Planning Distributed Energy Systems
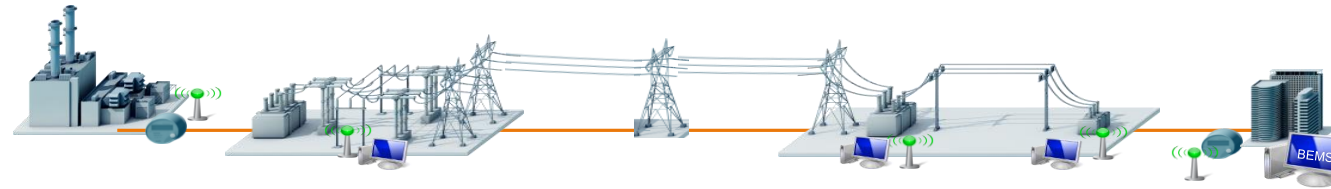
Ren Yu Jie CECEP
Stefan Niessen Siemens CT REE ENS
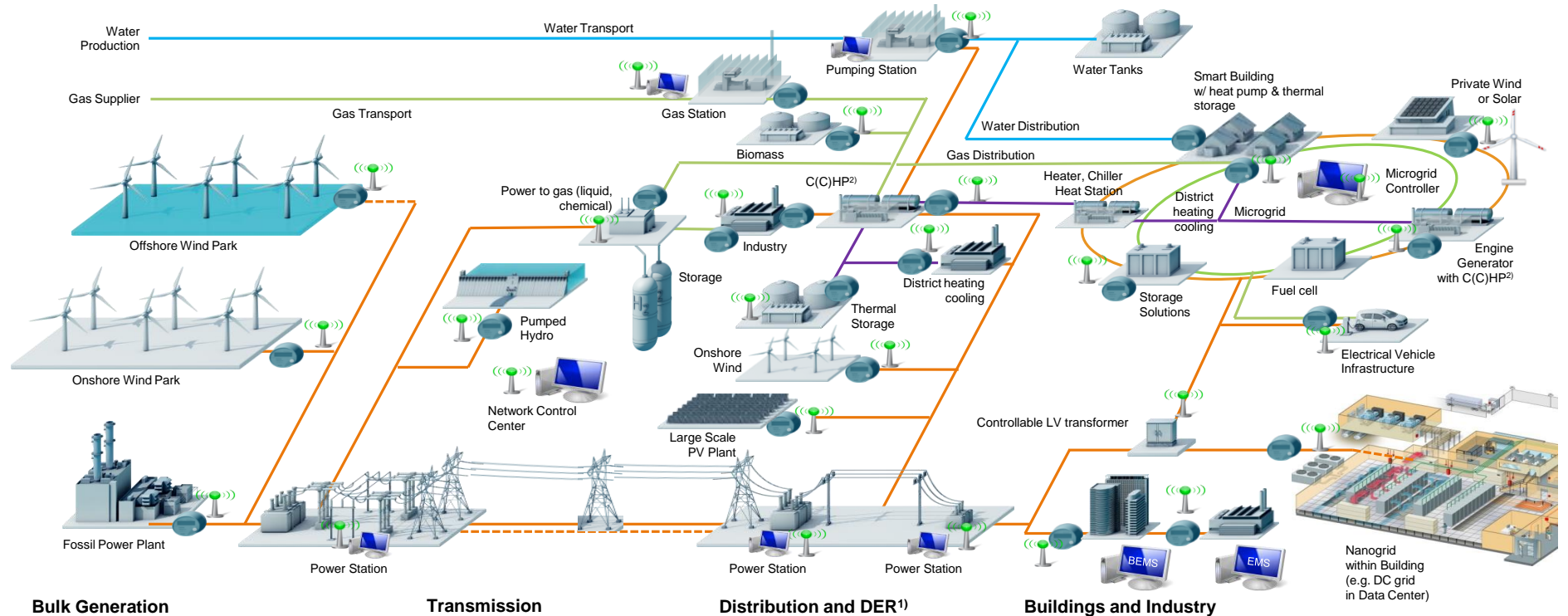Cheng Du, May 15th, 2019

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Fundamental changes in future energy systems:
Multimodal – flexible – decentralized – digital

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Past:
Electrical energy separately

Future:
Multimodal coupling

Water Production
Water Transport
Pumping Station
Water Tanks

Gas Supplier
Gas Transport
Gas Station

Smart Building w/ heat pump & thermal storage

Private Wind or Solar

Biomass
Water Distribution
Gas Distribution

Heater, Chiller Heat Station
Microgrid Controller

Power to gas (liquid, chemical)
C(C)HP[2]
District heating cooling
Microgrid

Offshore Wind Park
Industry
Storage

Engine Generator with C(C)HP[2]

Storage
District heating cooling

Pumped Hydro
Thermal Storage
Storage Solutions
Fuel cell

Onshore Wind Park
Onshore Wind

Network Control Center
Electrical Vehicle Infrastructure

Large Scale PV Plant
Controllable LV transformer

Fossil Power Plant
Power Station
Power Station
Power Station

Nanogrid within Building (e.g. DC grid in Data Center)

BEMS
EMS

Bulk Generation   **Transmission**   **Distribution and DER[1]**   **Buildings and Industry**

Energy System Analysis:
Reduce complexity with a stepwise approach

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A Multimodal analysis of province energy system

B Simulation of city energy system

C Design of energy system for site

Results
Long-term evolution of fundamental planning parameters like future
- energy prices
- technology mix

End-to-end energy system model

Results
Quantifying main city parameters such as
- air quality
- energy availability
- transport infrastructure

CyPT model

Results
Best combination of components with
- lowest system costs
- highest reliability of supply
respecting environmental requirements.

MM-ESD model

Increased level of detail

Plausibility checks through extrapolation
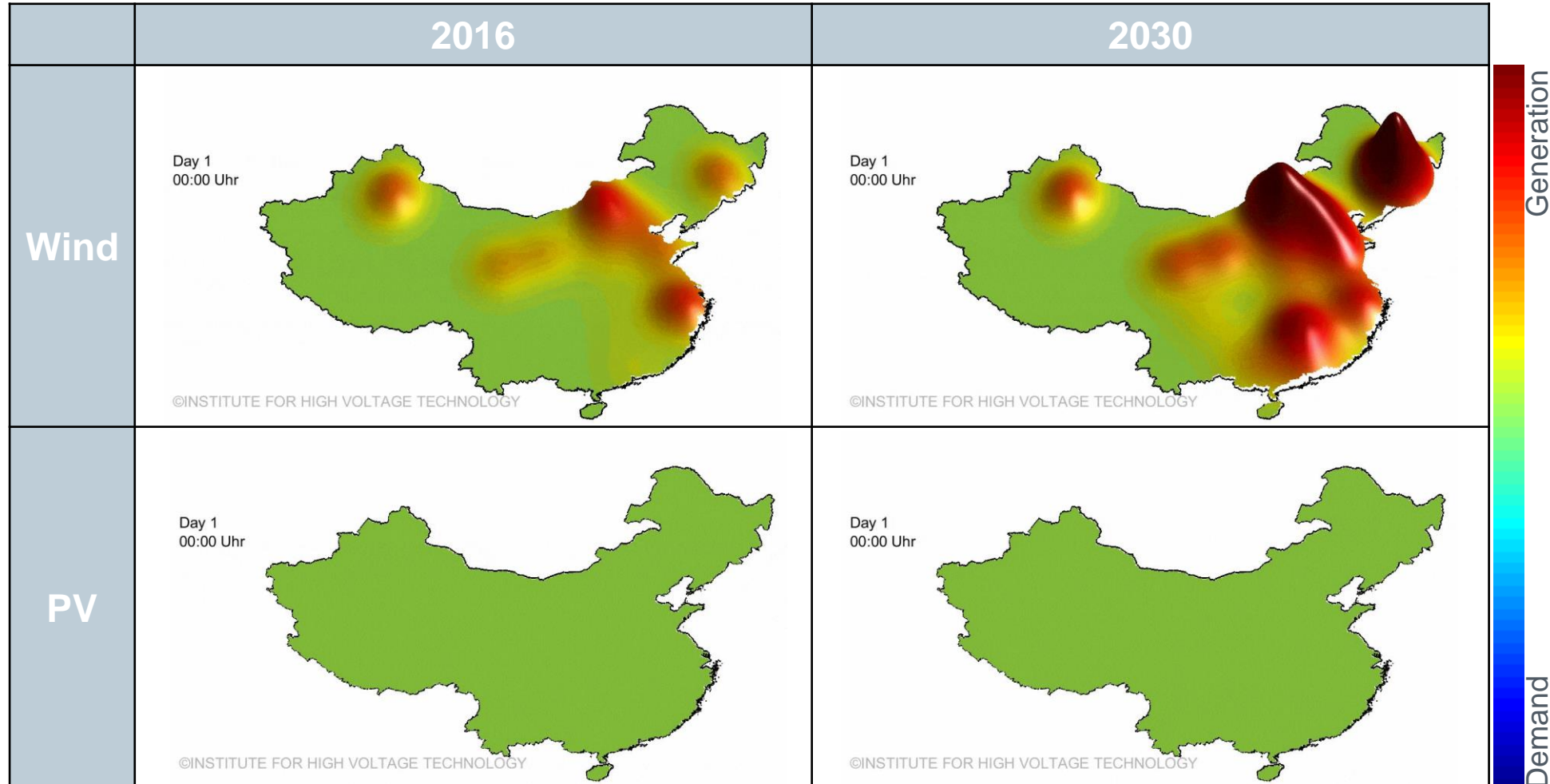
Energy Heartbeat China - illustrative

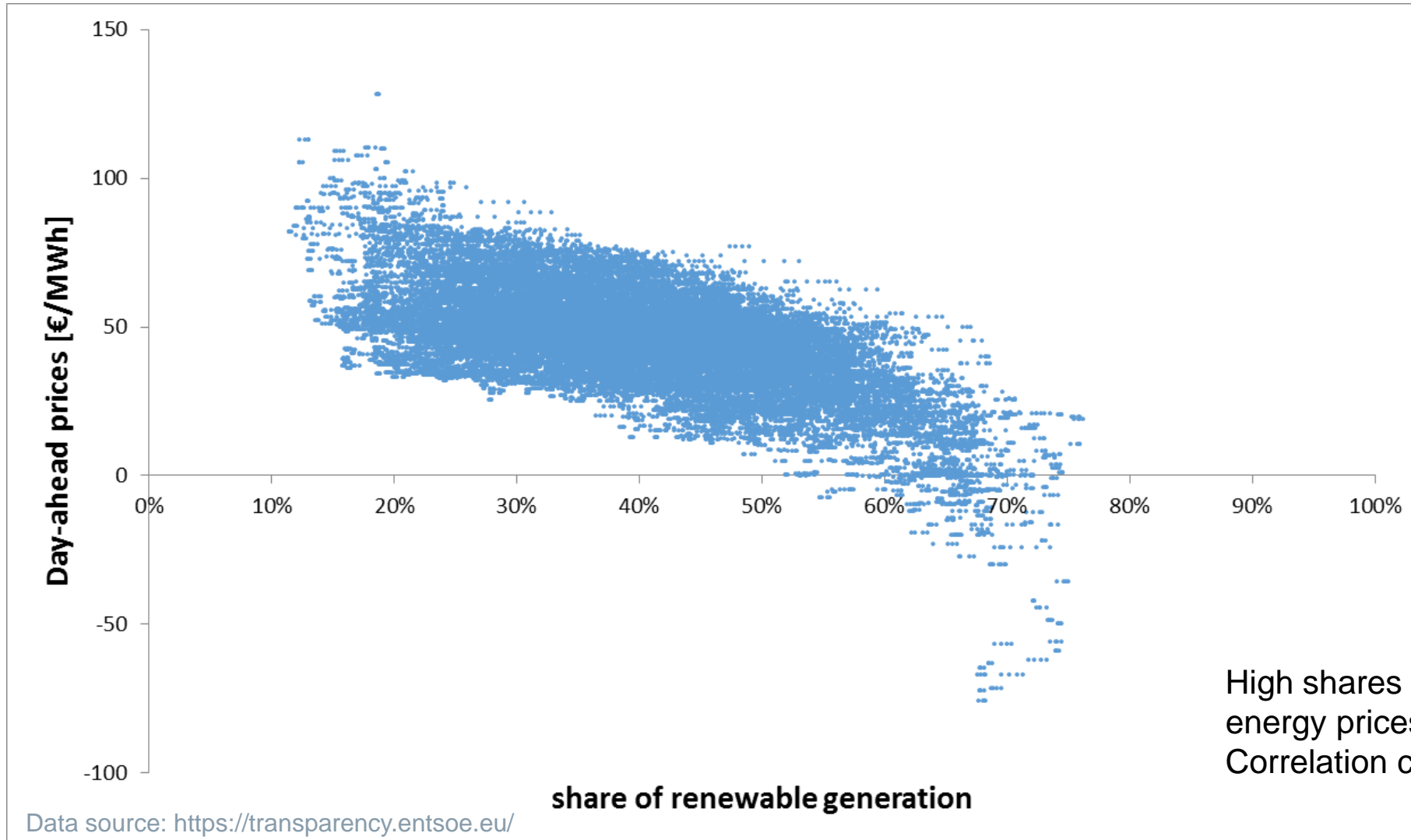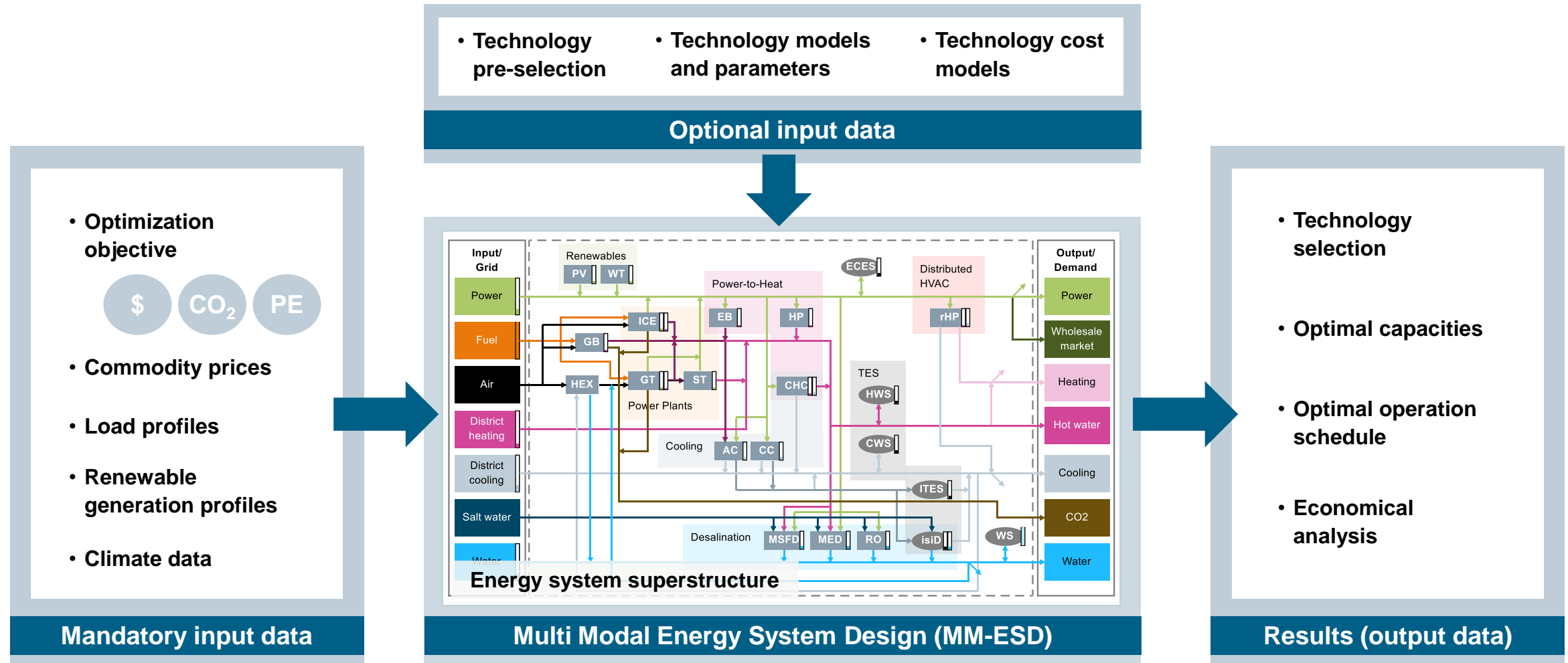Renewable generation patterns in China – 2016 and 2030

Wholesale electricity prices and share of renewables Germany 2018

High shares of renewables bring low energy prices:
Correlation coefficient: -0,65

Data source: https://transparency.entsoe.eu/

Multi-Modal Energy System Design (MM-ESD)
Inputs and Outputs

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Optional input data

- Technology pre-selection
- Technology models and parameters
- Technology cost models

Mandatory input data

- **Optimization objective**
  - $ — CO₂ — PE

- **Commodity prices**

- **Load profiles**

- **Renewable generation profiles**

- **Climate data**

Multi Modal Energy System Design (MM-ESD)

Energy system superstructure

Results (output data)

- **Technology selection**

- **Optimal capacities**

- **Optimal operation schedule**

- **Economical analysis**

Industrial processes provide potential for flexibility example: Siemensstadt Berlin

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Gas turbine factory

12,89 MW

Switch gear factory

6,93 MW

Measuring device factory

0,03 MW

1,64 MW

Dynamo factory

Industrial processes provide potential for flexibility example: Siemensstadt Berlin

SIEMENS
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Gas turbine factory

12,89 MW

Switch gear factory

6,93 MW

Measuring device factory

0,03 MW

Dynamo factory

1,64 MW

WIND**NODE**

29 Processes
4 Siemens
production facilies
(left) and the
respective industrial
loads (right)

0,05 MW — Cooling storage

0,55 MW — A/C

6,75 MW — Balancing machines

11,99 MW — Test field (HV)

0,98 MW — Oven

0,40 MW — Air pressure

0,003 MW — Charging station

0,2 MW — Soldering

0,58 MW — Molding machines
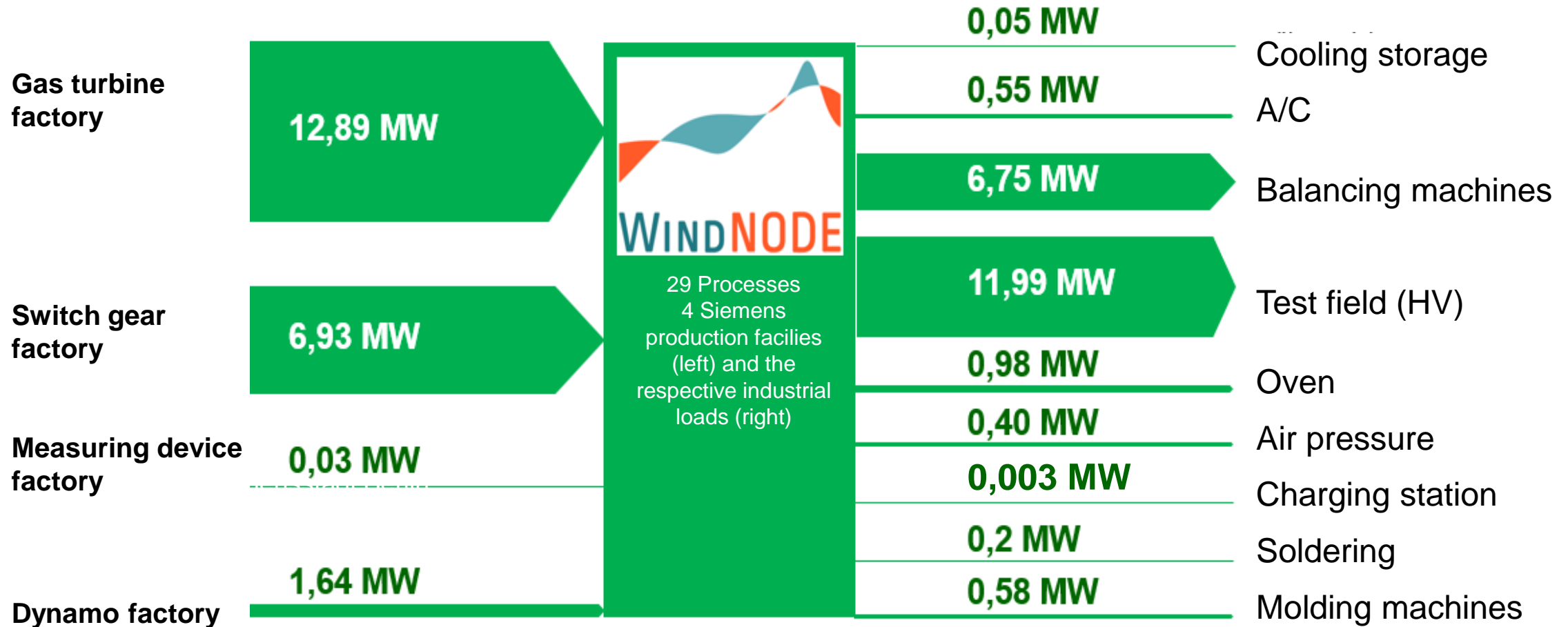
Outlook:
# Local markets harvest flexibility and support the grid
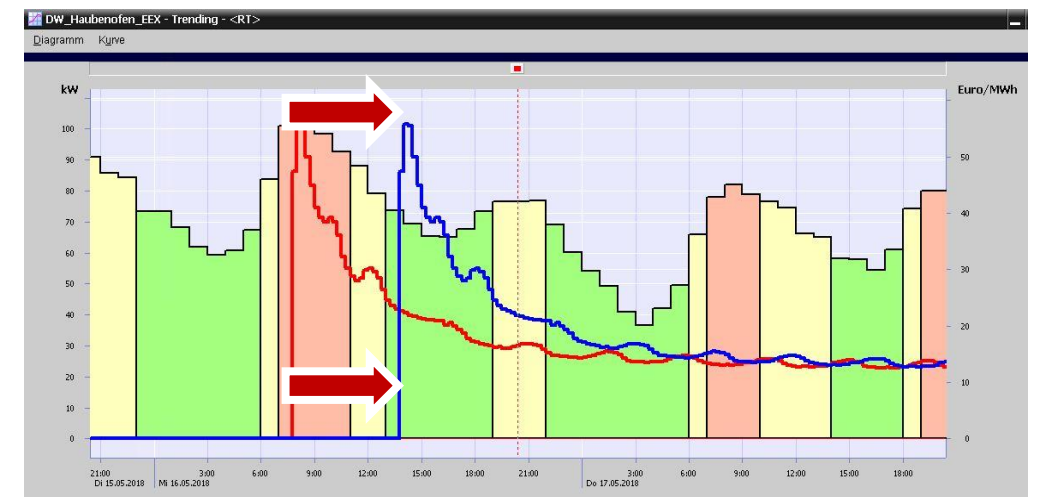
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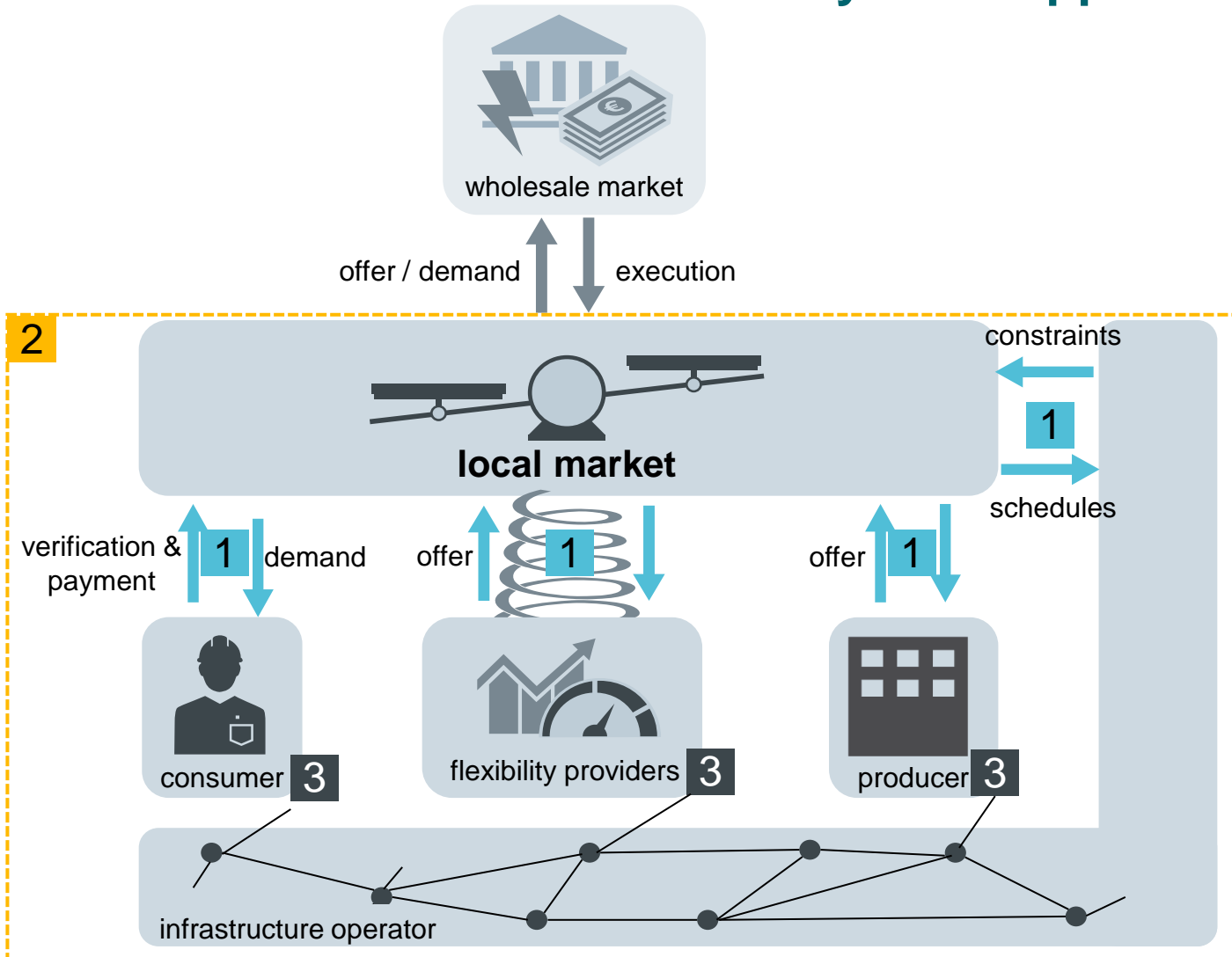
Advantages

- automated trading and settlement
- flexibility brings liquidity
- supporting the energy infrastructure
- contributes to resilience

Optimization process

- One optimization per grid connection

- Calculation with iterative search technique

- Input: price time series, flexibility time slots, opportunity costs

- Target function: total costs (power supply, network access, opportunity costs) → min!

- Degree of freedom: load profile of flexible processes ("typicals") can be shifted within the time slot

- Results: starting times of flexible processes and load prognose
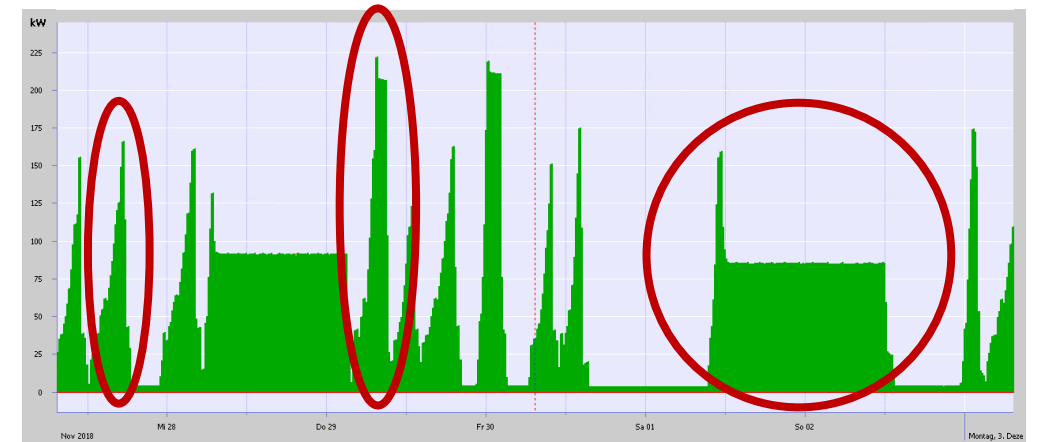
Soldering furnance with 3 typical production related load profiles
Optimized furnance process with eletricity price curve in the background

中国节能环保集团有限公司
CHINA ENERGY CONSERVATION AND ENVIRONMENTAL PROTECTION GROUP

Incremental Power Distribution Grid + Digital Energy Management Service
→ Reducing energy cost →
Creating intelligent, green and safe industrial park

Siemens Innovation Day,
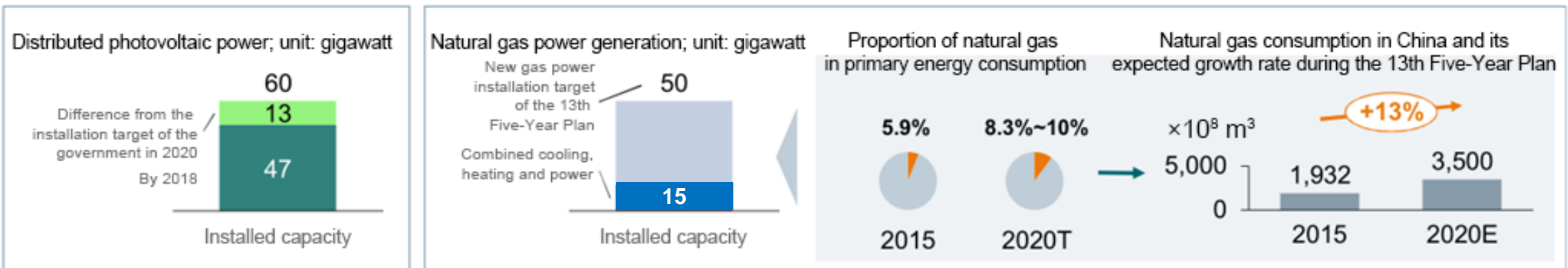**ChengDu, 15th May 2019**

Ren Yujie, CECEP Industrial Energy Conservation Co., Ltd.

Incremental Power Distribution Grid + Digital Energy Management Service → the core measure and irresistible trend according to the national energy strategy

- **Irresistible trend:** increasing renewable energy and natural gas, energy efficiency improvement, the energy cost reduction and further reshaping national energy structure
- **Energy reform means:** separation of transmission, distribution and trading of electricity, active power distribution grid, flexible power distribution grid, oil & gas from piping network
- **The latest achievement of industrial IoT technology lays a strong foundation for it:** electrification, automation, digitization, artificial intelligence and cloud service
- **Energy storage technology allows the separation of energy production from energy use in time, enhance the regional energy balancing capability**

Distributed energy growth target of the 13th Five-Year Plan of the State (excerpt)

Distributed photovoltaic power; unit: gigawatt

Difference from the installation target of the government in 2020

By 2018

60
13
47

Installed capacity

Natural gas power generation; unit: gigawatt

New gas power installation target of the 13th Five-Year Plan

Combined cooling, heating and power

50
15

Installed capacity

Proportion of natural gas in primary energy consumption

5.9%   8.3%~10%

2015   2020T

Natural gas consumption in China and its expected growth rate during the 13th Five-Year Plan

×10⁸ m³

+13%

5,000

0

1,932

3,500

2015   2020E

CECEP Industrial Energy Conservation Co., Ltd. actively promotes the incremental power distribution grid and multi-modal energy demonstration project

- CECEP is the only central enterprise with the main business of energy conservation and environmental protection, mainly providing service for industrial parks and industrial enterprises
- CECEP Industrial Energy Conservation Co., Ltd. has undertaken several national incremental power distribution grid pilot projects listed in the first batch, Ningxia governmental industrial park multi-modal energy demonstration projects for energy cost reduction, meanwhile the main responsible unit for national Yangtze River protection platform.
- CECEP joints together with Siemens to launch the optimized planning for multi-modal energy system and the digital energy management platform in the industrial park.
- Service mode: energy production + power distribution grid + electricity trading + value-added digital energy services to the enterprises in the park for cost reduction

① West District Pilot zone: 30.68km² To-be-developed zone: 5.45km²	② TMT Incubation Center Pilot zone: 3.52km² To-be-developed zone: 2.35km²	③ iBi Incubation Center Pilot zone: 3.52km² To-be-developed zone: 2.35km²

① Jingcheng - Urban Functional Area Pilot zone: 23km²	② Jingcheng - Riverside Industrial Park Pilot zone: 13km²	③ Hengcheng Pilot zone: 10km²
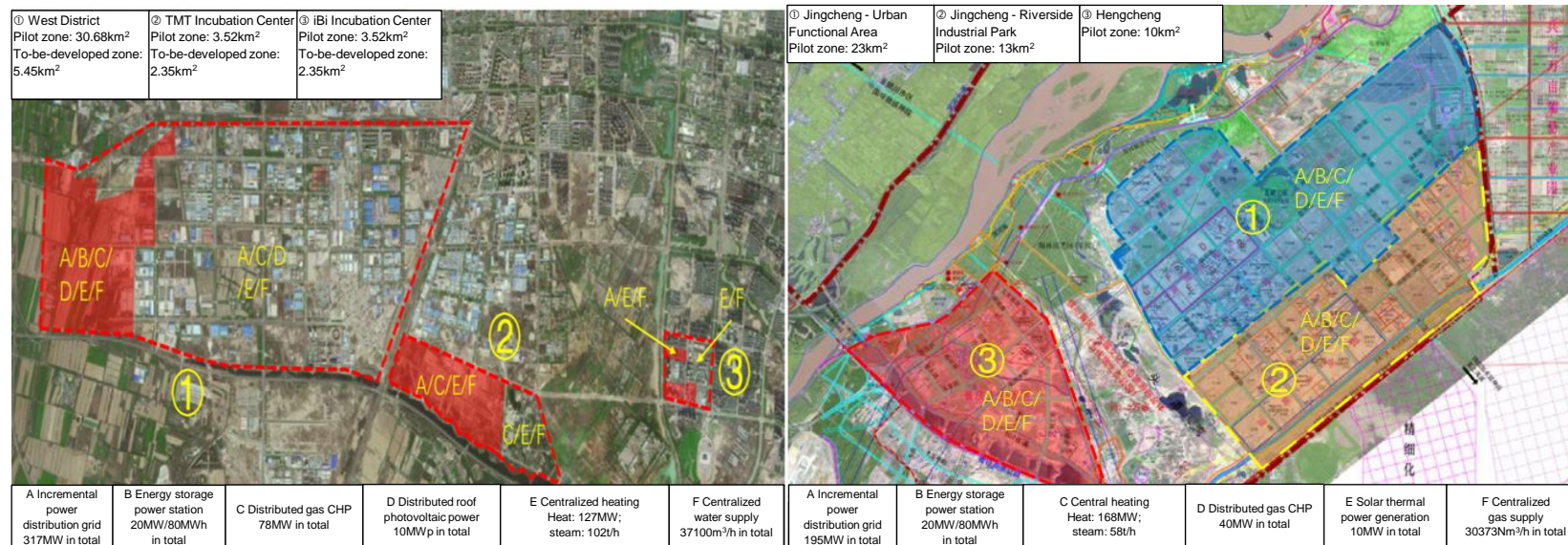
Incremental power distribution grid + multi-modal energy project ,

Bayanobao industrial park, Alxa Left Banner, Inner Mongolia

- 63km²
- short-term : 329.4MW
- 2020~2025: 419.6MW
- long-term: 1123.2MW

A Incremental power distribution grid 317MW in total	B Energy storage power station 20MW/80MWh in total	C Distributed gas CHP 78MW in total	D Distributed roof photovoltaic power 10MWp in total	E Centralized heating Heat: 127MW; steam: 102t/h	F Centralized water supply 37100m³/h in total

A Incremental power distribution grid 195MW in total	B Energy storage power station 20MW/80MWh in total	C Central heating Heat: 168MW; steam: 58t/h	D Distributed gas CHP 40MW in total	E Solar thermal power generation 10MW in total	F Centralized gas supply 30373Nm³/h in total

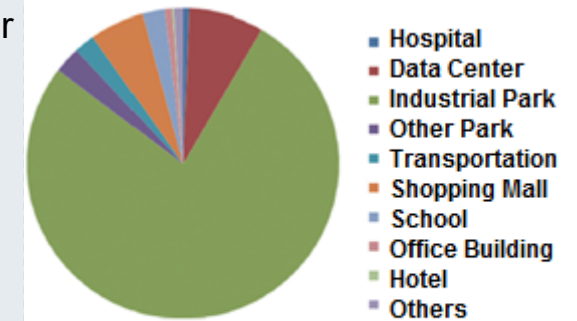# Incremental power distribution grid + digital energy services: opportunity and challenge

- **Accelerating national energy structure adjustment by electricity reform**
  - Since March 2015, the Central Committee of the Communist Party and the State Council have issued some documents: "Several suggestions for further deepening the reform of electric power system" (ZHONGFA [2015] No.9) , "Measures for orderly decontrolling the administration of power distribution grid"(FAGAIJINGTI [2016] No.2120) , to encourage the orderly investment of social capitals and incremental power distribution grid in national- and provincial-level industrial parks, and develop multi-modal energy system;
  - State Grid Corporation of China and China Southern Power Grid have also proposed multi-modal energy development.
- **Broad market of incremental power distribution grid and multi-modal energy system**
  - NDRC initiated 3 batches (320 in total) of incremental power distribution reform, projects, obtained the active response of social capitals

Legend:
- Hospital
- Data Center
- Industrial Park
- Other Park
- Transportation
- Shopping Mall
- School
- Office Building
- Hotel
- Others

DES Installation Market Share

  - Incremental power distribution grid concentrating in Industrial parks and circular economy parks, shares the major part of DES market in China
  - All industrial parks above county level are required to develop this work
  - Complete separation of transmission from distribution, follow distributed energy first and long-distance transmission second
- **Digital energy management to be crucial for incremental power distribution grid projects and distributed energy projects to realize favorable economic benefit**
  - The projects involve governments at all levels, power grid enterprises, social capitals, many links like energy planning, safety, electricity price and supervision, and the core for success is to adopt the digital energy management technology to realize energy as service, for energy cost reduction

Case for incremental power distribution grid demonstration project of CECEP Yinchuan Economic Technology Development Zone

Guiding thought:

- Extend the incremental power distribution grid to develop regional multi-modal energy system

- Make full use of the available resources, renewable and clean energy to supply high-efficient, safe and cheap energy for the enterprises in the park

- considering the coordination of the entire energy networks "source-grid-load-storage", provide the energy in a manner of "multi-energy complemented and intelligent energy operation".

One of the first batch of incremental power distribution grid pilot projects launched by the NDRC and the National Energy Administration：

- 1st phase: invest CNY 270 millions / construction capacity of 243MW
- 2nd phase: invest CNY 500 millions / construction capacity of 579MW
- 3rd phase: invest CNY 900 millions / construction capacity of 784MW

Specific issues of the park to be solved：

High energy cost	more than 50% of enterprises believe the electricity price higher than that of the surrounding areas like Inner Mongolia; many enterprises stop using centralized heat due to the high price.

Low energy supply quality	The energy quality conflict becomes obvious since the precision casting enterprises, food enterprises and large casting enterprises in the park don't manage separately according to electricity grade. As a consequence, the var impact, harmonic and negative sequence will greatly affect the load terminal of high-precision equipments.

Social effects

| Livelihood efficiency	**Power reform revitalizes industry chain.** Promote various industries to shift to the western region by reducing the electricity cost, forming cluster development trend of industrial capital concentration.
Industrial effect	**Boost the upgrade of traditional industries.** Power distribution and trading reform enable low-cost region, and invest more in innovation, improving management quality and efficiency.
Resource allocation effect	**Play the allocation role of the market to promote the reasonable utilization of resources.** Break the barrier of power grid enterprises and social capital operating, and break the integration pattern of transmission, "monopoly for purchases and selling", operation and trading

Siemens MM.ESD design optimization tool used for Yinchuan Economic Technology Development Zone
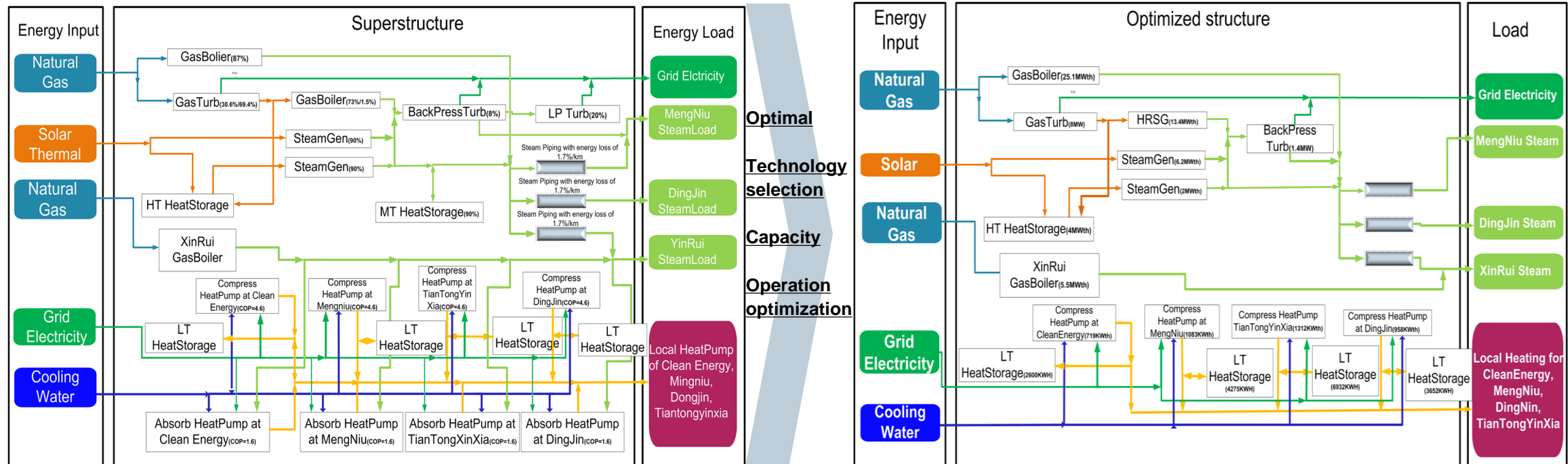
- The digital means of global energy system design optimization and dynamic optimal operation scheduling significantly improves the economical efficiency of such projects and reduces the energy cost.
- The superstructure diagram for optimization which covers all feasible technical routes.
- Technical combination, capacity and operation scheduling are optimized targeting at best economy; multi-scenario analysis strengthens the robustness of change of factors like price, policy, technical parameters, etc.
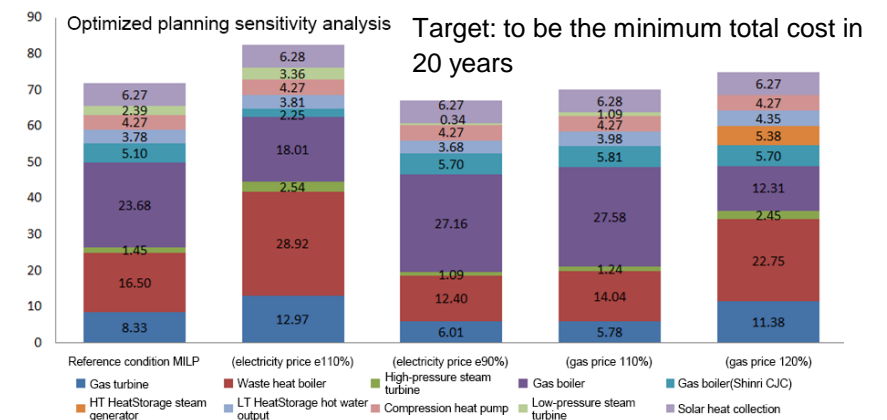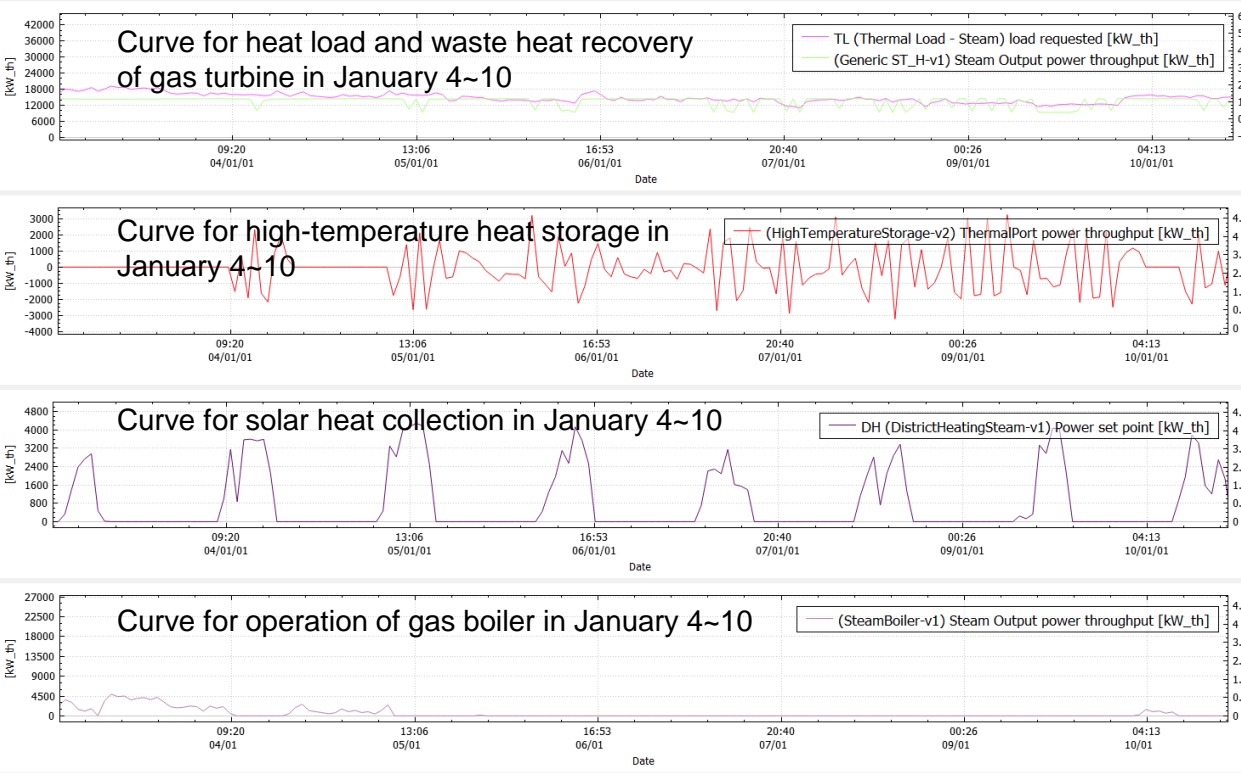
- Compared with traditional energy, the multi-modal energy covers a variety of sources, networks, storages, and loads with features of great fluctuation, intermittent, complex system and significant individual difference

The combined regulating of heat storage, solar thermal, gas turbine and gas boiler to meet the fluctuating load

Curve for heat load and waste heat recovery of gas turbine in January 4~10

Curve for high-temperature heat storage in January 4~10

Curve for solar heat collection in January 4~10

Curve for operation of gas boiler in January 4~10

- Hourly load profile show fluctuated greatly in a strong stochastic way
- gas turbine operating in a optimized way rather than traditionally following heat load entirely

- Where the price of natural gas is high in winter, the power of gas turbine may be reduced depending on the load size
- Where the price of natural gas is low in summer, the gas turbine basically operates at full load

Hourly load profile of 8,000h and output of HRSG of GT
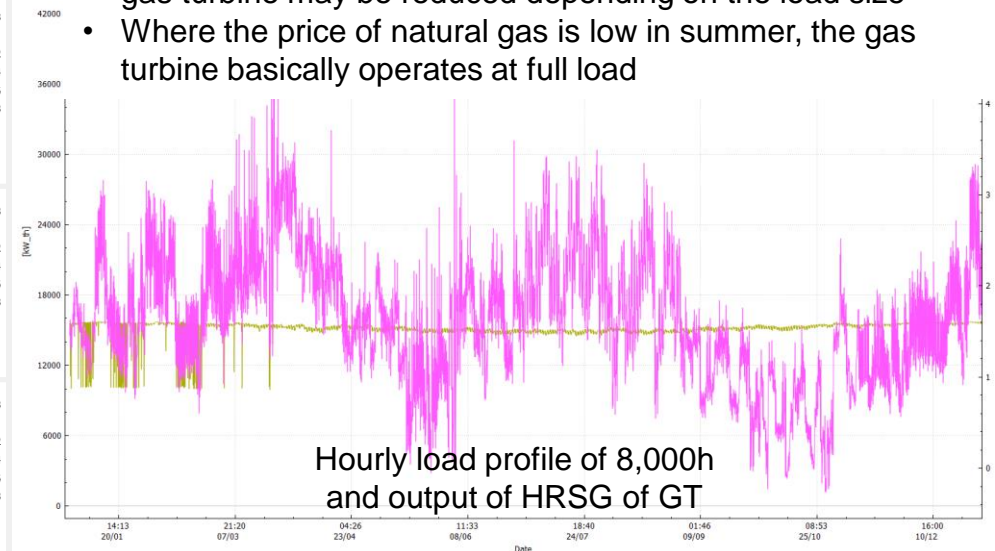
Main conclusions of multi-modal energy system optimized planning for Yinchuan Economic Technology Development Zone

- Reduce energy price by 20% to enterprises
- Energy saved by 14,100tce, water saved by 146,000t, and CO_2 emission reduced by 41,800t per year

Finalized Design:

- Based on Siemens SGT300 7.9MW gas turbine
- Double-pressure horizontal natural circulation HRSG with the CHP heat efficiency up to 88% .
- Back-pressure steam turbine of 1.4MW
- Solar heat station, based on US Solar-247 solar heat technology, 21.6 MWhth/d
- High temperature heat storage station: 2MWhth; solid to store the heat; working temperature up to 800°C
- 3 heat pump stations: 3.32MWth+1.54MWth+ 0.72MWth; hot water heat storage is applied
- Digital energy management and operation center

Regional energy management and operation platform provides energy services for local users

Higher level electricity trading market

Network management and control (gas-supply network, power grid, water-supply network, heat-supply network and cooling network)

Network manager DSOs

energy users and energy producers

Pro-consumers

○ Serve the regional management and control layer

- Develop the business model to form a regional energy market. Regional market mechanism can stimulate the flexibility available in energy production and consumption to facilitate the local energy balance
- Actively identify the behaviors of concerned stakeholders and accurately explore the flexibility and energy saving potential in energy generation and consumption
- Develop a intelligent contract library based on the technology and stipulations for stakeholders concerned
- Provide data-based cloud service to end users
- Apply blockchain technology to provide a transparent and trustworthy foundation on regional market transactions

○ Serve the comprehensive energy network layer

- Water network, power grid, gas network, heating network and steam network
- Network service is used to coordinate flexible production and consumption (e.g. optimized dispatch of energy storage, electric vehicle charging and heat pump, gas turbine gas boiler), and mobilize the marketing participation enthusiasm of DES producer, users and storage; reduce power grid expansion capacity by better balancing the load

○ Serve the comprehensive energy asset layer

- Decentralized photovoltaic, decentralized wind power, decentralized CCHP, energy storage, charging stations and various enterprise users
- Energy management for users. market participants buy and sell electricity in regional market and they can perform self-optimization through the energy management system

Innovation Conclusions of the CECEP Yinchuan Project

- The project covers CHP, solar thermal, high-temperature energy storage, cooling water based heat pump and other energy conversion technologies.
- Siemens special MMESD based on the hourly load curve, more precise and customized for multi-modal energy system, targeting at best economy to determine the system technology combination, capacity and operation scheduling, different from the traditional design ideas based on maximum load or average load, without so much consideration of operation scheduling.
- Solar thermal, the load of industrial steam and the load of heating are intermittent and random. Siemens short term operation optimization functionality in the digital energy management platform to take full use of the flexibility in the system, achieving the best economy and efficiency in operation.
- The first park solar thermal and high temperature storage project in Ningxia which improves the green energy penetration in the park.
- Digital energy management and operation platform creating a new business model and providing digital energy services to all stakeholders involved in the region.
- Demonstration of combination modal of multi-modal energy system + incremental power distribution grid in the industrial park.

Thank you!

Siemens Innovation Day China 2019 | May 14 - 15 Chengdu

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