Tendering scheme for innovative CHP and renewable district heating systems
创新型热电联产与利用可再生能源进行区域集中供热系统的招标方案

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Steinbach 博士，IREES——资源效率和能源战略研究所

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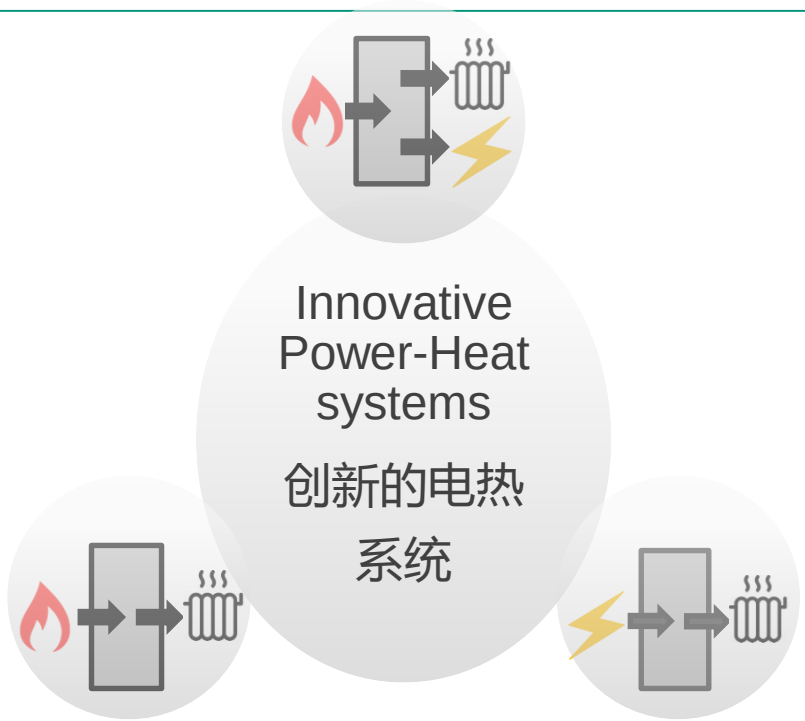

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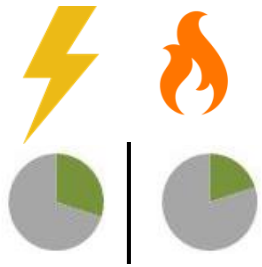
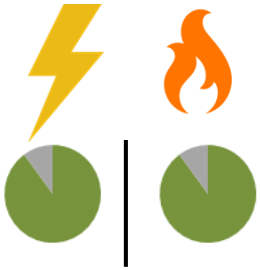
The role of combined heat and power systems today and in the future 热电联产系统在现今和未来的作用

RES-Share
可再生能源的发电供热占比



Today – Transition Phase 当今——转型阶段

- CHP replaces fossil electricity and heat generation
  热电联产代替了利用化石燃料的单一发电和供热
- High demand for CHP capacity which cannot be covered with lower GHG emissions
  对热电联产产能的高需求无法达到较低的温室气体排放标准



Future energy system 未来能源系统

- Rare demand for CHP el. capacity due to high RES feed-in
  由于大量可再生能源的应用，热电联产中发电量的需求降低
- High RES shares in heat and electricity markets, only demand for low GHG emission generation
  可再生能源在供热发电市场占比很高，仅是应对较低温室气体排放的需求。

CHP systems are promising if they represents cost-effective GHG saving solution in both, heat and electricity markets
热电联产系统将会大力推广，如果能够在热电两大市场提供具有成本效益的温室气体减排解决方案

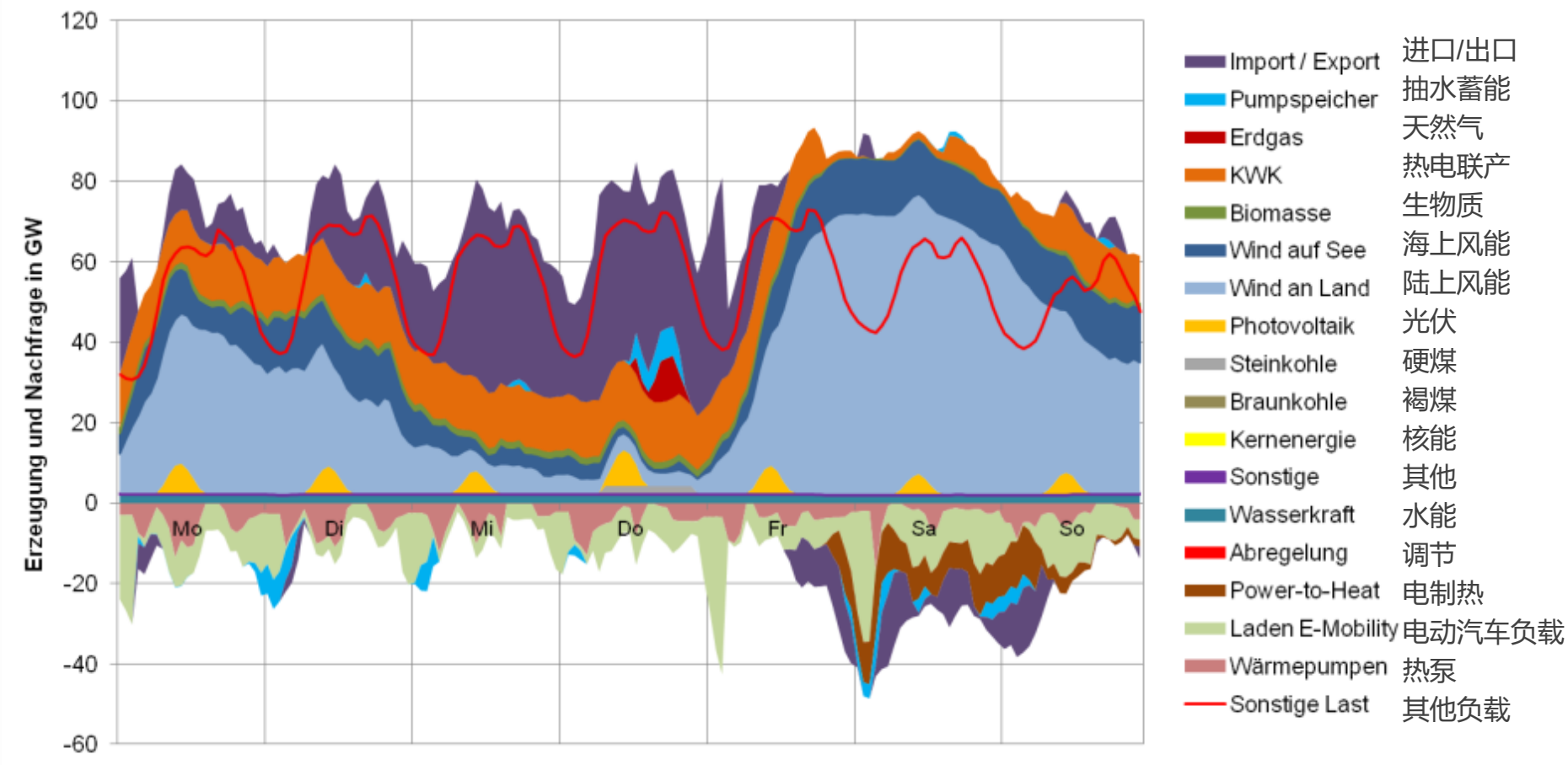
District heating networks are a strategic flexibility for the German Energy transition

区域集中供热网络体现了德国能源转型的战略灵活性

- Adaption and modernisation of supply technologies easier than decentral in millions of buildings
  提升供热技术的适应性以及其现代化将比在数百万建筑中分散供热更简易
  - Integration of RES-H, Power-to-Heat and storages
    结合可再生能源制热，电制热以及蓄热
  - Multivalent/ hybrid system design
    多功能和混合动力系统的设计
  - Flexible control with consideration of heat and electricity generation from RES
    考虑到可再生能源的供热发电的灵活控制
  - Prerequisite sector coupling: efficient and smooth coordination of electricity and heat generation
    必要的耦合：高效且顺畅的协调发电和供热

Example: Flexibility – CHP and power-to-heat
例子：灵活性——热电联产和电制热

Scenario results: hourly electricity generation winter week 2050 方案结果：2050年冬季一周每小时发电量



Source: Fraunhofer ISI, Pfluger, B. et al. 2017. *Langfristszenarien für die Transformation des Energiesystems in Deutschland* (BMWi-Langfristszenarien 2017)

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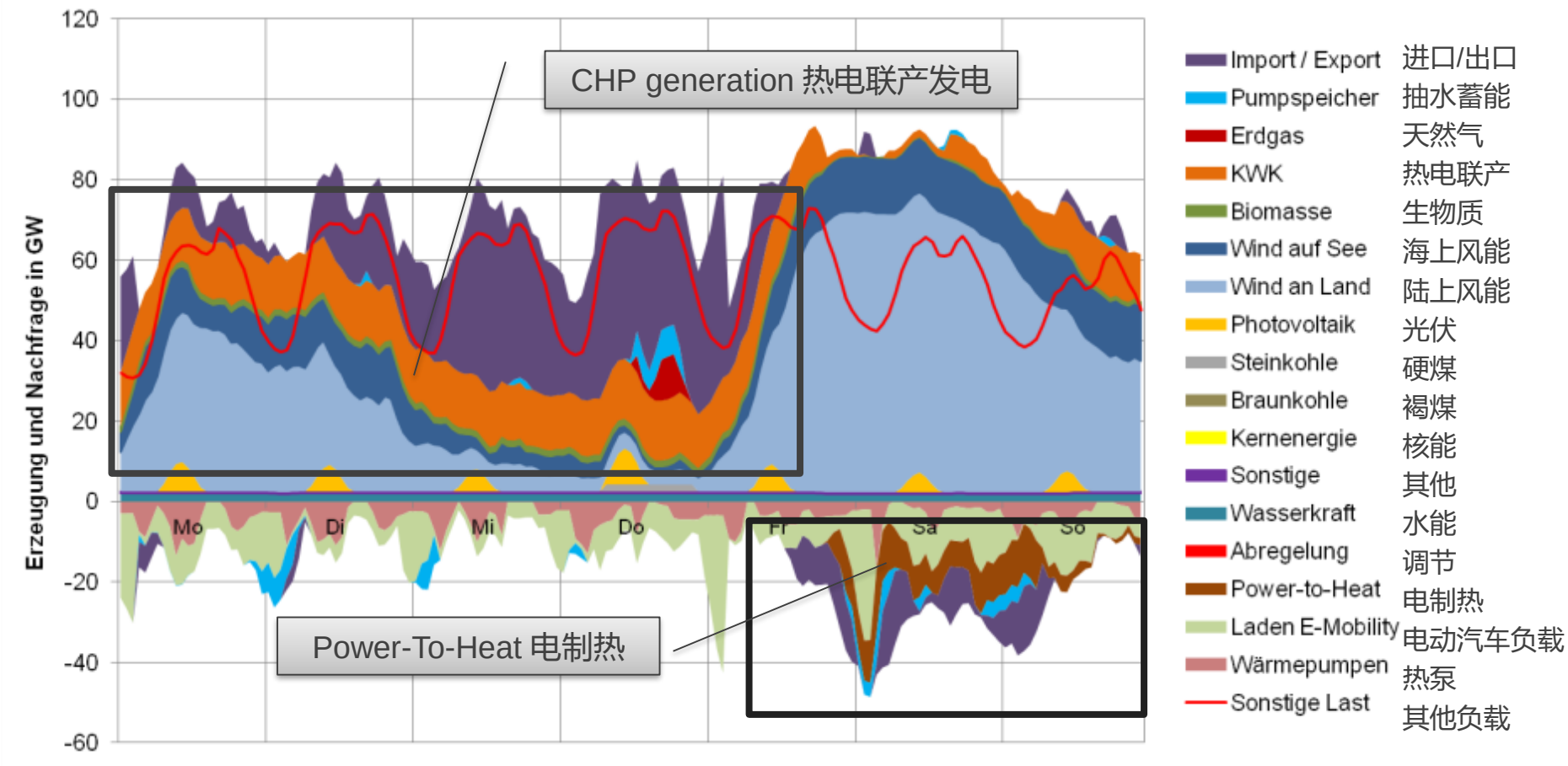
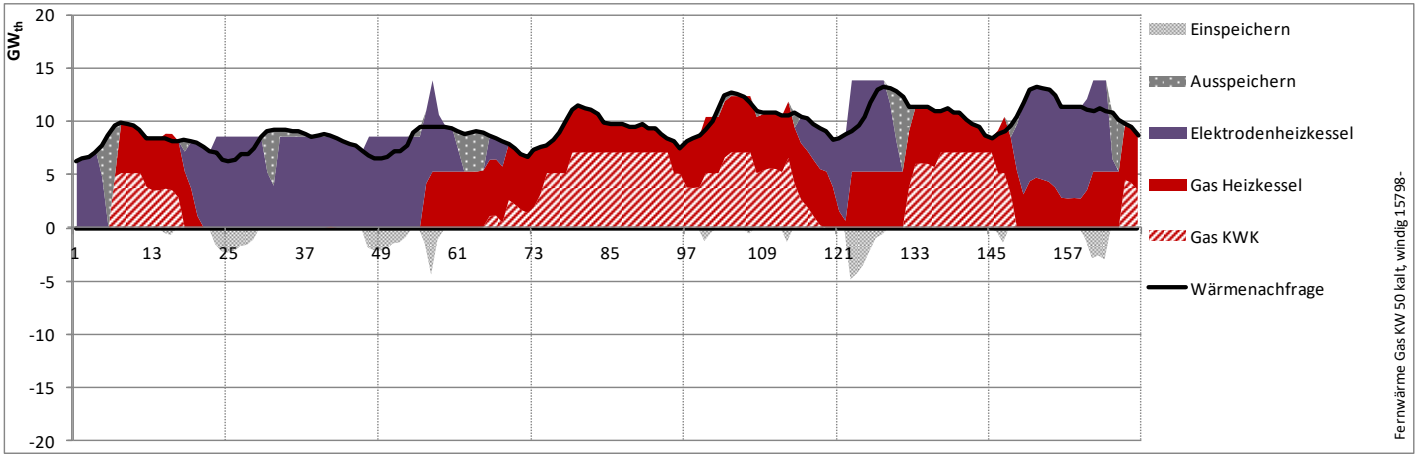


Source: Fraunhofer ISI, Pfluger, B. et al. 2017. *Langfristszenarien für die Transformation des Energiesystems in Deutschland* (BMWi-Langfristszenarien 2017)

Example: Synergies district heating networks and electricity generation 案例：区域供热网络与发电的协同

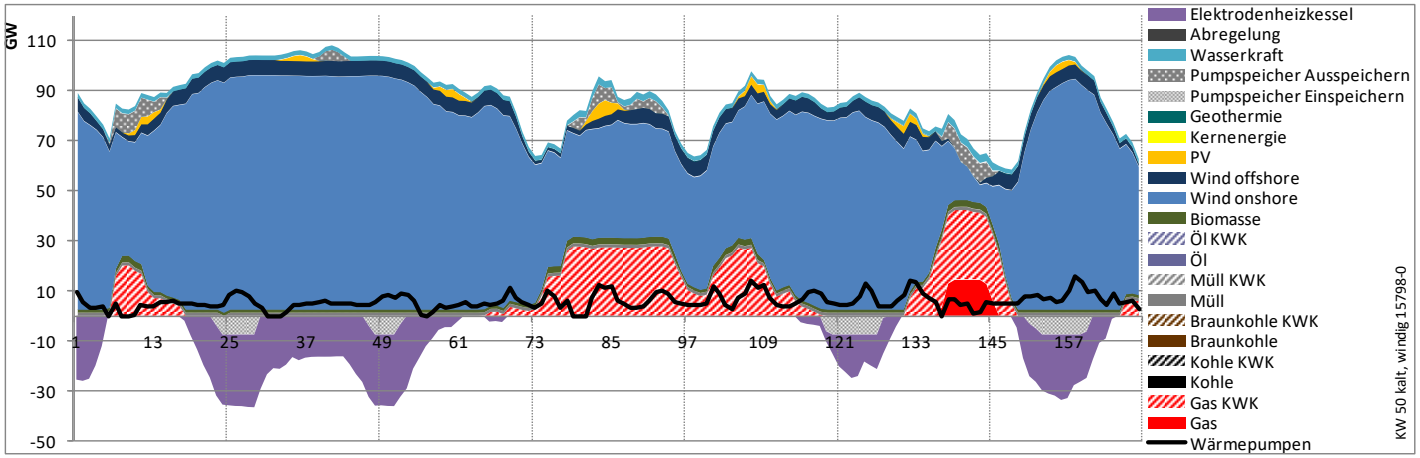
地区供热网

DH network



电网

Electricity grid



Source: Schubert (n.d.). Auswirkungen der Kopplung von Strom- und Wärmemarkt auf die künftige Integration der Erneuerbaren Energien und die CO2-Emissionen in Deutschland. Dissertation in Arbeit. Unveröffentlicht.

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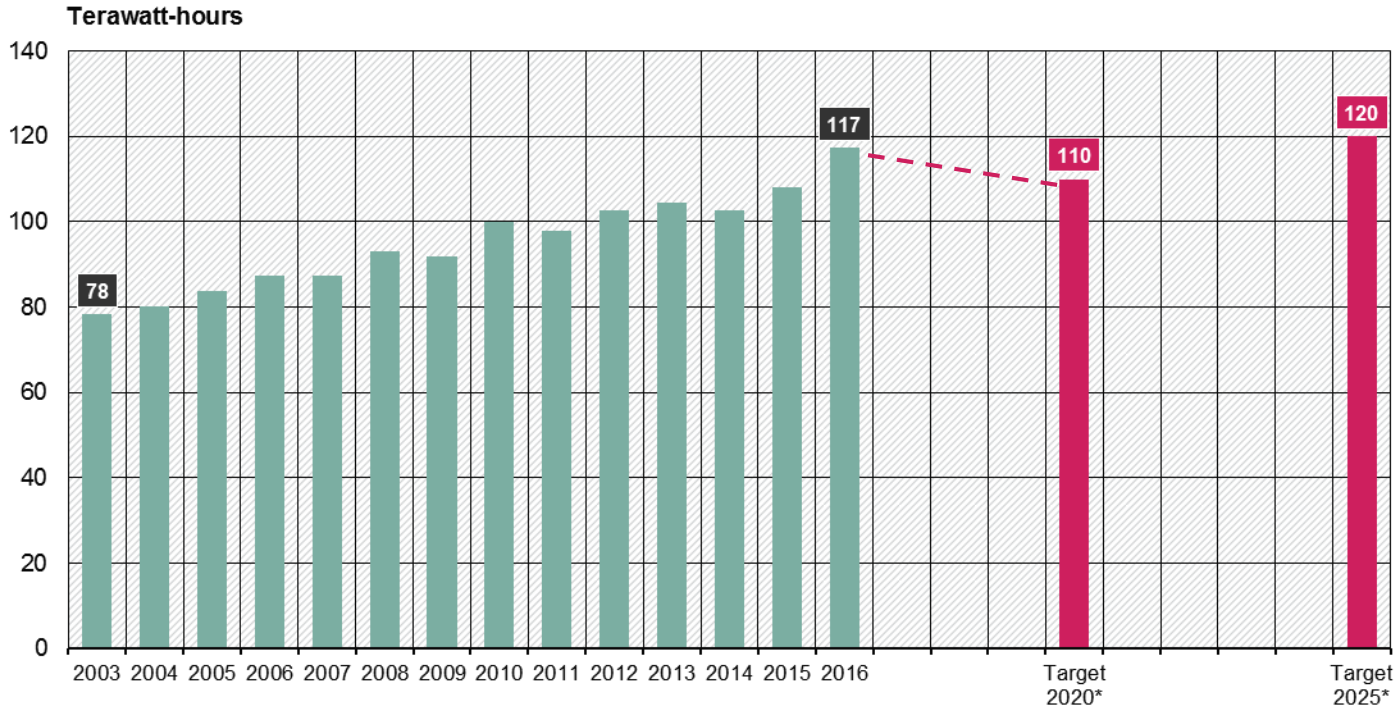
Combined heating and power generation and targets
热电联产及其目标

Net electricity generation using combined heat and power (CHP) and targets according to CHP Act
根据《热电联产法案》利用热电联产发电量的净值和目标



Source: Federal Statistical Office of Germany; Öko-Institut; German Environment Agency / Working Group on Renewable Energy Statistics, as of 11/2017

CHP ACT: From feed-in Tariff to Tendering Scheme
《热电联产法案》： 从固定电价到招标方案

CHP Act 《热电联产法案》

2002 -2015

- Fixed Feed-in tariffs (1.8 - 5.11 EUR-ct/ kWh)
  固定电价（1.8-5.11欧分每千瓦时）
- Supported CHP installation 2004 – 2018
  支持热电联产的安装 2004-2018
- Electricity generation: 271 TWh
  产电量：271太瓦时
- Total Remuneration: 8.2 billion EUR
  总补贴：82亿欧元

New CHP Act/tendering regulation

新《热电联产法案》和招标规定 2016/ 2017

- Introduction of a tendering scheme for medium-sized plants 1- 50 MW
  对中型电厂1-50兆瓦引进招标方案
- Auctions 2018 – 2021 补贴
- "Standard segment": 150 MW/a
  "标准区间"：150兆瓦每年
  - **"Innovative" CHP Systems:** 50 MW/a
    "创新的"热电联产系统：50兆瓦每年
- Bids on surcharge payment per kWh of CHP produced electricity fed into the grid 为热电联产每千瓦时的入网电力附加费用投标
  - Max bid price Standard segment: 7 ct/kWh
    标准区间内的最大投标价格：7欧分每千瓦时
  - Max bid price Innovative CHP: 12 ct/ kWh
    创新热电联产的最大投标价格：12欧分每千瓦时
- Duration of support 享有支持的持续时间
  - Standard segment: 30 000 full load hours 标准区间：3万满载小时
  - Innovative systems: 45 000 full load hours 创新系统：4.5万满载小时

Sources: netztransparenz.de (2013); Kraft-Wärme-Kopplungsgesetz vom 21. Dezember 2015 (BGBl. I S. 2498), zuletzt geändert durch Artikel 3 des Gesetzes vom 17. Juli 2017 (BGBl. I S. 2532); "KWK-Ausschreibungsverordnung vom 10. August 2017 (BGBl. I S. 3167)"

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Definition of innovative CHP systems
定义创新型热电联产系统

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What are “innovative” CHP systems?

什么是“创新型”热电联产系统?

Why are innovative CHP/ DH systems important for the energy transition?

为什么要创新型热电联产/区域集中供热系统对能源转型至关重要?

Definition of innovative CHP systems
定义创新型热电联产系统

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Definition according to German CHP Act
根据德国热电联产法案定义

- energy-efficient and low GHG emission systems
  节能和较低温室气体排放系统
- CHP plants generate electricity and heat in combination **with a high proportion of heat from renewable energies**
  热电联产电厂在热电联产的同时，**较大程度的结合可再生能源产出的热**

Why are innovative CHP/ DH systems important for the energy transition?

为什么创新型热电联产/区域集中供热系统对能源转型至关重要?

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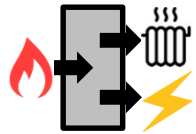
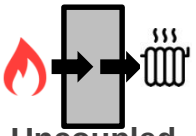
Requirements Innovative CHP systems according to CHP Act/tendering regulation
根据热电联产法案/招标规定对创新型热电联产系统提出的要求

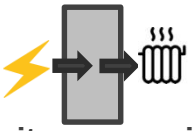
- Flexibility of heat generation with bi-/ multivalent systems and heat
  用双、多元系统来实现供热的灵活性



Cogeneration heat and electricity 热电联产



Uncoupled heat supply 非耦合供热



Electricity consuming heat supply 电能转化为供热

fossil fuels 化石燃料	RES 可再生能源	RES-H 可再生能源制热	Electricity 电能

CHP plant 热电联产厂房 + Innovative RES-H system 创新可再生能源制热系统 + Power-to-heat system 电制热系统

- New/ upgrade 新/升级
- High efficient 高能效

- SPF > 1.25 供暖和制冷的季节性能
- Min 30 % of total heat supply 最少30%的供热总量

- Min 30 % of maximum heat capacity of CHP plant 最少30%来源于热电联产工厂的最大热容量

SPF= Seasonal performance factor

Examples for innovative systems according to CHP act
创新型系统根据《热电联产法案》的应用案例

- Gas CHP plant/ biomass CHP plant +

  燃气热电联产电厂/生物质热 电联产电厂 +
  - Solar thermal collector field + Electric boiler

    太阳能集热站+电锅炉
  - Deep geothermal + Electric boiler

    深层地热+电锅炉
  - Electric heat pump

    电动热泵
  - Gas heat pump with biogas + Electric boiler

    生物气燃气热泵+电锅炉

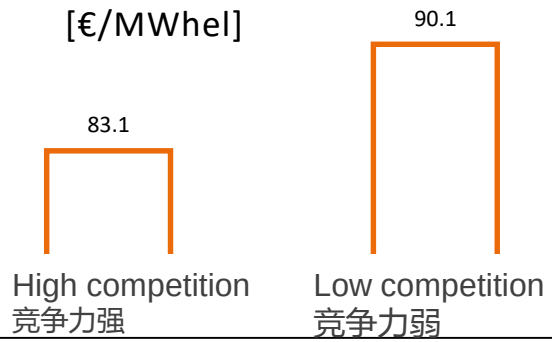
iCHP-Tool
热电联产集成工具

Example举例

CHP Plant热电联产电厂 5 MWth

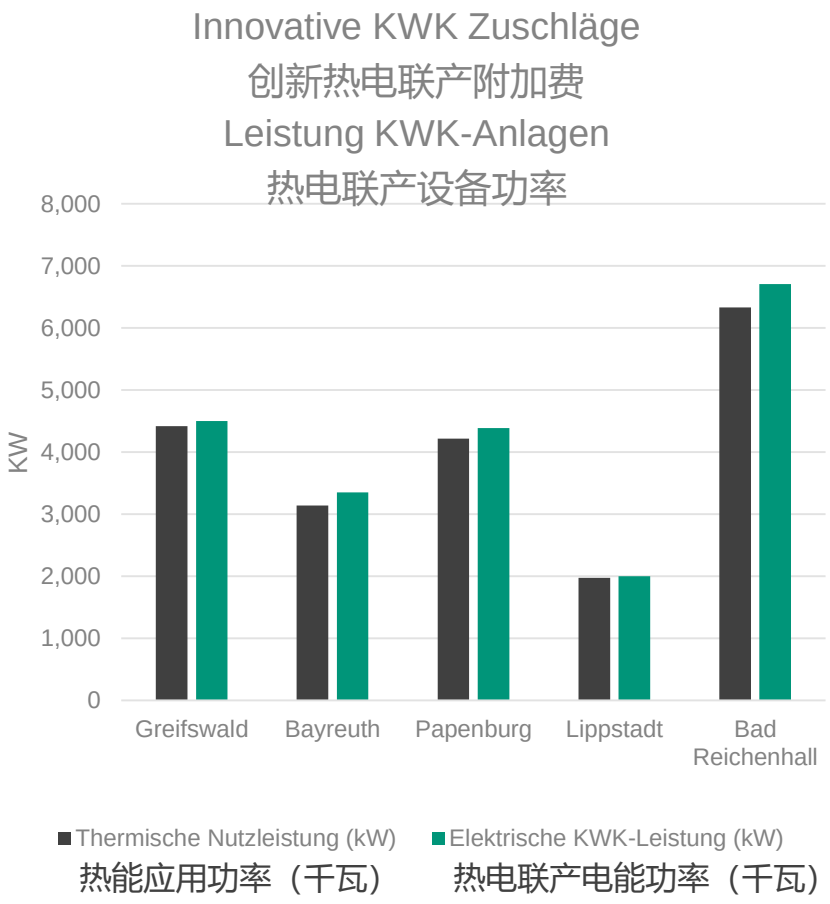
18 300 m²
solar thermal
光热

Calcualted bid price投标价格
[€/MWhel]



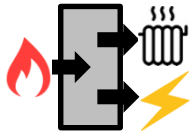
Results of the first auction on innovative CHP systems with renewable heating
利用可再生能源供热的创新型热电联产系统首次竞标结果

- Tendering volume: 25 Mwel
  投标容量： 25 兆瓦电能
- Awarded volume: 23 Mwel
  中标容量： 23兆瓦电能
- 7 bids with 5 awards
  7个投标，5个中标
- Bidding prices
  投标价格
  - Lowest: 89,7 EUR/Mwhel
    最低89.7欧每兆瓦时电能
  - Highest: 109,4 EUR/Mwhel
    最高109.4欧每兆瓦时电能

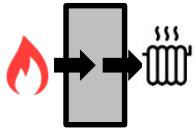


Tendering design leads to smaller applications
招标设计引领更小功率的应用

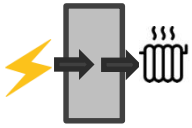
- Utility city of Greifswald
  格赖夫斯瓦尔德的应用



CHP 4,5 Mwel
热电联产发电4.5兆瓦

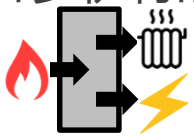


Solar thermal field
太阳能热站
Heat storage 250 MWh
储热 250兆瓦时

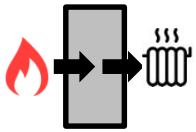


Electric boiler 5 Mwel
电力锅炉发电5兆瓦

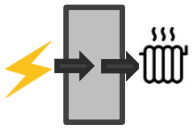
- Utility city of Bayreuth
  拜罗伊特的应用



BHKW 3,5 MWel
热电联产发电 3.5兆瓦



Heat pump 热泵

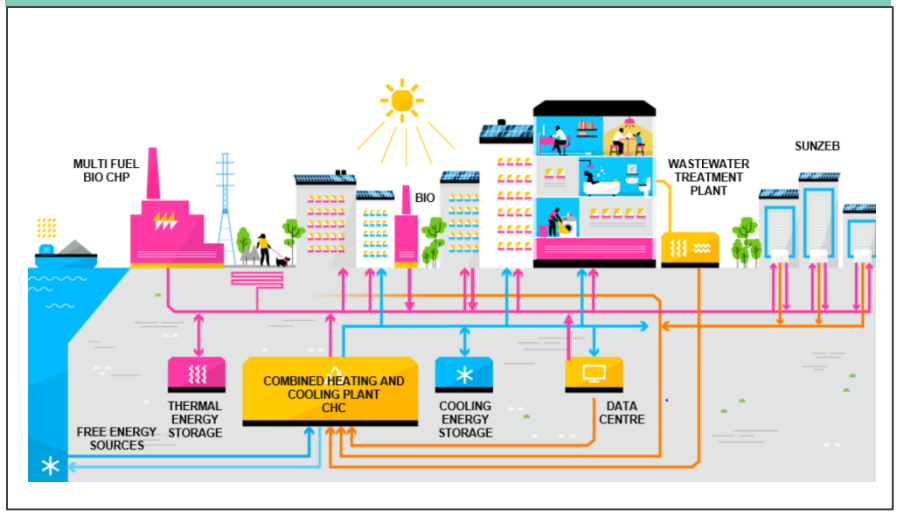


Electric boiler 电力锅炉

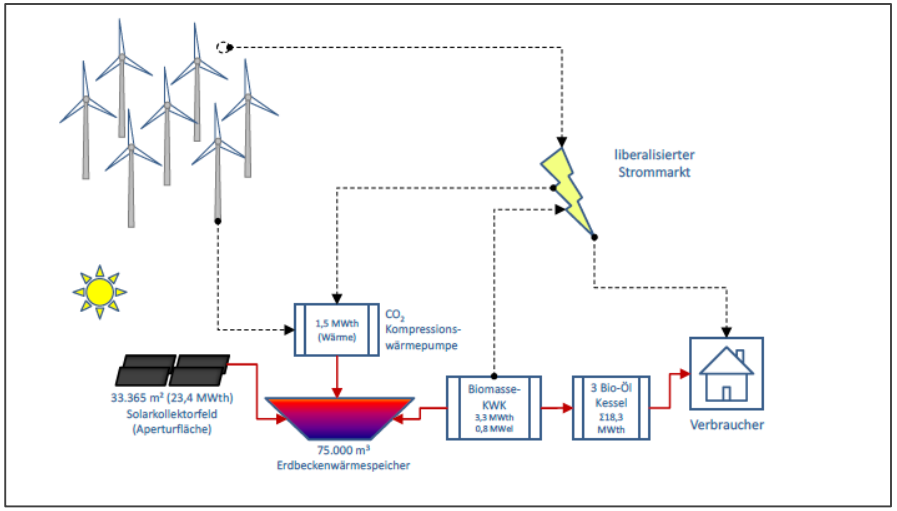
- Heating and cooling network of university 学校的供热制冷管网
- Existing system 现存的系统
- Investment: 5 million EURO
  投资：5百万欧元

Examples for innovative electricity-heat system from other European countries
其它欧洲国家在创新型热电联产系统方面应用的案列

Heating and cooling networks in Finland with large heat pumps
连接大型热泵的芬兰供热制冷管网



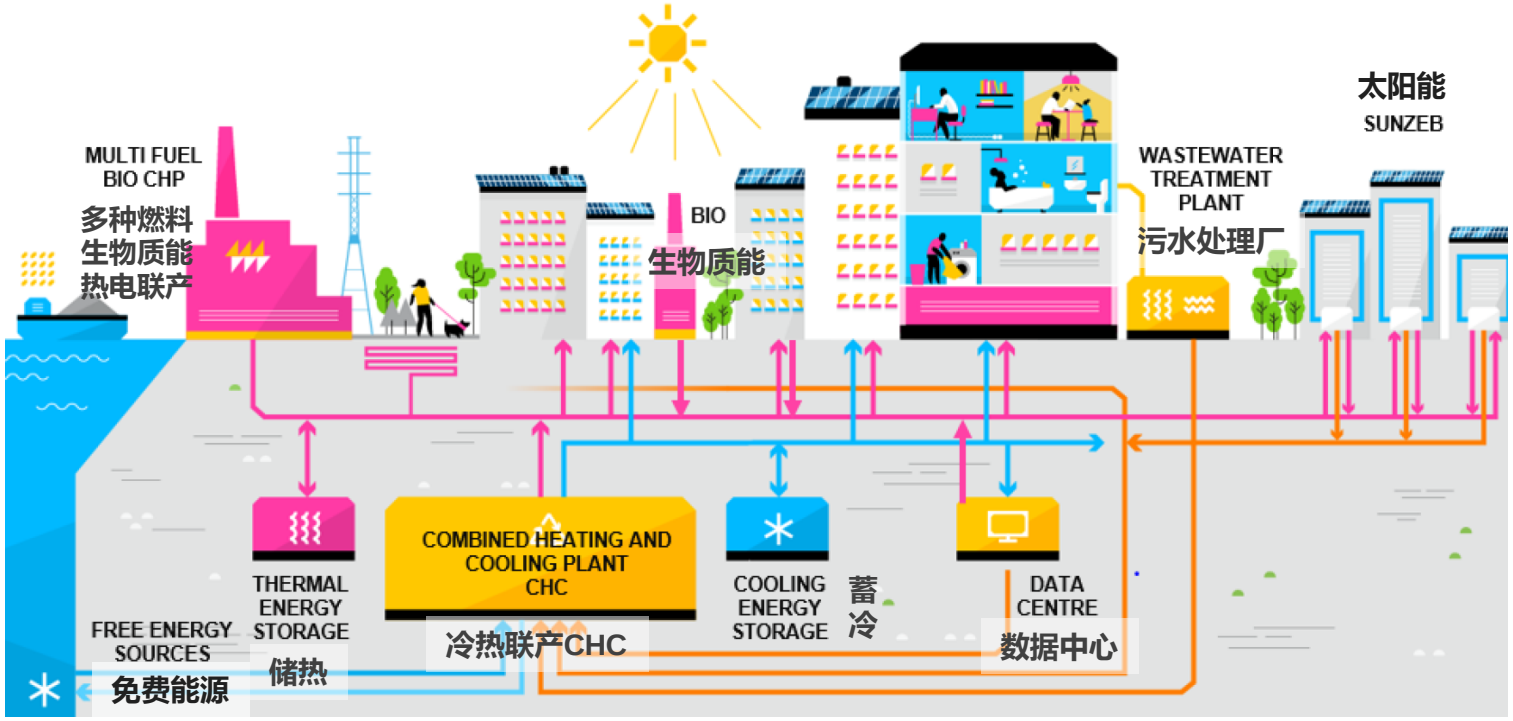
Large solar district heating in Denmark
丹麦的大型太阳能区域集中供热



Helsinki, Finland: Combined heating and cooling plant
芬兰赫尔辛基：冷热联产设备

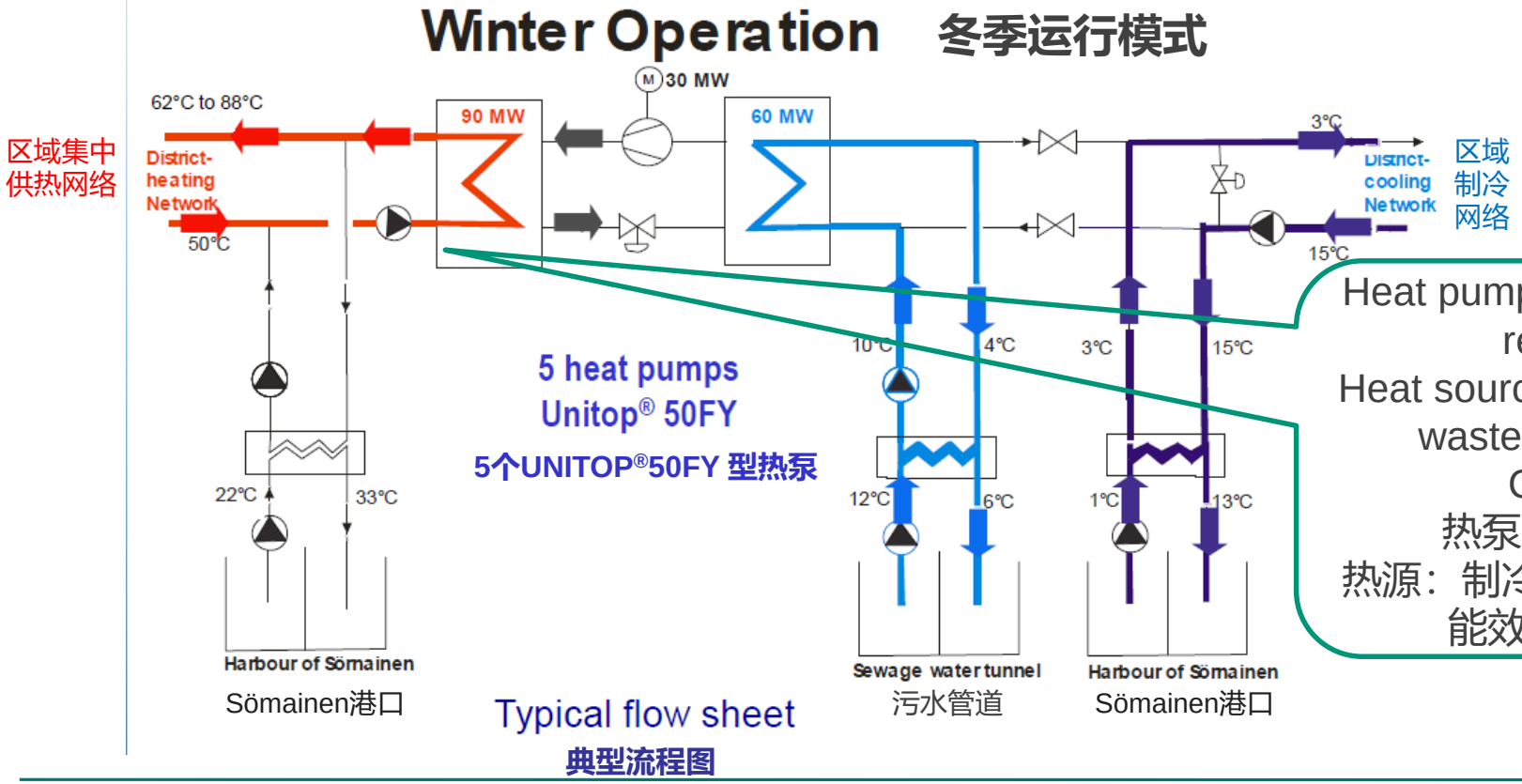
- Largest combined heating and cooling plant
- 90 % connection rate
- Integration of large heat pumps

- 最大的冷热联产设备
- 连接率90 %
- 接入大型热泵



Helsinki, Finnland: Combined heating and cooling plant
芬兰赫尔辛基：冷热联产

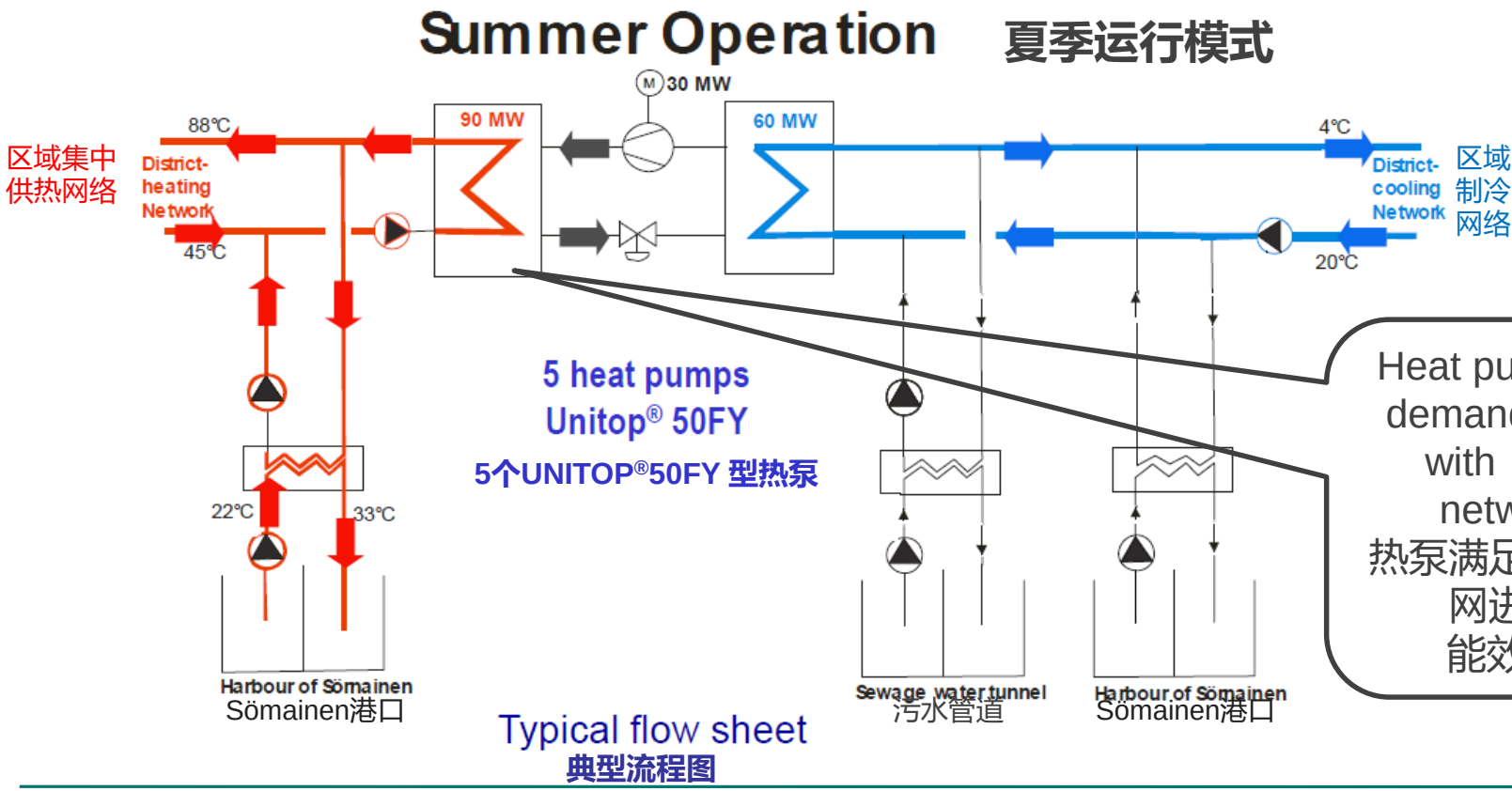
- Integration of 5 x 16,8 MW heat pumps in existing heating and cooling network
- 在现有冷热联产网中接入了5个功率为16.8兆瓦的热泵



Heat pumps for preheating of return flow:
Heat source: cooling network, waste and sea water
COP: 3,51
热泵用于回水余热
热源：制冷系统、废水和海水
能效比COP: 3.51

Helsinki, Finnland: Combined heating and cooling plant
芬兰赫尔辛基：冷热联产

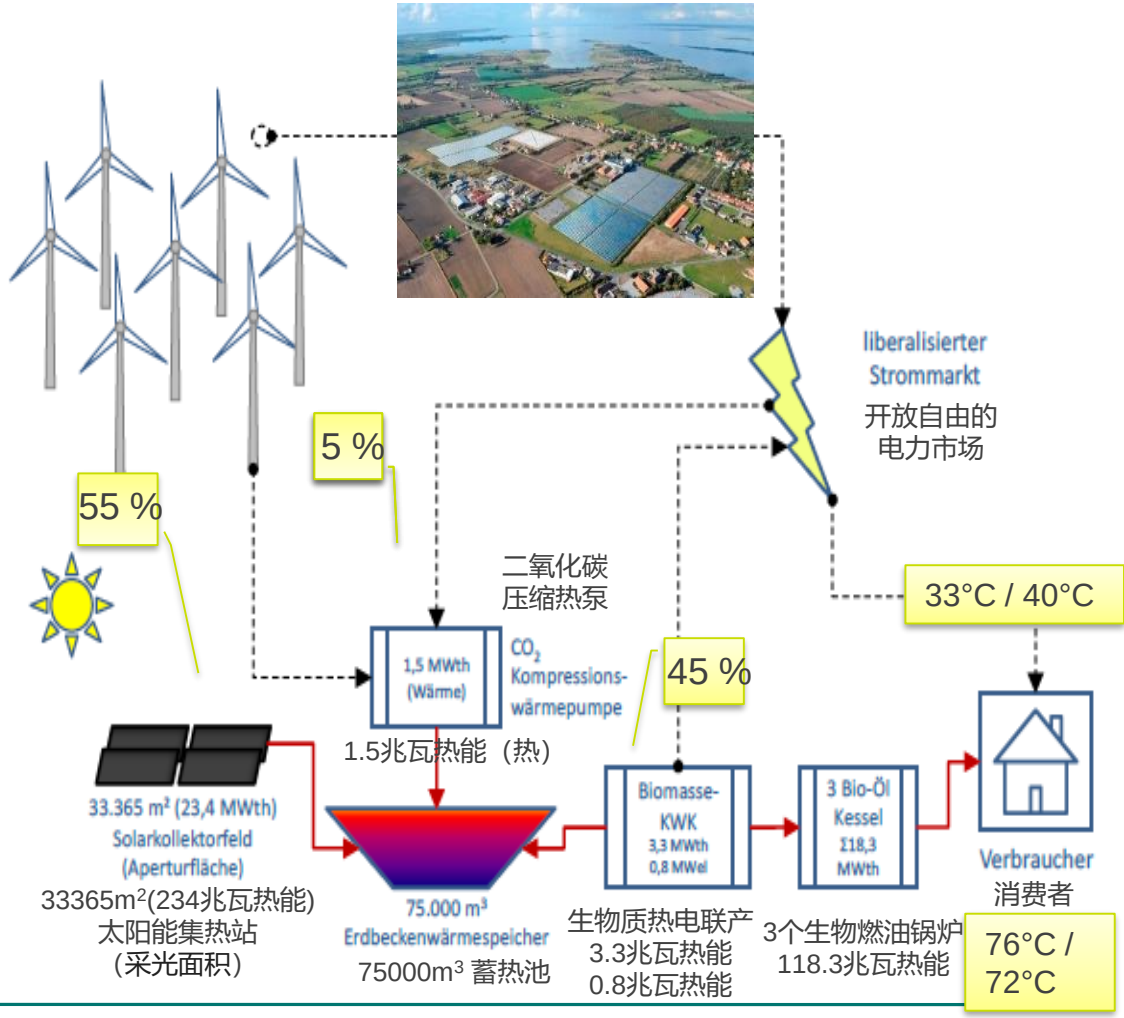
- Integration of 5 x 16,8 MW heat pumps in existing heating and cooling network
- 在现有冷热联产网中集成5个功率为16.8兆瓦的热泵



Heat pumps cover cooling demand and feed-in heat with 88°C in heating network COP: 2,96
热泵满足制冷需求，供热管网进水温度达88℃
能效比COP：2.96

„Smart district heating“ Denmark
丹麦“智能区域供热”

- Optimal integration of different renewable options with district heating and local electricity generation
- Components
  - Solar collector field
  - Biomass ORC plant
  - Bio-oil Heating plant
  - Large heat pump
- Economic feasible 100 % heating supply
  - Heat generation costs 50–60 €/MWh
- 选择不同的可再生能源匹配区域供热和地方发电的特点
- 包括太阳能集热站、生物质有机朗肯循环（ORC）电站、生物燃油供热设备、大型热泵
- 经济可行性：100%满足供热需求
  - 供热成本： 50 – 60欧元/兆瓦时



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Summary 总结

- **Role of „standard“ CHP Systems ”标准“热电联产系统的作用**
  - Bridge technology 桥梁性质的技术
  - Ensuring emission savings and power supply 确保温室气体减排与能源供应
- **Increasing flexibility with innovative CHP/DH systems 创新热电联产区域供热系统使灵活性得以提升**
  - RES will be major supply technology in electricity and heat market in the long terms → substantial demands on flexibility
    可再生能源将成为电热市场的长期主要的方式→ 对灵活性的持续需求
  - Consistent price signals are needed for efficient operations
    有效的运行需要一致的价格信号
  - District heating networks provide strategic flexibility for the energy transition
    区域集中供暖网络为能源转型提供了战略灵活性
- **Innovative CHP tendering schemes 创新型热电联产招标项目**
  - Opportunity for stakeholders/ utilities to make investments which are profitable today and are of strategic importance
    不仅为利益相关方和公共事业公司提供有利可图的投资机会，而且在战略意义上也十分重要

IREES as enabler of energy efficiency and sustainable energy supply
IREES助力节能与可持续的能源供给

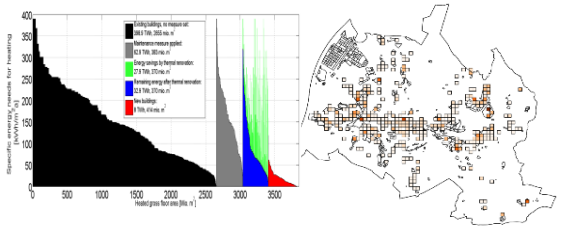
Make it happen / 创造可能

Development of sound policy strategies and framework conditions / 制定健全政策和框架条件

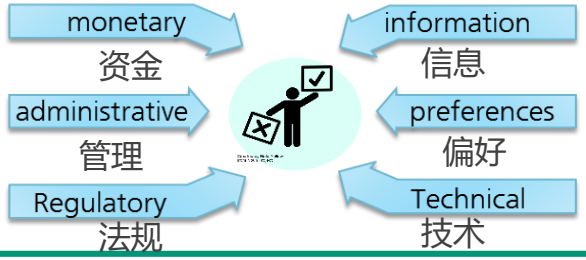
IREES clients: European Commission, Federal Ministries Germany, Europe and South America

IREES客户：欧盟委员会，德国联邦各部委，欧洲和南美

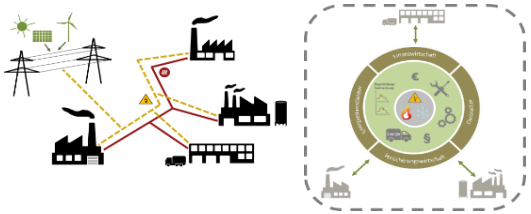
Energy scenarios and smart energy models
能源情景和智慧能源模型



Human-technology interaction
人类技术的交互



Energy management and strategies
能源管理及战略



Make it work / 保证效果

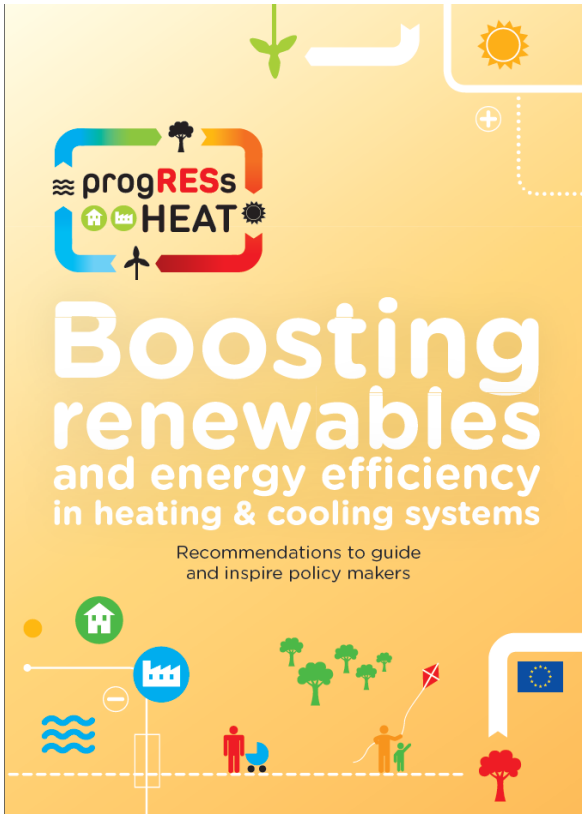
Implementation and accompanying pilot projects – Technology and social acceptance

试点项目实施与跟踪：技术和社会接受度

IREES clients / partners: industrial companies, housing companies, municipalities, associations

IREES客户/合作伙伴：工业企业，建筑企业，市镇政府及协会

Further reading – project progRESsheat
进一步阅读——ProRESsHEAT刊物



http://www.progressheat.eu

战略计划
提升意识，技能与竞争
法律工具
经济援助

Thank you for your attention
感谢您的聆听

Beijing, 11 December 2018,
北京，2018年12月11日

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