Planning Distributed Energy Systems

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Stefan Niessen Siemens CT REE ENS
Cheng Du, May 15th, 2019
Fundamental changes in future energy systems:
Multimodal – flexible – decentralized – digital

Past: Electrical energy separately

Future: Multimodal coupling
Energy System Analysis: Reduce complexity with a stepwise approach

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

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

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

End-to-end energy system model

CyPT model

MM-ESD model

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Page 3 May 2019
Energy Heartbeat China - illustrative
Renewable generation patterns in China – 2016 and 2030

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2016 | 2030

Wind

PV

Day 1: 00:00 Uhr

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Wholesale electricity prices and share of renewables
Germany 2018

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

High shares of renewables bring low energy prices:
Correlation coefficient: -0.65
Multi-Modal Energy System Design (MM-ESD)

Inputs and Outputs

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

Output/ Demand

• Technology selection
• Optimal capacities
• Optimal operation schedule
• Economical analysis

Results (output data)
Industrial processes provide potential for flexibility
example: Siemensstadt Berlin

- Gas turbine factory: 12.89 MW
- Switch gear factory: 6.93 MW
- Measuring device factory: 0.03 MW
- Dynamo factory: 1.64 MW
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29 Processes
4 Siemens production facilities (left) and the respective industrial loads (right)

- Cooling storage: 0.05 MW
- A/C: 0.55 MW
- Balancing machines: 6.75 MW
- Test field (HV): 11.99 MW
- Oven: 0.98 MW
- Air pressure: 0.40 MW
- Charging station: 0.003 MW
- Soldering: 0.2 MW
- Molding machines: 0.58 MW
Outlook:
Local markets harvest flexibility and support the grid

- 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 prognosis

Soldering furnace with 3 typical production related load profiles
Optimized furnace process with electricity price curve in the background
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)

<table>
<thead>
<tr>
<th>Distributed photovoltaic power; unit: gigawatt</th>
<th>Natural gas power generation; unit: gigawatt</th>
<th>Proportion of natural gas in primary energy consumption</th>
<th>Natural gas consumption in China and its expected growth rate during the 13th Five-Year Plan</th>
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<tbody>
<tr>
<td>Distributed by 2018, 60, 13, 47</td>
<td>New gas power installation target of the 15th Five-Year Plan, 50, 15</td>
<td>5.9% 8.3%~10%</td>
<td>×10^8 m³, 5000, 1,932, 3,500</td>
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<tr>
<td>Combined cooling, heating and power</td>
<td></td>
<td>2015 2020T</td>
<td>2015 2020E</td>
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Page 12
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 joins 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.

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
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

  • 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

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.

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

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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.
Examples for fluctuate and stochastic load curves and optimized operation scheduling

- 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

- 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
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 CO₂ 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 MWth/d
- High temperature heat storage station: 2MWth; 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

- 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.
• 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!