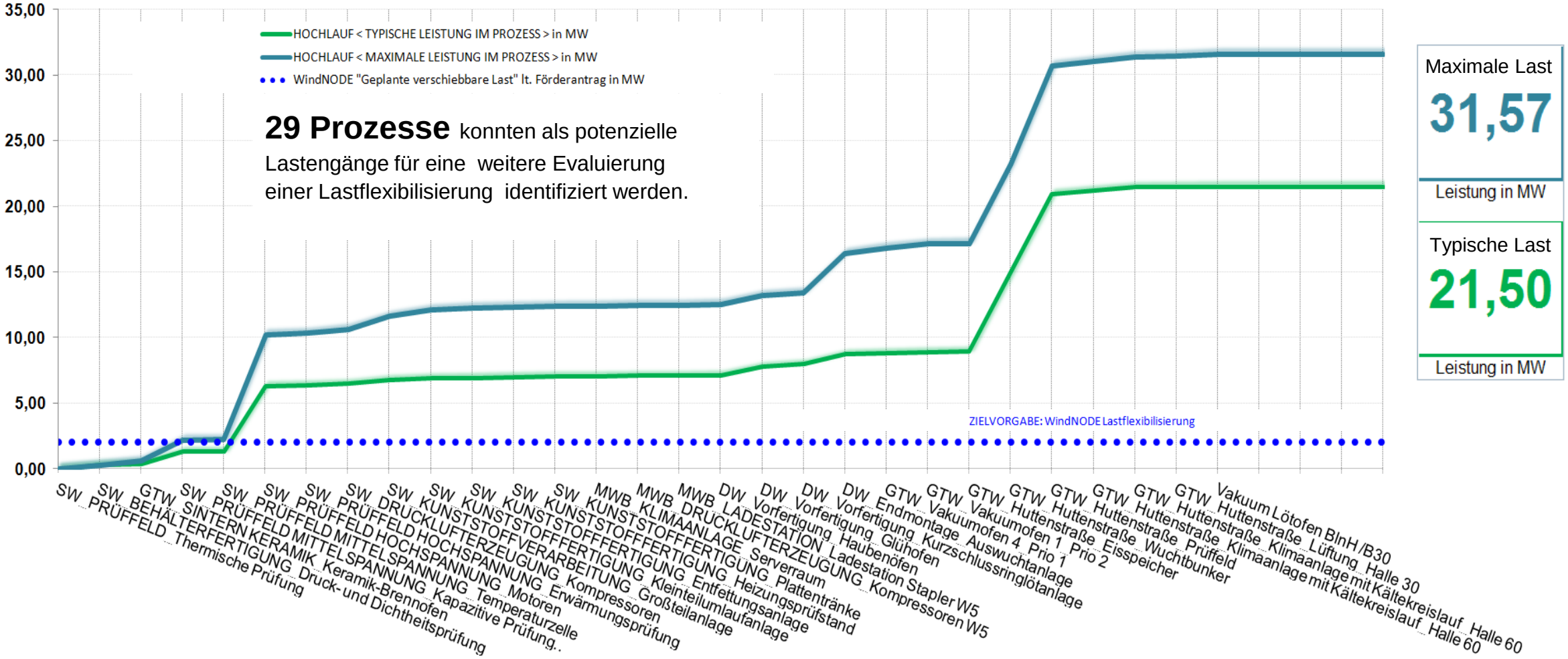
- WindNODE flexibility platform starts test operation, 11 Nov 2018, by 50Hertz, Stromnetz Berlin and various DSOs
- First real trade at the flexibility platform, 14 March 2019, with offers by Lidl, Siemens and Vattenfall
- Continuation of test operation

50hertz
IKEM
SIEMENS
Stromnetz Berlin
UNIVERSITÄT LEIPZIG
berlin
WEMAG NETZ GmbH
e2m

Demand Side Flexibility
Collection of flexibility potentials



Driver and barriers for industrial load management

Barriers	Energy costs are small compared to total production costs (processes looked at above) High implementation effort (change in manufacturing setup) Future competition: Flexible power applications, e.g. e-mobility, P2G and power storages
Drivers	Increase of renewables installation/ decrease of controllable power generation New energy services (e.g. flexible electricity tariffs) Flexibility friendly or obligate regulation Synergies with predictive maintenance and energy efficiency measures Increasing digitalization of production Increasing demand of carbon neutral power

New perspectives on energy transition: “Energy & Art“

The vision: “Joint responsibility for a successful energy transition“

One example out of 50 artworks which have been jointly created in groups of energy experts together with artists

Source: Maria Reinisch Marketing Kommunikation | Künstler des Bildes: Fion-Jasper Hoppmann

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