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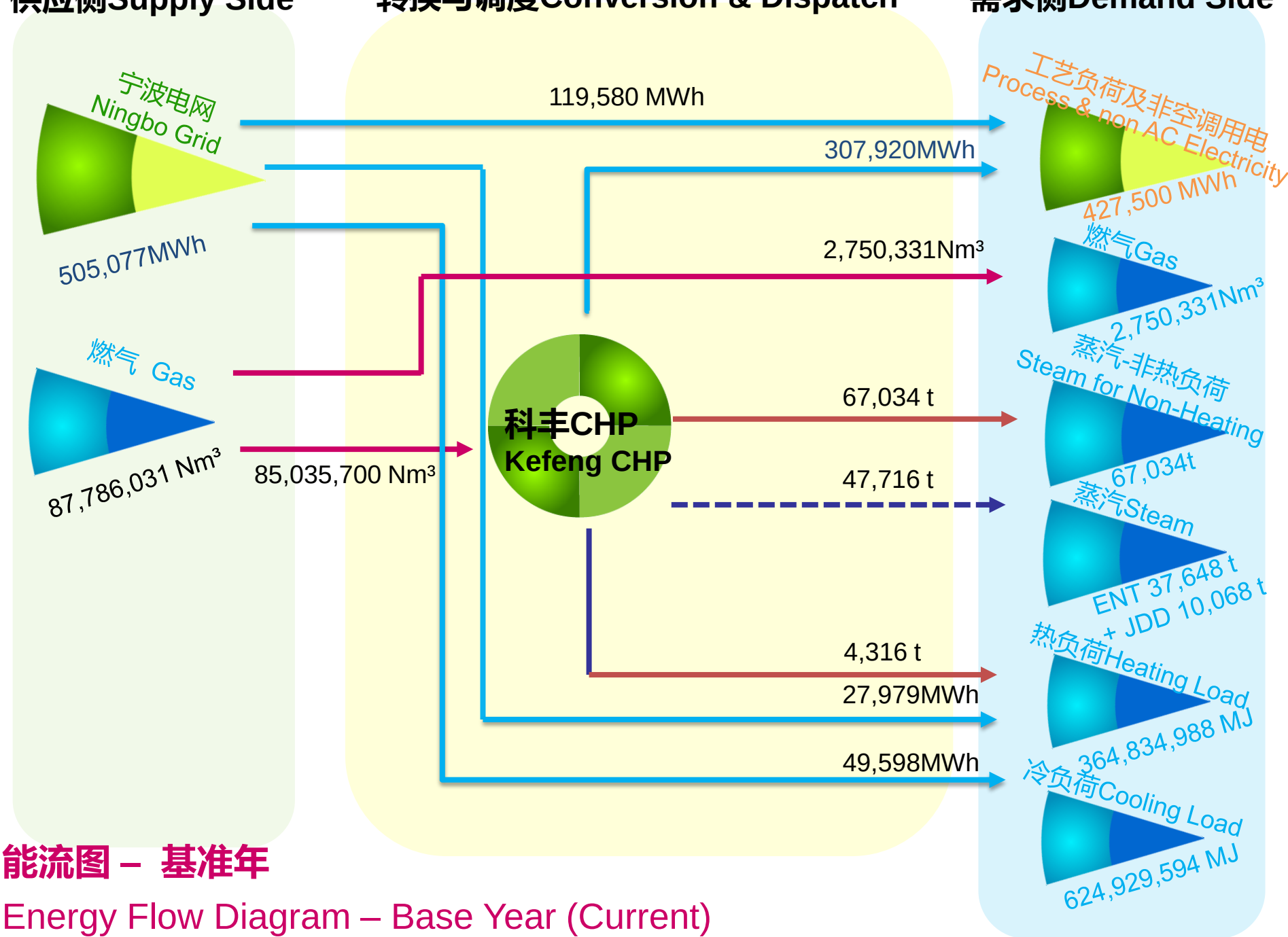
College of Mechanical Engineering

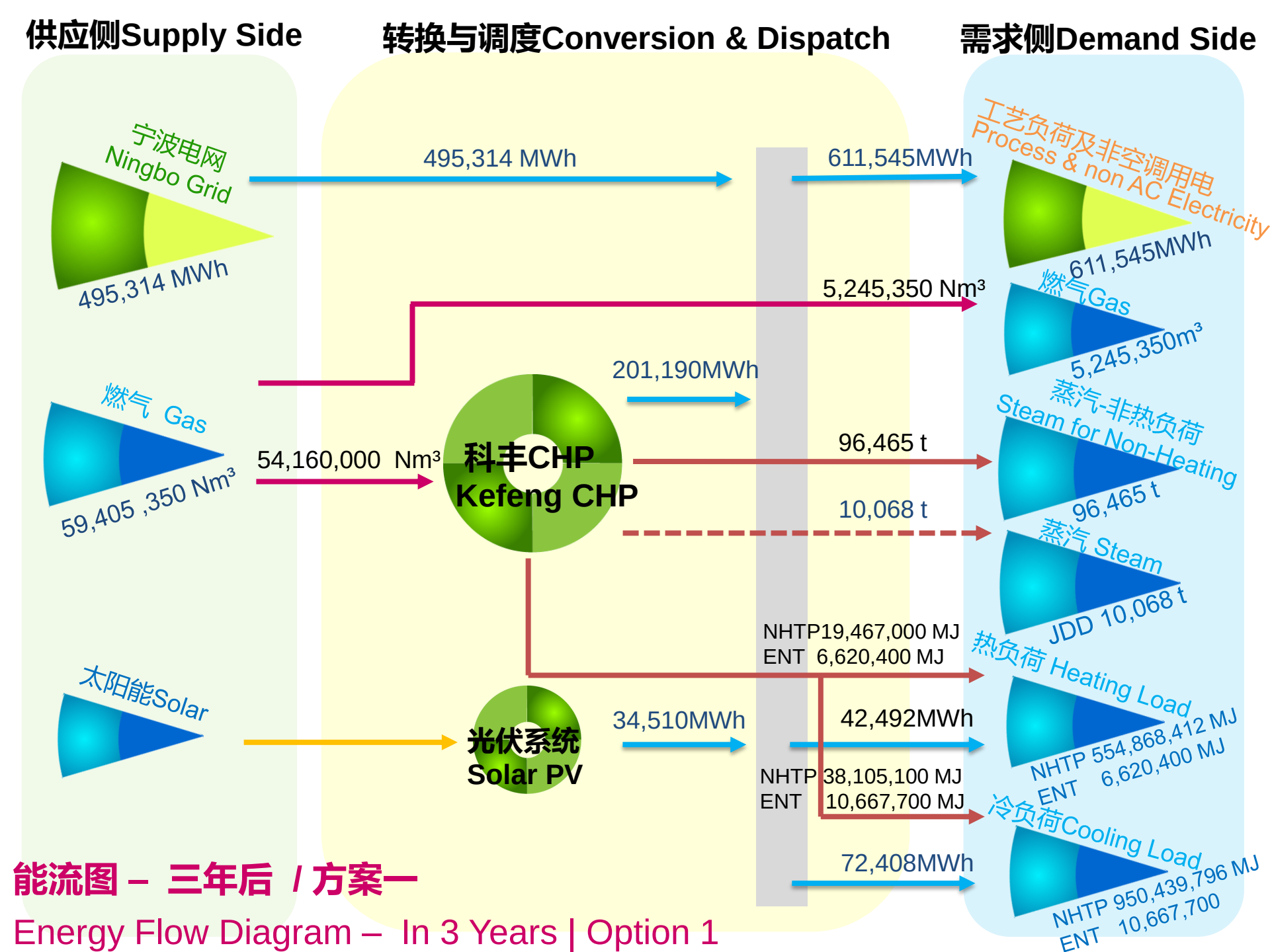
CHP/DCHP区域能源规划案例分析 - 宁波高新区

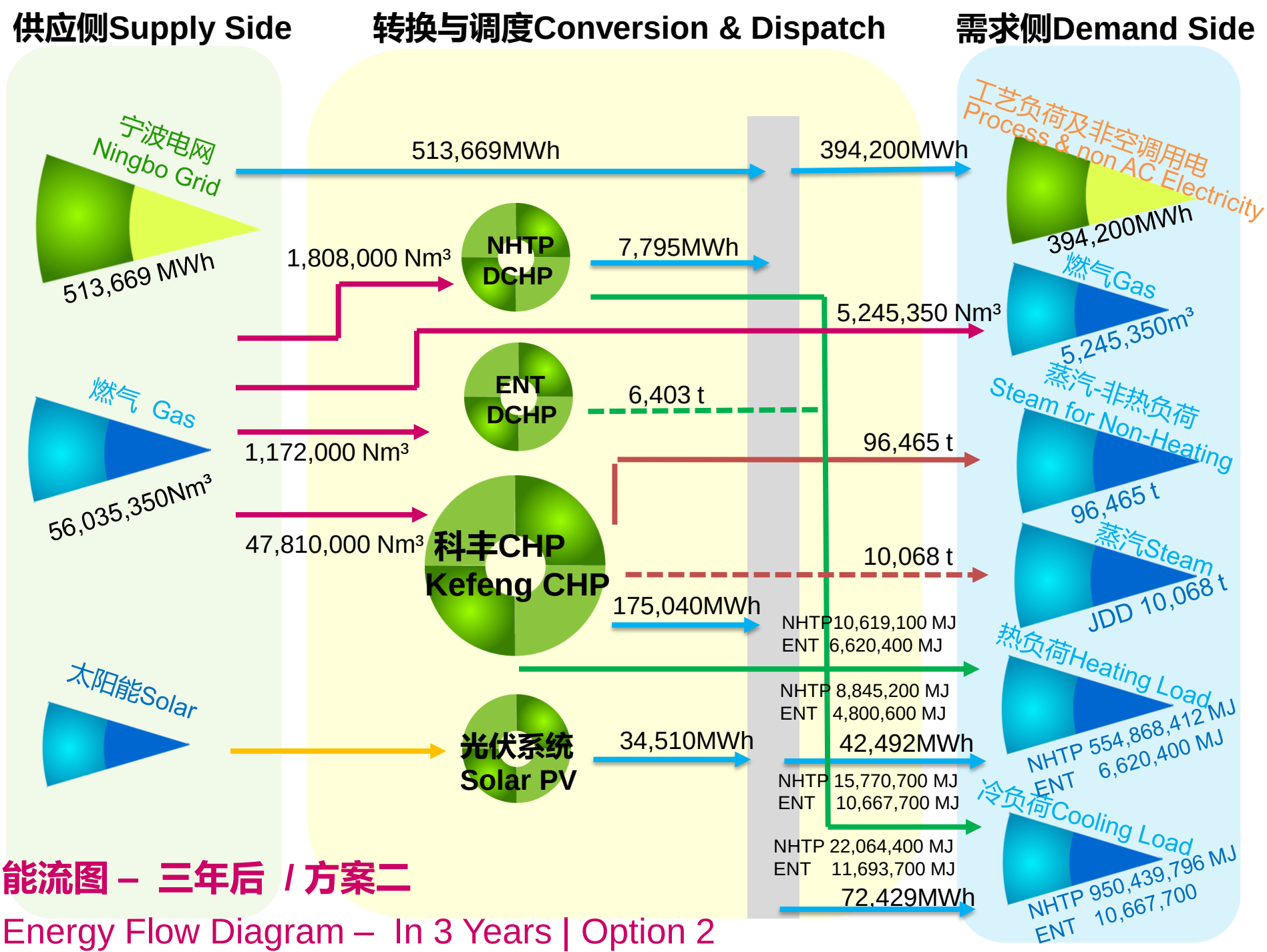
技术方案、经济分析、运营模式



能流图 – 基准年

Energy Flow Diagram – Base Year (Current)


供应侧Supply Side
转换与调度Conversion & Dispatch
需求侧Demand Side
宁波电网
Ningbo Grid
495,314 MWh
495,314 MWh
611,545MWh
工艺负荷及非空调用电
Process & non AC Electricity
611,545MWh
5,245,350 Nm³
燃气Gas
5,245,350m³
燃气 Gas
59,405 ,350 Nm³
54,160,000 Nm³
科丰CHP
Kefeng CHP
201,190MWh
96,465 t
蒸汽-非热负荷
Steam for Non-Heating
96,465 t
10,068 t
蒸汽 Steam
JDD 10,068 t
NHTP19,467,000 MJ
ENT 6,620,400 MJ
太阳能Solar
光伏系统
Solar PV
34,510MWh
42,492MWh
热负荷 Heating Load
NHTP 554,868,412 MJ
ENT 6,620,400 MJ
NHTP 38,105,100 MJ
ENT 10,667,700 MJ
冷负荷Cooling Load
72,408MWh
NHTP 950,439,796 MJ
ENT 10,667,700
能流图 – 三年后 / 方案一
Energy Flow Diagram – In 3 Years | Option 1



能流图 – 三年后 / 方案二

Energy Flow Diagram – In 3 Years | Option 2

项目概述 Project Overview

- **项目背景及目标** Background and Purpose
- **重点概念** Key Concepts

项目背景及目标 Background and Purpose

- **研究范围 Geographic Scope of This Project :**

  - **宁波市国家高新区**，总占地面积18.9万平方公里。包括三类耗能主体：轻工业695.5万平方米，商业办公1125.4万平方米和住宅755.6万平方米。

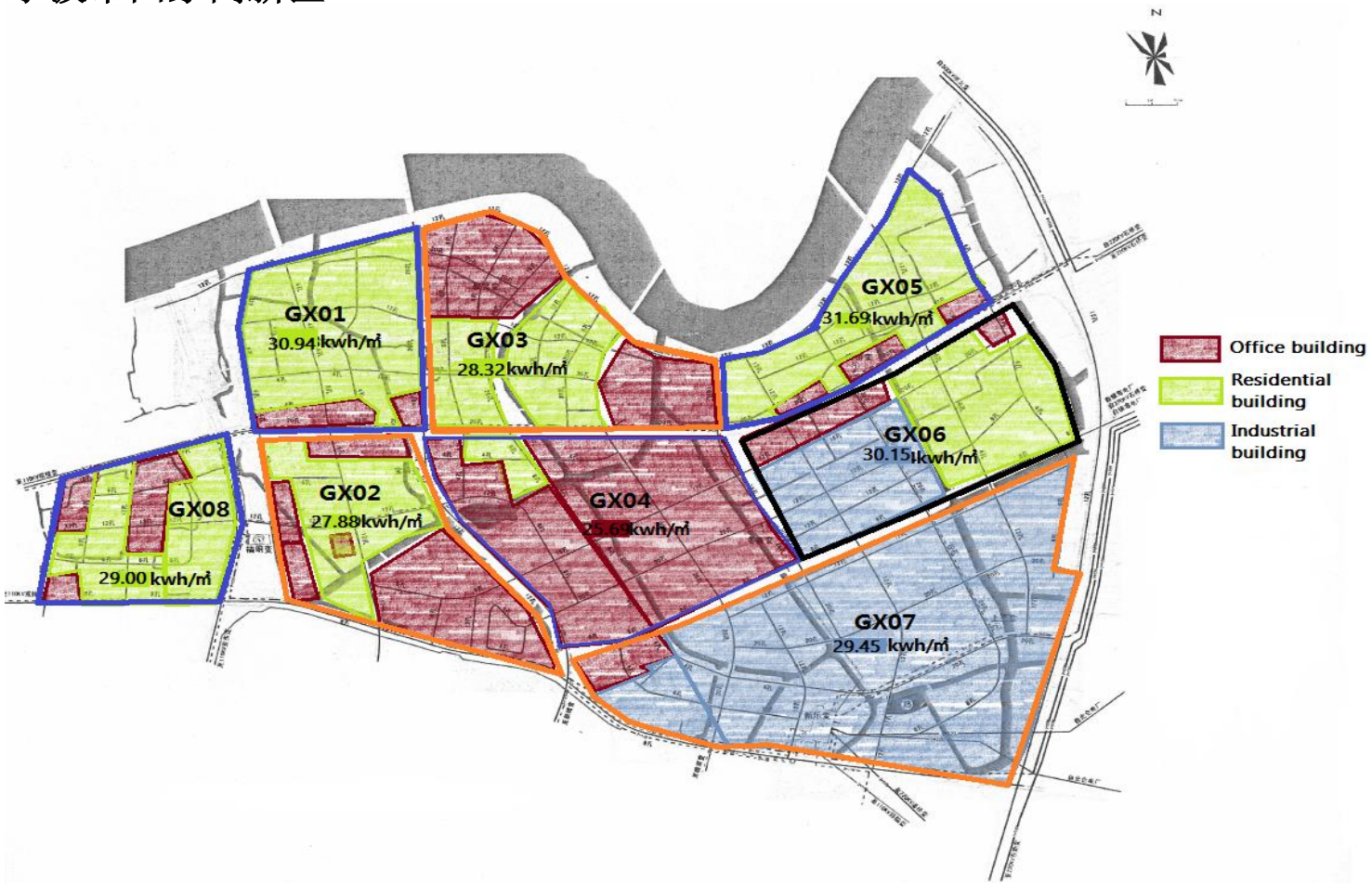
    Ningbo High-Tech Park(NHTP), a mixed community covering a land area of 18.9km^2. Major energy users within the park are light industries with a total area of 6.95 million m^2, commercial buildings with an area of 11.25 million m^2, and residential buildings with an area of 7.55 million m^2.

  - **东部新城**，建筑面积近900万平方米。核心区以办公、商务、会展为主。外围布置混合使用区、住宅、学校、医院等生活设施。

    East New Town (ENT), with a built area of close to 9 million m2, the core area of which has been fully constructed. The core area is designed for residential, schools, hospitals and exhibitions while the peripheral area is designed for residential, schools,hospitals and other facilities.

项目背景及目标 Background and Purpose

- **研究范围 Geographic Scope of This Project :**
  - 宁波市国家高新区



- **能源现状 Current Supply-side:**
  - 高新区：(a)电力方面：科丰热电厂所发的电并入国家电网，高新区再从宁波电网购买电力支持高新区电力需求；(b)燃气方面：高新区内除科丰热电厂的燃气是由浙江省天然气公司提供外，其它所有高新区用户的燃气均是由兴光燃气公司提供；(c)供热方面：高新区的供热管网是由科丰热电厂负责运营和管理。

    As for Ningbo High-Tech Park(NHTP) :

    (a) power supply: power generated from Kefeng CHP Plant is first fed into the State Grid, NHTP then purchases electricity from Ningbo Power Grid to meet its power demands;

    (b) gas supply: with exception of Kefeng CHP, which procures gas from the Zhejiang Natural Gas Company, all users within the park utilizes gas provided by the Xingguang Gas Group;

    (c) heat supply: NHTP's heat supply pipelines are currently under the operation and management of Kefeng CHP Plant.
  - 东部新城区域：仅考虑热需求，区域内无工业区，热需求仅限于生活用水和供冷、供热需求，由科丰提供蒸汽。

    As for East New Town (ENT) : only refers to the heat demand . With no industrial zone located within, heat demand of ENT is generated only through domestic hot water usage, heating, and cooling.

- **项目目标 Project Objectives：**

  - 调查宁波高新技术高新区的能源效率情况

    Survey the energy efficiency performance of NHTP .

  - 确定降低能耗和峰值负荷的节能措施和技术方案

    Identify energy saving opportunities, and technical solutions for minimizing energy consumption and peak loads.

  - 拟定微电网建设管理机制

    Propose a regulatory framework for the establishment of a micro-grid.

  - 拟定能源管理中心融资和实施行动方案

    Propose an action plan to finance the project and to implement the energy.

方法论 General Methodology

政策分析
Policy Analysis

调整工业结构 Adjust Industrial Structure

节能 Saving Energy

优化能源结构（微网）Optimize Energy Structure (micro-grid)

当地减排上的努力Practicing mitigation efforts in localities

生命周期分析
Life-Cycle Assessment

碳减排
Carbon Mitigation

政策Policy

供应侧&需求侧方法:
Supply-side & Demand-side Approaches:
能源效率 Energy Efficiency
微网结构 Micro-grid framework
低碳指标 Low-carbon indicators
系统优化 System Optimization

高级别 KPI High-level KPI
能源优化 Energy Optimization

利用最新创新性低碳技术
Leverage on up-to-date innovative low carbon technologies

融资模型，例如PPP (公共私人合作模式）
Financing Assessment and business model

技术Technology

经济Economics

现状Current State

未来趋势Future State

微网与能源管理中心的建立 Establishment of Micro-grid and EM Center

重点概念 Key Concepts

- **分布式能源 Distributed Energy Sources:**

  是一种分布在用户端的能源综合利用系统。本项目重点考虑了热电联产、分布式热电联产以及分布式光伏发电；其中涉及到本项目的包括大型热电厂和区域性分布式热电厂。

  It refers to an integrated energy utilization system distributed on the user side. The team focuses on the CHP, DCHP and Distributed PV Power Generation of the user-side in accordance with the project's specific conditions. CHP has various types of applications, the ones relevant to this project include large-scale thermal power plant and regional Distributed Combined Heat and Power (DCHP).

- **微电网 Micro-grid：**

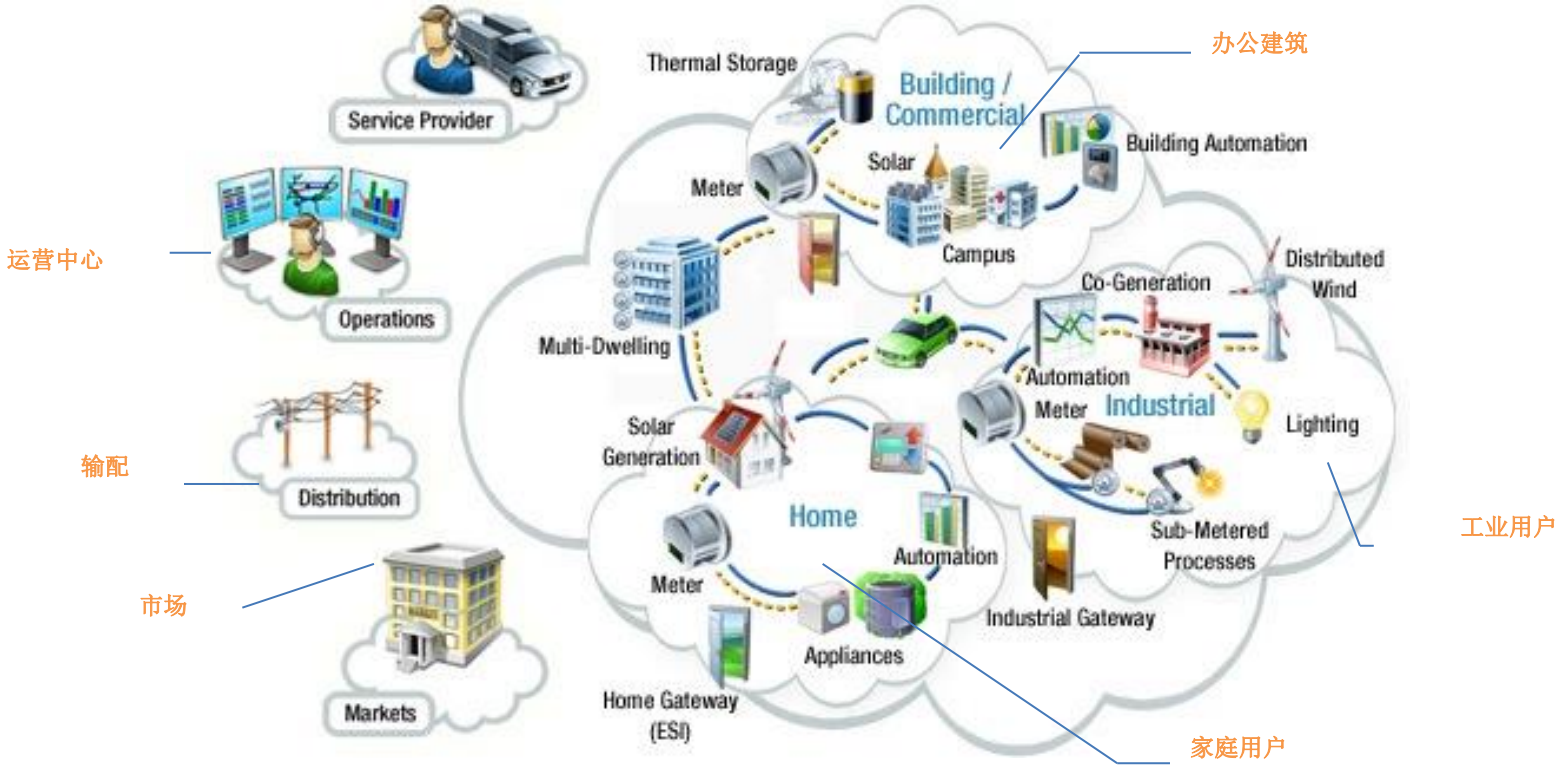
微电网系统可以定义为在一个给定的供电区域内一群互相连接的电力负荷与分布能源资源，功能模块包括：能源供应系统、能源储存能力、需求侧与系统效率度量系统、能源管理、电网并网

A micro-grid system can be defined as a group of interconnected power loads and distributed energy resources located within a fixed energy supply zone. Functional modules include : an energy supply system, energy storage capacity, measurement of the system efficiency, energy management and connection to the power grid.

- **区域能源管理中心 District Energy Management Center:**

区域能源管理中心主要功能包括能源供应侧调度管理、能源需求侧管理与市场交易平台三个方面。区域内的发电与分布发电调度管理用于协调优化供电侧的系统。能源需求侧管理以电力为主，通过能源管理系统（Energy Management System or EMS）监控和管理区域楼宇的电力使用，从而达到节能的目的以及为调峰控制。

The chief functions of a district energy management center include energy supply-side management, energy demand-side management, and the provision of a platform for energy trading. Within the district, electricity generation and management of distributed generation are harnessed to optimize the utilization of energy supply resources. Energy demand-side management focuses on primarily on the monitoring and management of power consumption of buildings in the region through an energy management system (EMS), which facilitates energy conservation and peak regulation.



微电网和能源管理中心

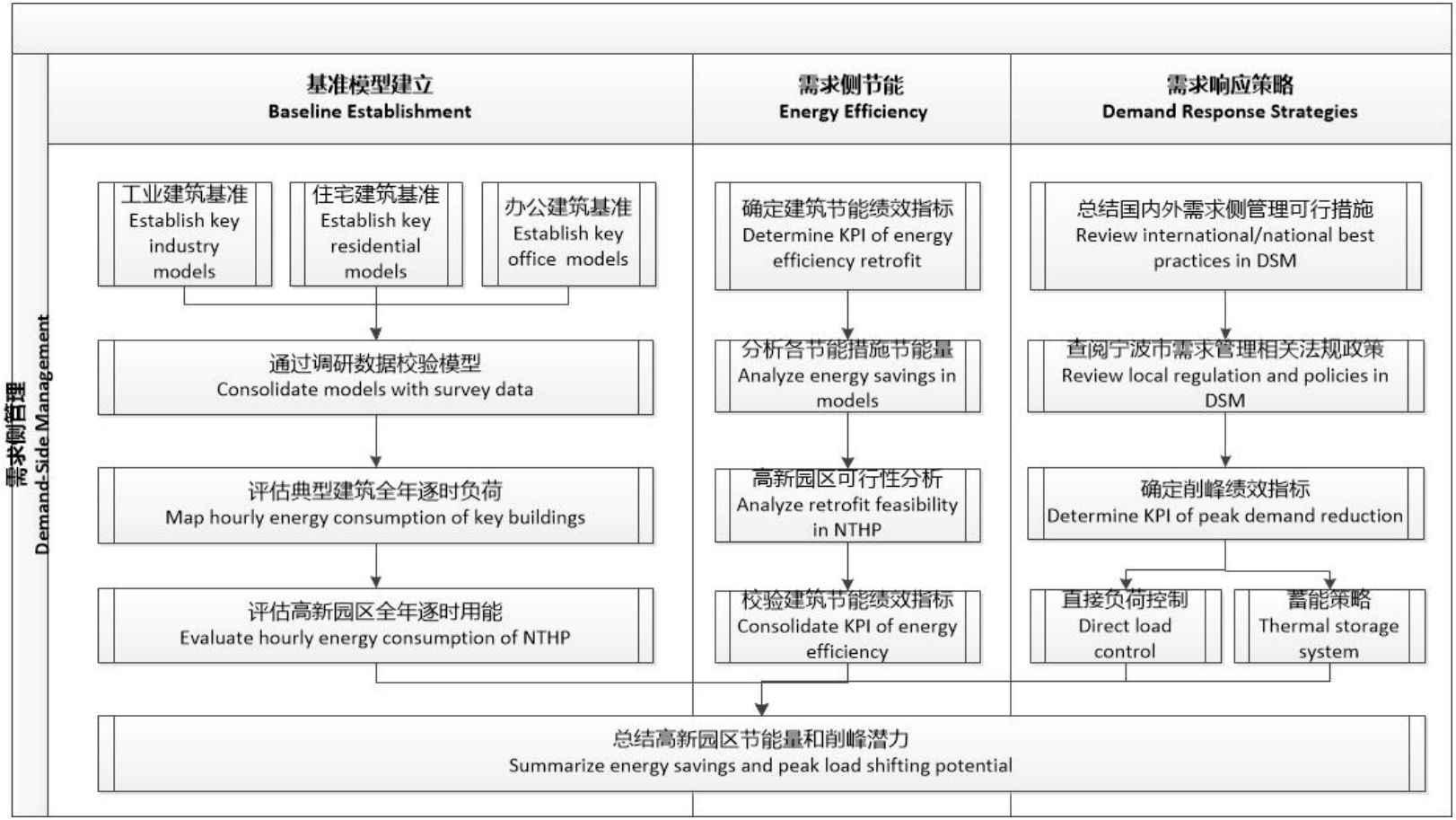
Micro-grid and Energy Management Center

需求侧管理 DSM

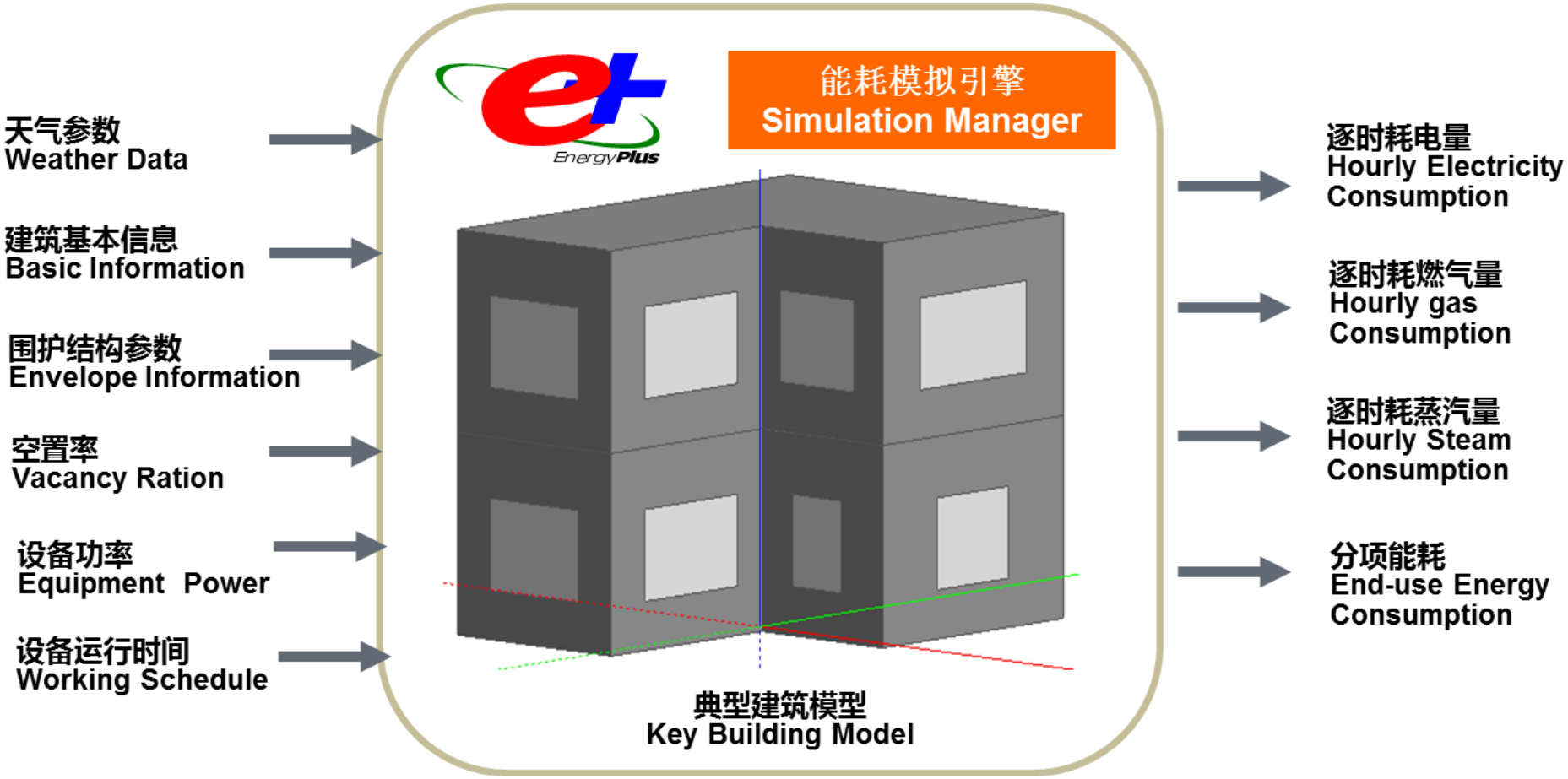
- **需求侧管理方法论** Methodology of Demand Side Management
- **高新区需求侧用能现状及三年后用能预测** Current Situation and 3-Year Projection of Energy Consumption in NHTP
- **东部新城需求侧用能现状及三年后用能预测** Current Situation and 3-Year Projection of Energy Consumption in ENT
- **需求侧节能措施** Demand-side Energy Efficiency Measures

需求侧管理方法论

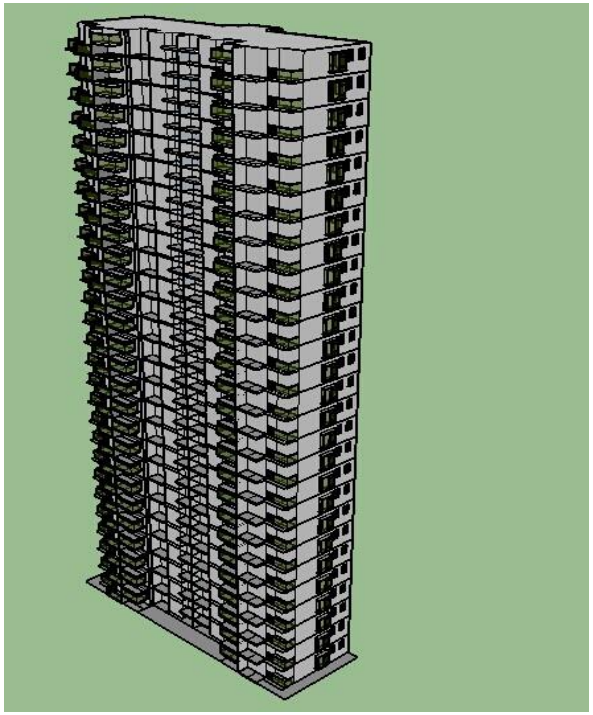
Methodology of Demand-Side Management



基准模型建立
Baseline Establishment



基准模型建立 Baseline Establishment



D:\许门\宁波低碳\DSM建模\guanweihui Load\guanweihui final\guanweihui_final.idf

New Obj | Dup Obj | Del Obj | Copy Obj | Paste Obj

Class List

[0017] DesignSpecification:ZoneAirDistribution
[0001] Sizing:Parameters
[0017] Sizing:Zone
[0003] Sizing:System
[0003] Sizing:Plant
[0017] ZoneControl:Thermostat
[0001] ThermostatSetpoint:DualSetpoint
[0013] ZoneHVAC:FourPipeFanCoil
[0004] ZoneHVAC:TerminalUnit:VariableRefrigerantFlow
[0015] AirTerminal:SingleDuct:VAV:NoReheat
[0015] ZoneHVAC:AirDistributionUnit
[0017] ZoneHVAC:EquipmentList
[0017] ZoneHVAC:EquipmentConnections
[0002] Fan:ConstantVolume
[0003] Fan:VariableVolume

Comments from IDF

Explanation of Object and Current Field

Object Description: Four pipe fan coil system. Forced-convection hydronic heating-cooling unit with
supply fan, hot water heating coil, chilled water cooling coil, and fixed-position

Field	Units	Obj1	Obj2	Obj3
Name		Thermal Zone 1 Far	Thermal Zone 2 Far	The
Availability Schedule Name		FanAvailSch	FanAvailSch	Farv
Capacity Control Method		ConstantFanVariabl	ConstantFanVariabl	Cycl
Maximum Supply Air Flow Rate	m3/s	autosize	autosize	autc
Low Speed Supply Air Flow Ratio		.33	.33	.33
Medium Speed Supply Air Flow Ratio		.66	.66	.66
Maximum Outdoor Air Flow Rate	m3/s	autosize	autosize	0
Outdoor Air Schedule Name				
Air Inlet Node Name		Thermal Zone 1 Far	Thermal Zone 2 Far	The
Air Outlet Node Name		Thermal Zone 1 Sup	Thermal Zone 2 Sup	The
Outdoor Air Mixer Object Type		OutdoorAir:Mixer	OutdoorAir:Mixer	Outc
Outdoor Air Mixer Name		Thermal Zone 1 OA	Thermal Zone 2 OA	The
Supply Air Fan Object Type		Fan:ConstantVolum	Fan:ConstantVolum	Fan:
Supply Air Fan Name		Thermal Zone 1 Sup	Thermal Zone 2 Sup	The
Cooling Coil Object Type		Coil:Cooling:Water	Coil:Cooling:Water	Coil:
Cooling Coil Name		Thermal Zone 1 Coo	Thermal Zone 2 Coo	The
Maximum Cold Water Flow Rate	m3/s	autosize	autosize	autc
Minimum Cold Water Flow Rate	m3/s	0	0	0
Cooling Convergence Tolerance		.001	.001	.001
Heating Coil Object Type		Coil:Heating:Water	Coil:Heating:Wa	Coil:

高新园区对各类能源的年需求量模拟值和真实值对比
Comparison between Demand Simulation and Actual Demand of Energy within NHTP

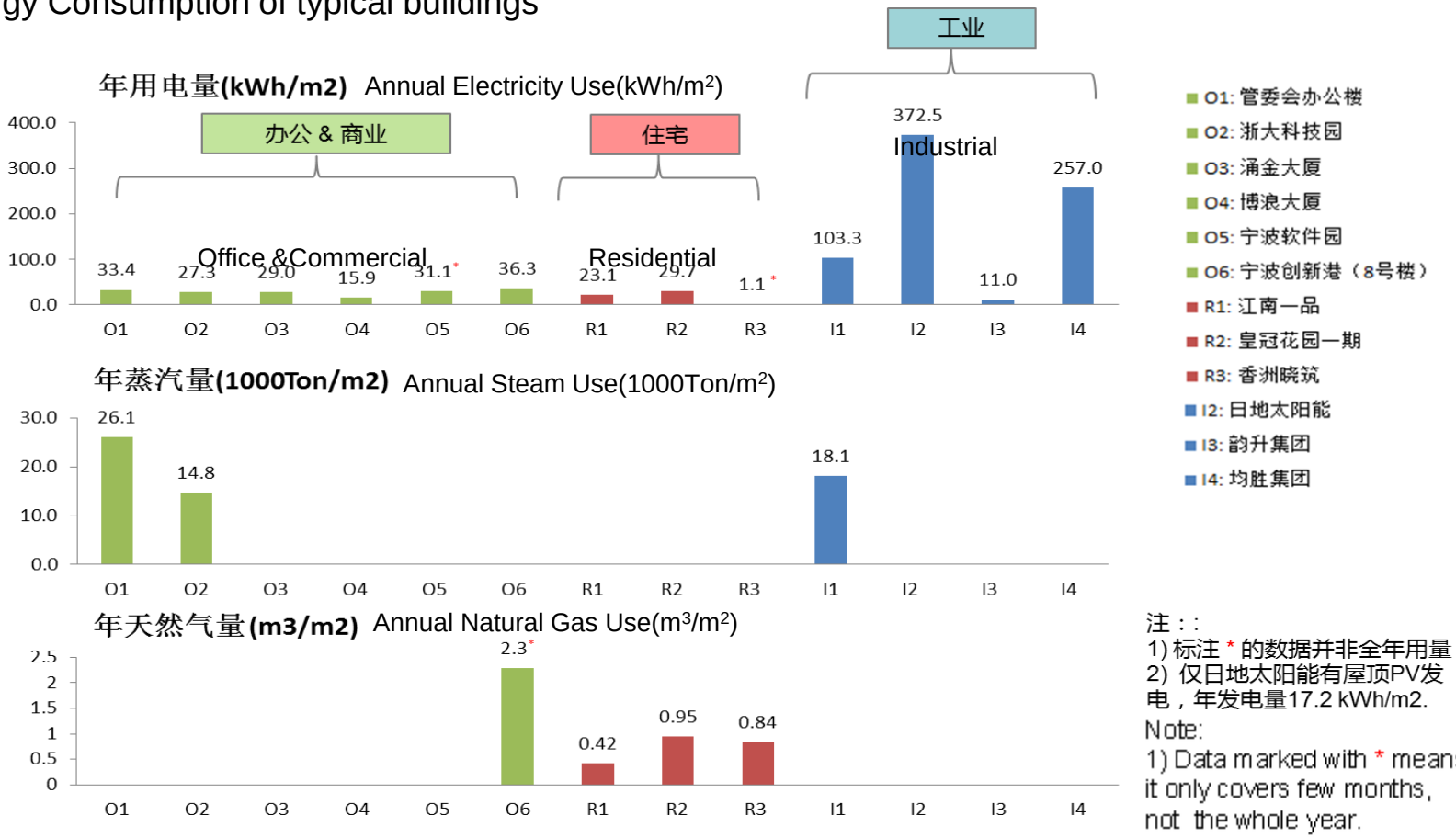
	商业建筑 Commercial building	工业建筑 Industrial building	住宅建筑 Residential building	园区总量 NHTP total
模拟电耗 mwh Simulated power consumption	164,326	247,534	93,389	505,250
调研电耗 mwh Actual power consumption	160,094	247,535	96,728	504,356
相对误差 Relative error	2.64%	0.00%	-3.45%	0.18%
模拟耗燃气量 m^3 Simulated gas consumption	N/A	N/A	2,519,999	N/A
调研耗燃气量 m^3 Actual gas consumption	211,293	56,354	2,482,684	2,750,331
相对误差 Relative error	N/A	N/A	1.5%	N/A
调研耗蒸汽量 t Actual steam consumption	8,406	59,448	5	67,859

高新区需求侧用能现状及三年后用能预测

Current Situation and 3-Year Projection of Energy Consumption in NHTP

典型建筑能耗

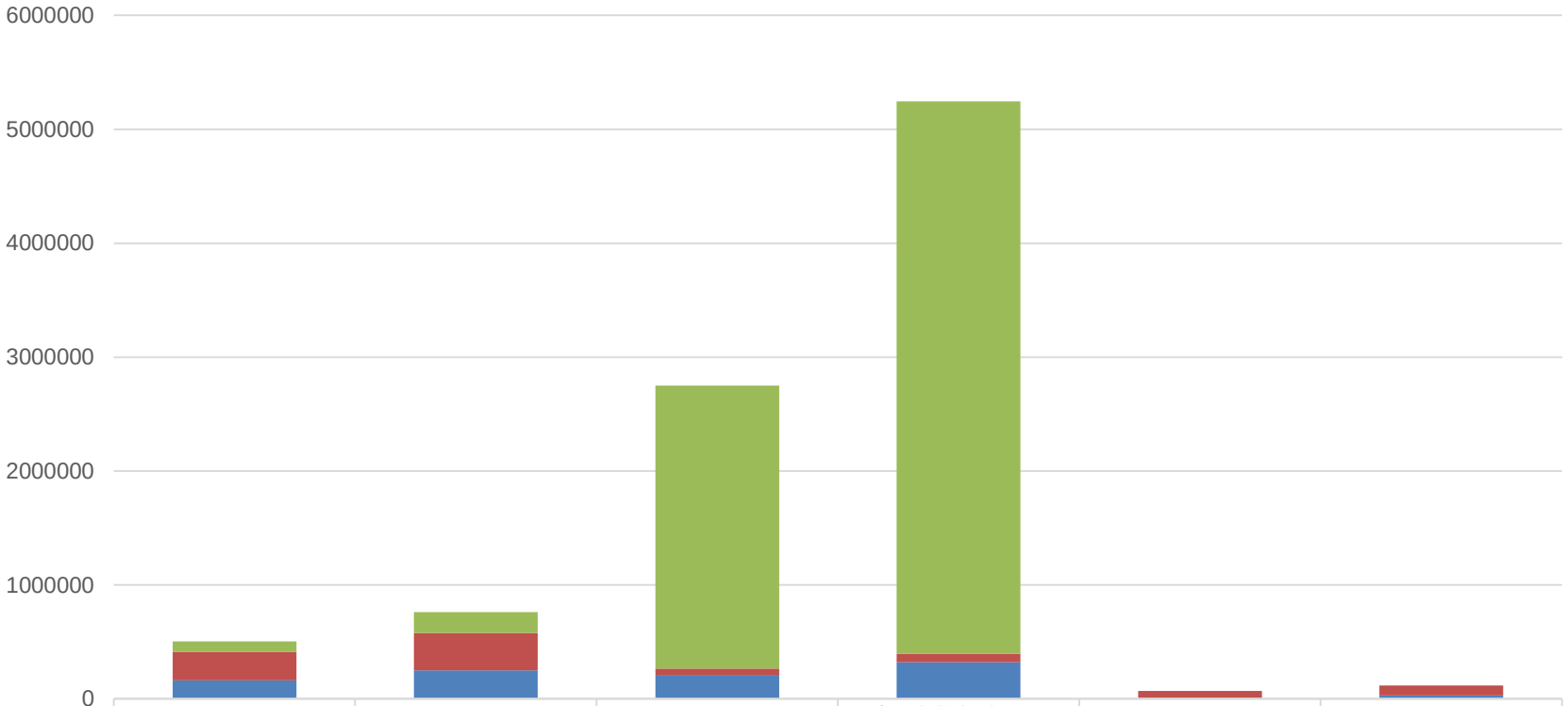
Energy Consumption of typical buildings



注：:
1) 标注 * 的数据并非全年用量
2) 仅日地太阳能有屋顶PV发电，年发电量17.2 kWh/m2.

Note:
1) Data marked with * means it only covers few months, not the whole year.
2) Only Sun-Earth Power has roof PV panels, annual power production is 17.2 kWh/m2.

高新园区三年后总能耗预测
Three-Year Prediction of Demand-Side Energy Consumption of NHTP

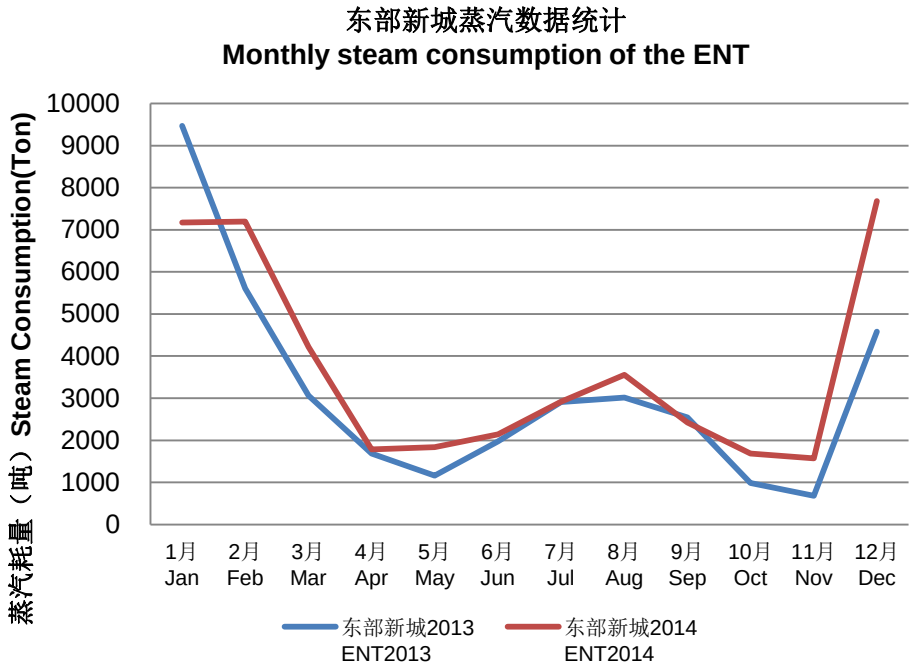


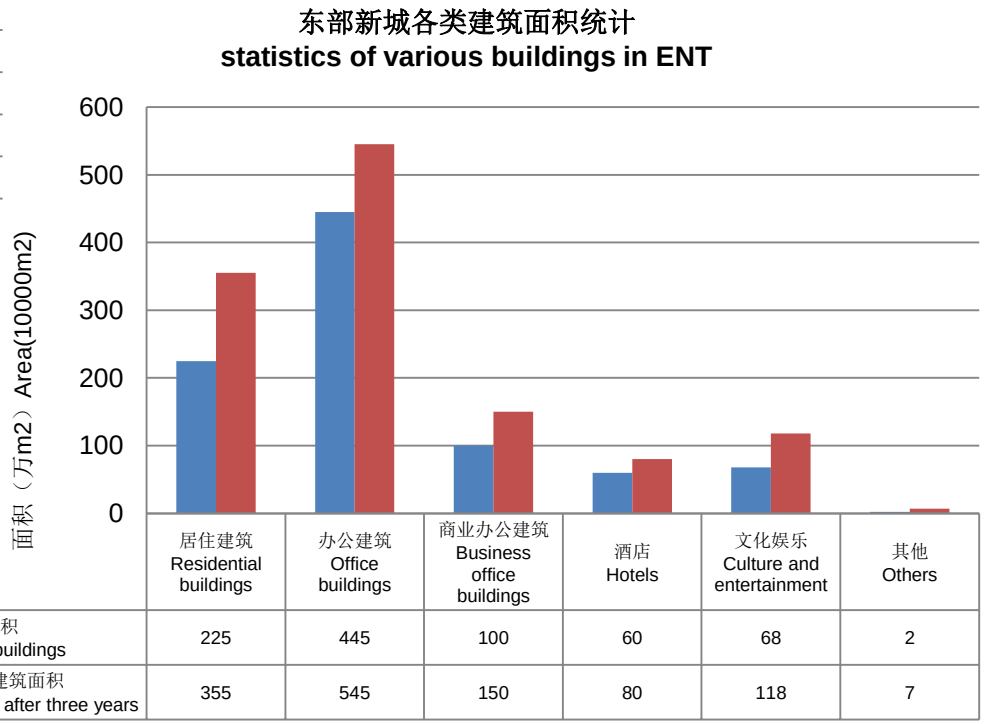
	目前电耗 Current Power Consumption（MWh）	三年后电耗 Three-year Later Power Consumption（MWh）	目前耗燃气量 Current Gas Consumption（m3）	三年后耗燃气量 Three-year Later Gas Consumption（m3）	目前耗蒸汽量 Current Steam Consumption（吨）	三年后耗蒸汽量Three-year later steam consumption（吨）
居住建筑 Residential Buildings	93389	182402	2482684	4848992	0	0
工业建筑 Industrial Buildings	247534	329469	56354	75007	62788	87903
办公建筑 Office Buildings	164326	249919	211293	321350	8562	29885

东部新城需求侧用能现状及三年后用能预测

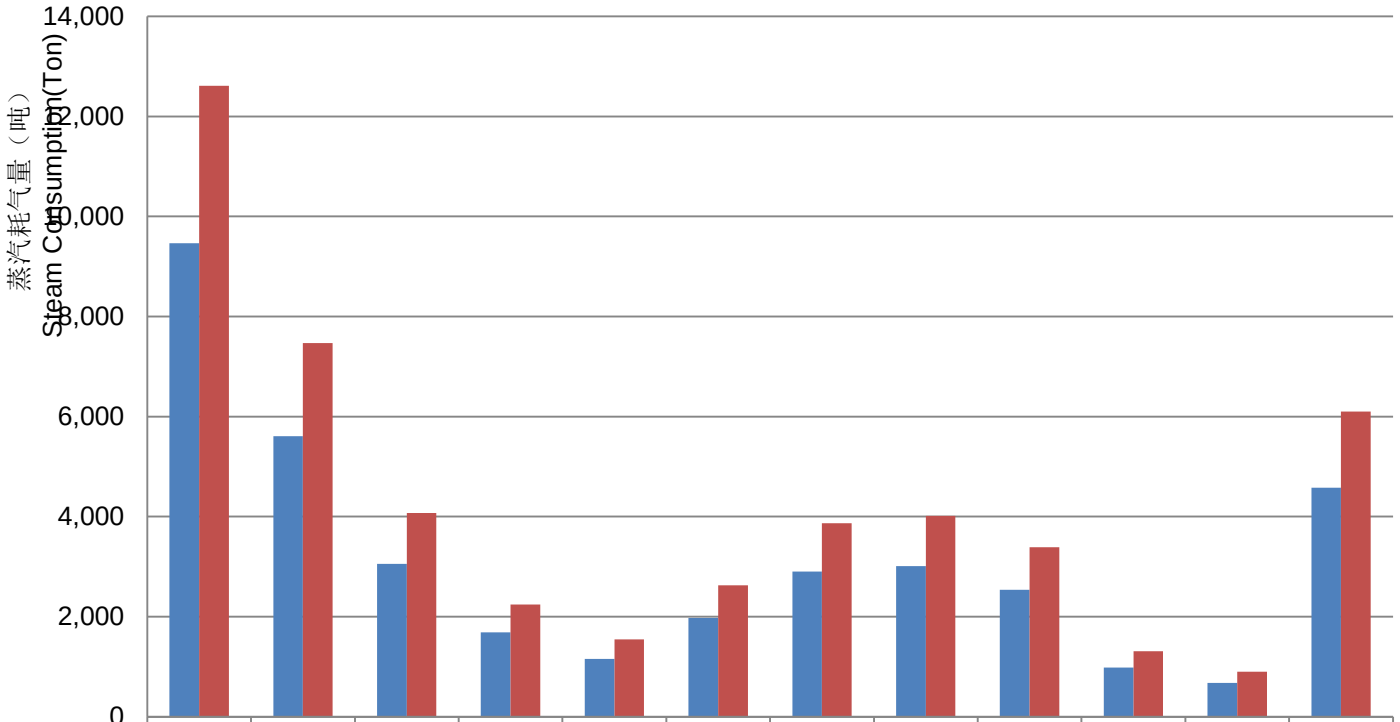
Current Situation and 3-year Projection of Energy Consumption in ENT

蒸汽耗量现状 Current Steam Consumption





东部新城三年后蒸汽耗气量
Steam consumption in ENT in three years



	1月 Jan	2月 Feb	3月 Mar	4月 Apr	5月 May	6月 Jun	7月 Jul	8月 Aug	9月 Sep	10月 Oct	11月 Nov	12月 Dec
2013年（吨Ton）	9,467	5,606	3,058	1,685	1,159	1,974	2,905	3,012	2,541	984	678	4,579
三年后（吨） Three-year Later	12,614	7,469	4,074	2,245	1,544	2,630	3,871	4,013	3,386	1,311	903	6,101

需求侧节能措施 Demand-side Energy Efficiency Measures

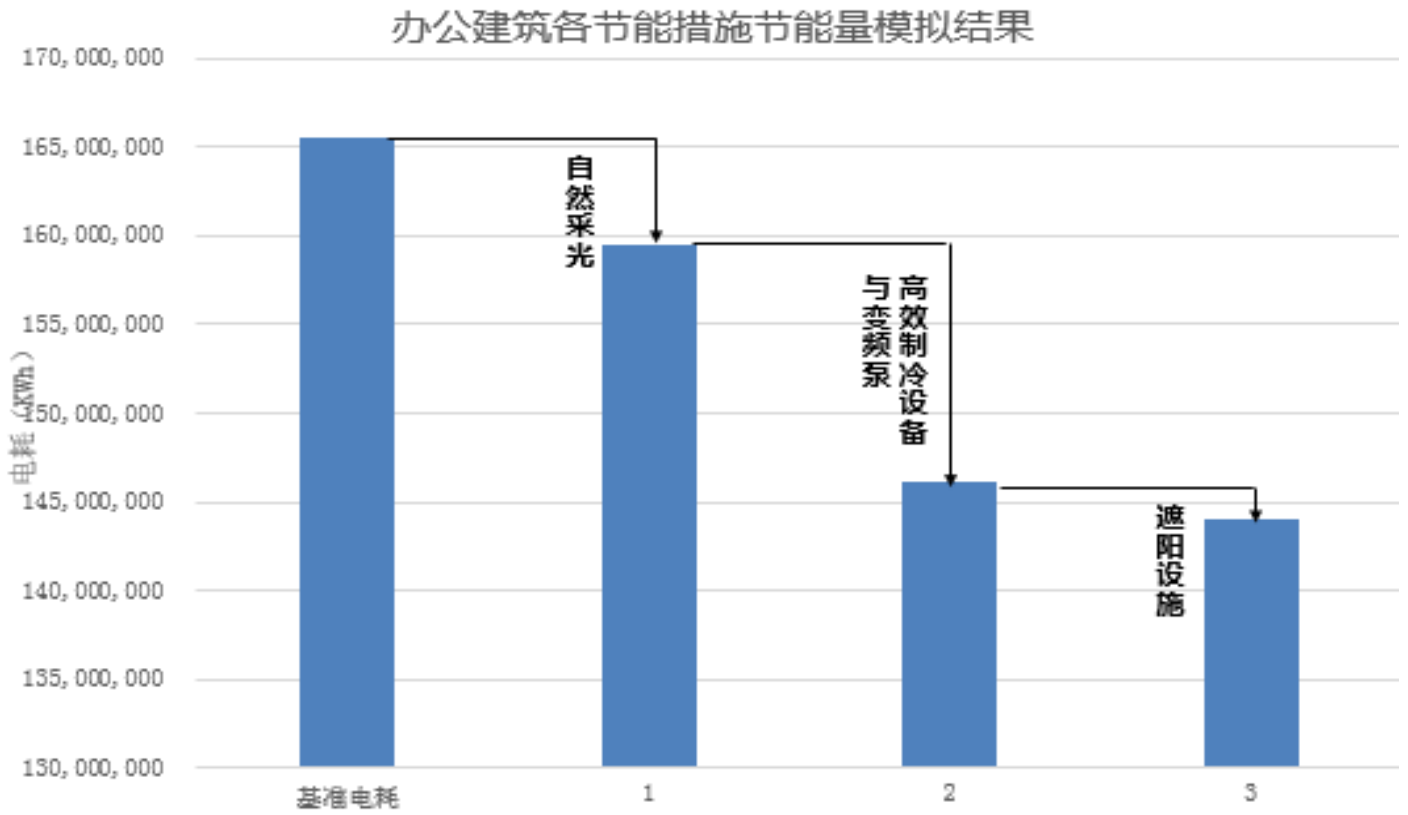
	目前现状 Current State	节能建议 Recommend Measures	节能量 Energy Savings (MWh)	节能百分比 Energy Saving Percentage	减少碳排放量 Reduced Carbon Emission
照明系统 Lighting System	LED灯，但缺少智能控制. LED lamp, but without intelligent control	LED灯，增加自然采光控制. LED lamp with additional day lighting control	6,115.17	3.69%	4,953.29
遮阳设施 Sunshade facilities	凹窗，依靠建筑自身结构遮. Concave window, shade structure of buildings	南立面增加水平遮阳，西立面增加垂直遮阳. Horizontal shading on the south façade, vertical shading on the east façade	4,665.57	2.82%	3,779.11
制冷机组 Refrigeration unit	办公建筑VRV机组制冷制热效率低于3. Cooling and heating efficiency of the VRV units of office buildings is less than 3.	提高VRV机组制冷制热效率至3.5. Increase the cooling and heating efficiency of the VRV units to 3.5.	13,339.18	8.06%	10,804.74
输配系统 Transmission and distribution	空调系统中泵多为定流量泵 Constant flow pump	更换成变流量泵 Change to variable flow pump			

考虑工业建筑工艺能耗过程较为复杂性，而居住建筑用能特点的不确定性，需求侧节能措施重点围绕办公建筑群实施；

The aforementioned energy conservation improvements are input into the office building benchmark model and the energy conservation recommendations are quantified, which yielded significant impacts.

办公建筑采取上述节能措施，可在园区层面节能**4.3%**。

Based on the combined energy saving measures, The energy saving of the entire NHTP can rea



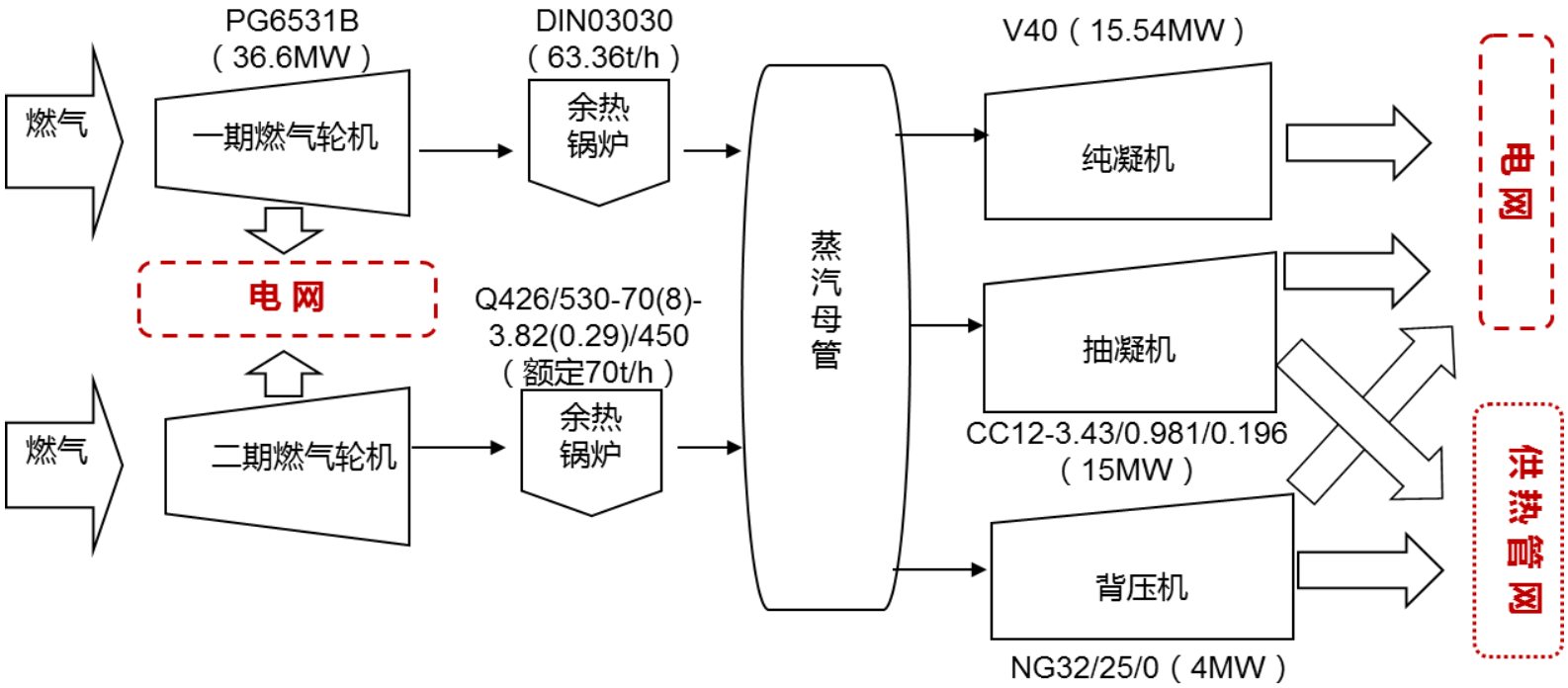
供应侧优化技术方案
Supply-side Technical Optimization Options

- **科丰热电厂供热现状**
  Current Situation of Heat Supply by Kefeng CHP Plant
- **热负荷及热平衡分析**
  Analysis of Heat Load and Heat Balance
- **新增空调负荷及工业负荷预测**
  Forecast of New AC Load and Industrial Heat Load
- **新增空调用热方案选择**
  Options for Meeting New AC Heat Demand
- **两种技术方案的预期结果**
  Anticipated Outcome of Two Technical Options

科丰热电厂供热现状
Current Situation of Heat Supply by Kefeng CHP Plant

机组现状 Condition of Unit：

- 一期一套52.14MW燃气-蒸汽联合循环发电机组
  Phase I : one gas-steam combined cycle generator unit with installed capacity of 52.14 MW
- 二期一套58.62MW燃气-蒸汽联合循环发电机组
  Phase II: one gas-steam combined cycle generator unit with installed capacity of58.62 MW
- 另有两台额定供汽能力为20吨/时的燃气锅炉
  Two gas boilers with rated steam supply capacity of 20 tons/hour



科丰热电厂供热现状
Current Situation of Heat Supply by Kefeng CHP Plant

- **运行时间:** 电网调峰机组，按早起晚停运行（8:00-22:00）

  Operating hours：For peak regulation, operating principle is morning-on and night-off (8:00 – 22:00)
- **运行工况:** 机组的运停将根据蒸汽需求进行调整

  Operating condition: adjusted based on steam demand
  - 当蒸汽需求小于40吨/时，由燃气轮机+抽凝机进行供应；

    When steam demand <40 tons /hour, the gas turbine and extracting-condensing steam turbine is turned on;
  - 当蒸汽需求大于50吨/时，由燃气轮机+背压机进行供应。

    When steam demand >50 tons /hour, the gas turbine + backpressure steam turbine on
- **最大供热能力:** 科丰热电厂最大供热能力达到137吨/时，其中燃气-蒸汽联合循环机组最大供热能力97吨/时。当机组达到最大供热量时，机组发电功率将减少17MW。

  The maximum heat supply capacity is 137 tons /hour,
- **热电联产机组理论效率**为62.0%，热电比0.98。

  The theoretical efficiency is 61.4% and the heat-power ratio is 0.96 .

科丰热电厂供热现状
Current Situation of Heat Supply by Kefeng CHP Plant

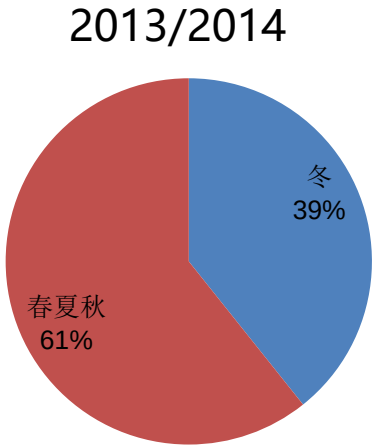
- **蒸汽管网损失:** 全年平均蒸汽供应管损达到29.4%，其中冬季管损19.4%，春夏秋季管损32.8%。

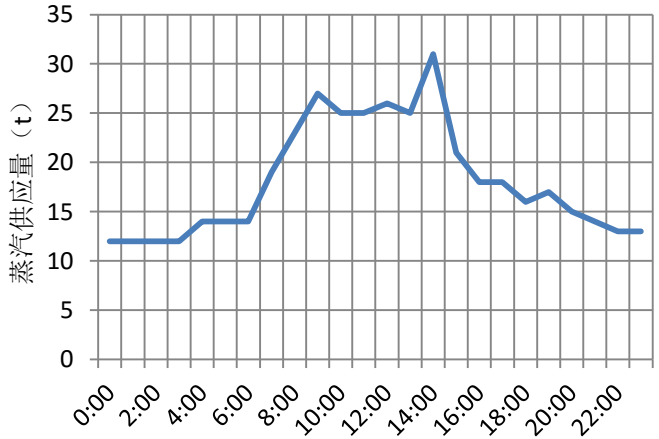
  Heat Loss: The pipeline loss of steam supply averages at 29.4% for the full year. The number is 19.4% for winter months (December, January and February) and 32.8% for spring, summer and autumn ,all relatively high numbers.

热负荷分析 Analysis of Heat Load

- 季节分布特性: 冬季负荷较大，春夏秋季较小，各月蒸汽用量明显分为两个层次——冬季和春夏秋季。根据2013年至2014年冬季12月、1月、2月蒸汽需求量占比，预测到2016年冬季需求量占比约为0.391。
  Seasonal characteristics: Heat load is larger in winter months and smaller in spring and summer months.
- 典型日热负荷特性：最大供汽量与平均供汽量的比值为1.706。
  Heat load characteristics in a typical day: ratio between the maximum steam supply and the average is 1.706.

	2013年	2014年
全年总和（吨）	119,066	131,683
冬季12、1、2月（吨）	46,764	51,598
春夏秋（吨）	72,302	80,085
冬季需求量占比	39．28 %	39．18 %





热平衡分析 Analysis of Heat Balance

Data: 2013

热负荷 Heat load	最大 Max. instant flow rate t/h	平均 Ave flow rate t/hr
Winter	90.8	53.2
Spring, summer, autumn	47.1	27.6
科丰出厂热负荷 Demand on Kefeng heating		
Winter	112.6	66.0
Spring, summer, autumn	70.1	41.1
科丰供热能力 Heat supply capacity of Kefeng		
Unit #1	40	
Unit #2	57	
gas boiler	40	
Max. heat supply capacity	137	
热平衡 Heat supply capacity surplus		
Winter	24.4	71
Spring, summer, autumn	66.9	95.9

- 当蒸汽需求为额定状态下，仅1套燃气轮机+抽凝机机组开启即可满足其额定负荷；
  the rated level steam demand can be satisfied by one gas turbine plus the extracting-condensing turbine;
- 当蒸汽需求达到最大时，可开启燃气轮机+背压机机组进行蒸汽供应。
  The maximum steam demand can be satisfied by the gas turbine + the backpressure turbine.

新增空调热负荷及工业热负荷预测
Forecast of New AC Load and Industrial Heat Load

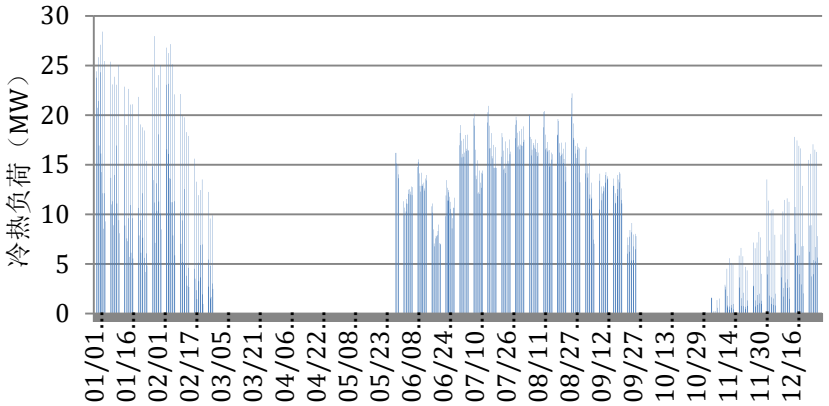
- **商用办公热负荷研究假设** Assumption of heat demand for office and retail

  高新区：约10%的新建及改造办公和商业建筑有新增的空调用热需求

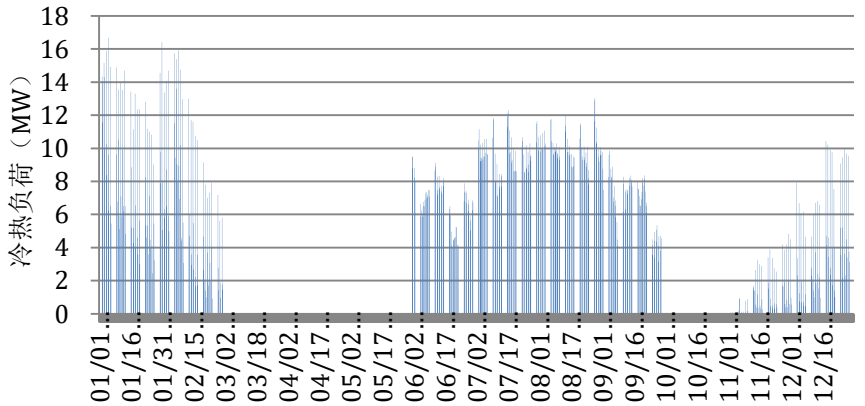
  NHTP: approximately 10% new built or existing buildings are potential to use heat for AC.

  东部新城：未来3年有25%的新建办公及商业建筑有新增的空调用热需求

  ENT: approximate 25% new buildings are potential to use heat for AC in future three years.



高新区全年空调用热逐时需求
Hourly heat demand for AC in NHTP



东部新城全年空调用热逐时需求
Hourly heat demand for AC in ENT

- **根据上述的假设，3年后高新区全年商用蒸汽需求量增加21323吨，东部新城全年商用蒸汽需求量增加12513吨。**

  Based on above assumption, there are 21323t and 12513t new steam demand for commercial buildings in NHTP and ENT respectively.

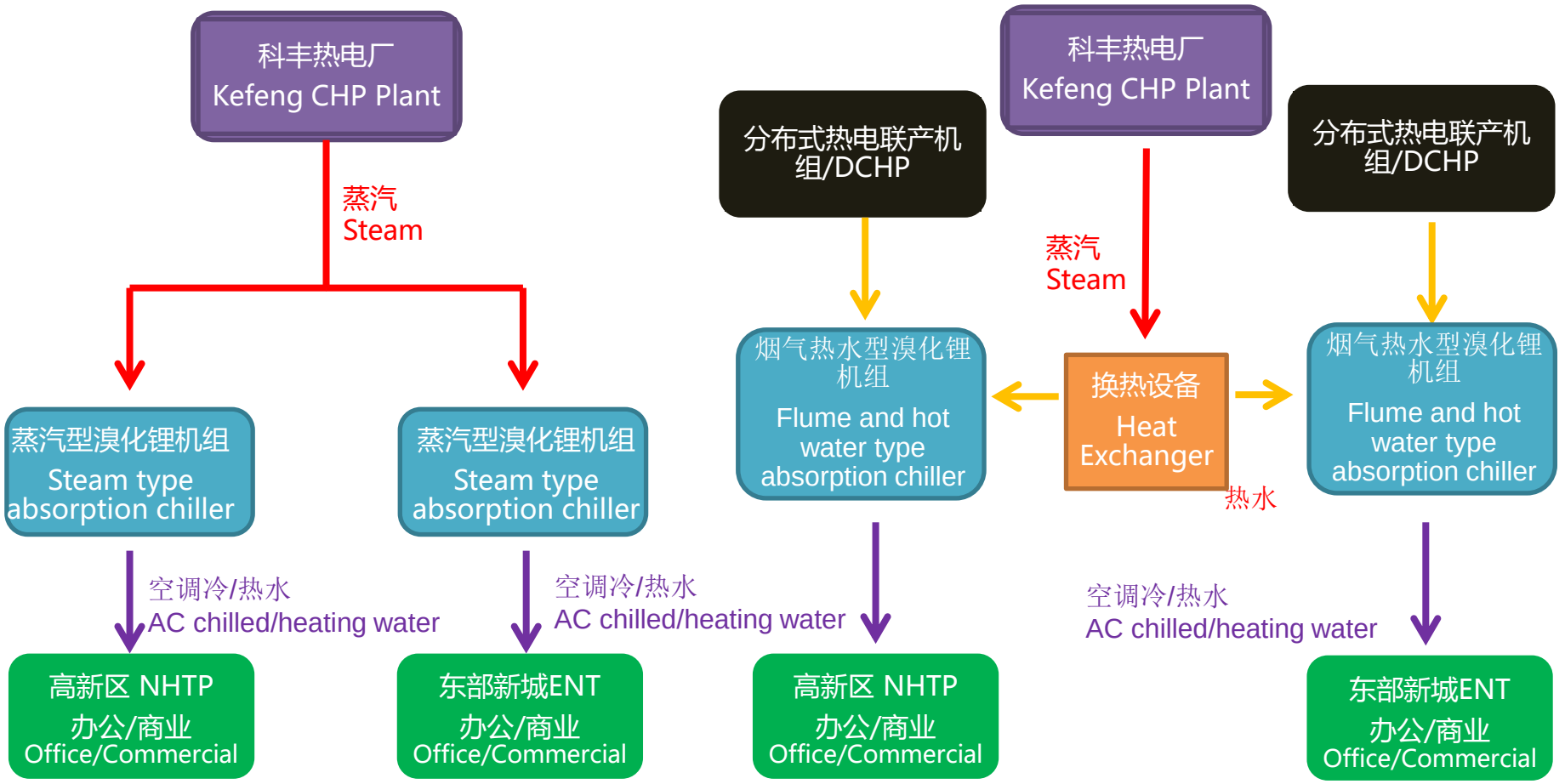
新增空调热负荷及工业热负荷预测
Forecast of New AC Load and Industrial Heat Load

- **工业热负荷预测假设** Assumption of heat load for industrial

  2013年办公及商业用户的蒸汽用量约占高新区全部蒸汽用量的12%；
  industrial steam accounts for approximately 88% of the total steam consumption in NHTP
  3年后供应高新区工业用总量增长40%.
  in three years, steam demand for industrial use will grow by 40% in total

	2013 (t)	2016 (t)
高新区 NHTP	71,350	117,788
—其中工业industrial	62,788	87,903
—其中商用commercial	8,562	29,885
东部新城 ENT	37,648	50,161
江东区JDD	10,068	10,068
蒸汽需求总量Total	119,066	178,017

新增空调用热的方案选择
Options for Options for Meeting New AC Heat Demand



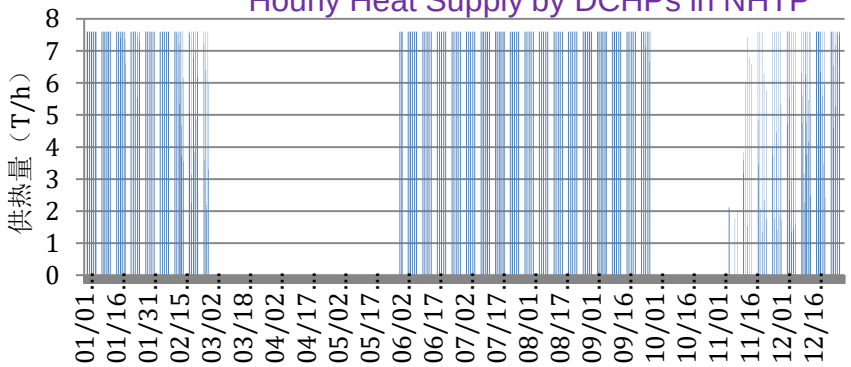
方案一：CHP
Option 1

方案二: CHP+DCHP
Option 2

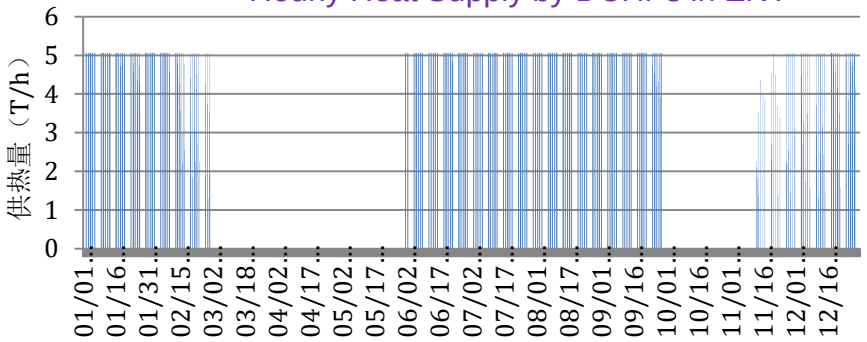
DCHP定容 Capacity of DCHP

- DCHP容量依据约20%得峰值负荷来选取
  Capacity of all DCHPs is approximately 20% of peak load
- 供热需求高于DCHP供应能力的部分及供热需求低于单台DCHP机组50%供热能力时，由科丰蒸汽管网补充
  When the heat demand is beyond the capacity of DCHP units, CHP from Kefeng will cover the shortage by providing steam. When the heat demand is less than 50% of one DCHP unit, CHPs from Kefeng need providing steam.

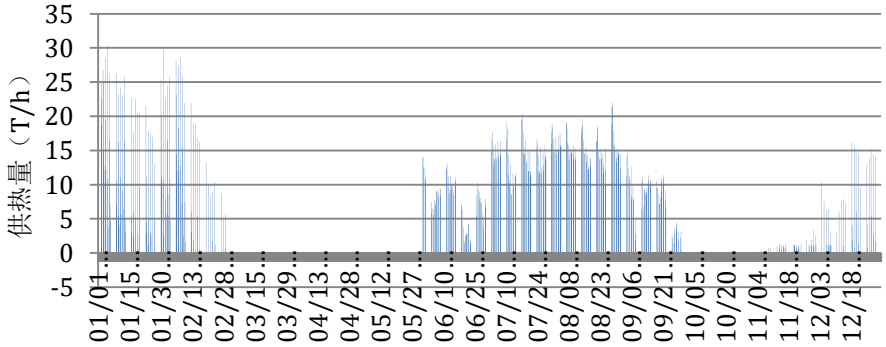
高新区DCHP逐时供热量
Hourly Heat Supply by DCHPs in NHTP



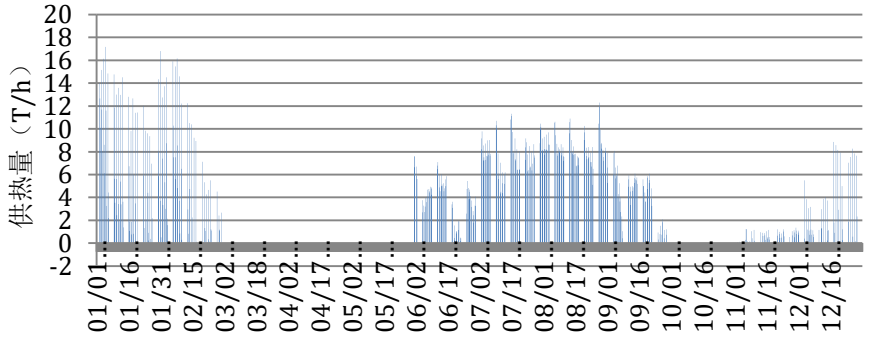
东部新城DCHP逐时供热量
Hourly Heat Supply by DCHPs in ENT



高新区科丰管网逐时供热量
Hourly Heat Supply by Kefeng CHPs in NHTP

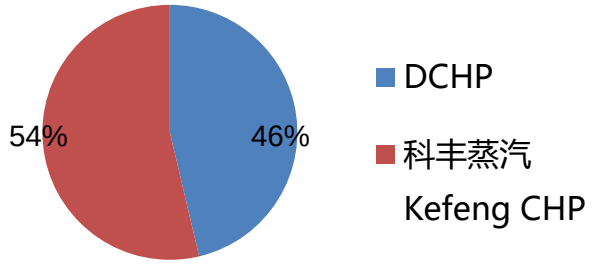


东部新城科丰管网逐时供热量
Hourly Heat Supply by Kefeng CHPs in ENT

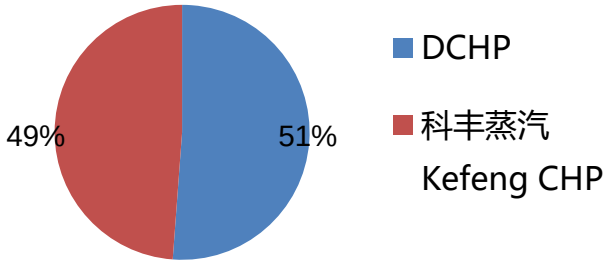


新增办公及商业CHP和DCHP联合供热情况
Operation Condition of CHP and DCHP for Office/Commercial

高新区年供热量
Annual Heat Supply in NHTP



东部新城年供热量
Annual Heat Supply in ENT



类别 Type	高新区DCHP机组 DCHP units of NHTP	东部新城DCHP机组 DCHP units of ENT	合计 Total
全年供热量, t Full year heat supply	9,874	6,403	16,277
全年发电量, kWh Full year electricity generation	7,795,000	5,055,000	12,805,000
全年天然气用量, Nm3 Full year NG consumption	1,808,000	1,172,000	2980,000
DCHP运行小时数, h DCHP Operation hour	1428	1365	
DCHP利用小时数, h DCHP utilization hour	1300	1263	

两种技术方案结果
Outcome of Two Technical Options

- **方案一 option I**

采用科丰电厂扩容的方式满足3年后冬季需要达到最大流量168.4吨/时，增加两台15吨/时的燃气锅炉。

科丰电厂年上网电量达20119万kwh，蒸汽销售量达178017t，天然气耗量为5416万Nm3。

- **方案二 option II**

采用新增DCHP机组+科丰电厂扩容的方式。科丰电厂需满足补充DCHP机组不足部分，冬季需要达到最大流量153.9t/h——增加两台10t/h的燃气锅炉。

科丰电厂年上网电量达17504万kwh，蒸汽销售量达161739t，天然气耗量为4781万Nm3，DCHP机组上网电量达1285万kwh，蒸汽销售量达16277t，天然气耗量为298万Nm3。

	方案一 Option I	方案二 Option II	
	CHP	CHP	DCHP
蒸汽销售量, t Steam sales volume	178,018	161,739	16,277
上网电量万, kWh Grid electricity	20,119	17,504	1,285
天然气用量万, Nm3 Gas consumption	5,416	4,781	298
机组综合效率（包括管道损失） integrated efficiency	71.1% （63.2%）	71.3% （63.4%）	86.40%

热电厂优化方案碳排分析

Carbon Emission Analysis of optimized options for Kefeng

三年后CHP扩容与CHP+ DCHP方案CO_2排放量

CO2 emissions of the two alternative solutions in three years

	2013年现状 Status in 2013		三年后方案一 Option 1 in 3 years		三年后方案二 Option 2 in 3 years			
	CHP	碳排（吨）Carbon Emission (t)	科丰CHP扩容 Kefeng CHP capacity expansion	碳排（吨）Carbon Emission (t)	科丰CHP Kefeng CHP	高新区DCHP机组 NHTP DCHP unit	东部新城DCHP机组 ENT DCHP unit	碳排（吨）Carbon Emission (t)
蒸汽销售量：高新区（吨） Steam sales: NHTP (t)	71,350	17,292.95	167,949	44,682.22	151,670	9,874.00	6,403.00	44,681.74
蒸汽销售量：东部新城（吨） Steam sales: ENT (t	37,648	9,124.67						
蒸汽销售量：江东区（吨） Steam sales: JDD (t)	10,068	2,440.16	10,068.00	2,440.16	10,068.00			2440.160319
科丰上网电量（MWh）	307,920	249,415.20	201,190.00	162,963.90	175,040	7,795.00	5,055.00	152187.093
小计		278,272.98		210,086.28				199,308.99

- 仅从蒸汽量供应和发电量供应来说，热需求一样的情况下，方案二发电量少于方案一。

  Only from the perspectives of steam supply and electricity supply - provided that the heat demand is the same, the electricity generation of Option II is lower than that of Option I.

- 在碳排的比较上，取决于**CHP**、**DCHP**发电的碳排因子与宁波电网的碳排因子的比较。由于上述数据的不确定性，电力碳排因子均取值华东电网**0.8100**吨**CO2/MWh**，三年后方案一碳排放量**210,086.28**吨，方案二**CO2**排放**199,308.99**吨。但这个数字尚不能说明二者哪个方案在碳排上更有优势。

  The comparison of carbon emissions depends on the comparison of the carbon emission factors of CHP, DCHP, and Ningbo Grid. Due to the uncertainty of such data, the electrical carbon emission factor is valued according to that of East China Grid, i.e. 0.81 ton CO_2/MWh. In three years, Option I has a carbon emission of 210,086.28 tons, while Option II has a carbon emission of 199,308.99 tons. Based on these numbers, one cannot deduce which option is better in terms of carbon emission.

供应侧分布式太阳能光伏利用

- **可行性分析**

  Feasibility analysis

- **太阳能光伏发电机组**

  Solar photovoltaic power generation unit

可行性分析

在这项研究中，三种可再生能源（太阳能光伏、太阳能热/冷、以及地热）被列入考虑范围。经过现场调查和初步分析，由于以下的原因，集中太阳能加热和地热没有列入下一步调查。

- 在已建宁波高新区，不可能在每个建筑物中铺设小区的供暖地面。
- 系统利用率太低，宁波每年只需供冷两个月以及供暖一个月。
- 宁波高新区地下质条件不支持地热热泵。最近的河流离新区中心太远。

因此，此次供应侧能源的研究重点是太阳能光伏发电。宁波年均日照时数约1900小时，年均太阳辐射总量约4700MJ/m2，属太阳能资源四类地区，尚具备利用的可能性。

太阳能光伏发电机组

经计算考虑在宁波高新区峰值日照辐射时间为每年峰值小时是1302.42小时，按系统综合效率76%，年利用小时数约为985.94小时，计算可知首年上网电量约为34.51GWh。据经验，年衰减率取0.8%，使用寿命20年。

宁波高新区太阳能首年发电量

符号	名称	单位	数值
W	装机总量	MW	35.00
H[1]	年峰值日照小时数	h	1,302.43
	年可利用小时数	h	985.94
η	光伏电站系统总效率	1.00	0.76
	水平面年总辐射量	MJ/m^2	4,700.00
L_0[2]	首年年发电量	GWh	34.51
b	年衰减率		0.8%

宁波高新区太阳能逐年发电量

年数	年衰减率（b）	发电量(GWh)
1	0.00	34.51
2	0.008	34.23
3	0.008	33.96
4	0.008	33.69
5	0.008	33.42
6	0.008	33.15
7	0.008	32.88
8	0.008	32.62
9	0.008	32.36
10	0.008	32.10
11	0.008	31.84
12	0.008	31.59
13	0.008	31.34
14	0.008	31.09
15	0.008	30.84
16	0.008	30.59
17	0.008	30.35
18	0.008	30.10
19	0.008	29.86
20	0.008	29.62
总数		**640.14**
年平均发电量		**32.01**

分布式太阳能光伏利用碳排分析

Analysis of carbon emission of distributed solar PV utilization

宁波高新区太阳能首年发电量
First year solar power generation in NHTP

符号Symbol	名称Description	单位Unit	数值Value
W	装机总量Total installed capacity	MW	35.00
H[1]	年峰值日照小时数Annual peak sunshine hours	h	1302.43
	年可利用小时数Annual available hours	h	985.94
η	光伏电站系统总效率Total efficiency of PV station systems	1.00	0.76
	水平面年总辐射量Annual total radiation on horizontal surface	MJ/m^2	4700.00
L_0[2]	首年年发电量First year annual power generation	GWh	34.51
b	年衰减率Annual attenuation rate		80%

总结 Summary:

- 利用太阳能的清洁发电，投产后首年可发电**34.51GWH**；

  The first year grid-connection electricity is calculated to be about 34,510,000kWh.

- 根据《中国能源统计年鉴**2013**》火电厂供电煤耗每节约**1**度**(kWh)**电,就相应节约了**0.325kg**标准煤,与常规燃煤火力发电厂相比，首年可节约标煤月**11215.75**吨**.**

  According to the data of coal consumption for power supply in thermal power plants included in 'China Energy Statistics Yearbook for Year 2013', the saving of each kWh in electricity is the saving of 0.325kg standard coal equivalent. Compared with conventional coal-fired thermal power plants, 11,215.75 tons of standard coal equivalent can be saved in the first year using solar power.

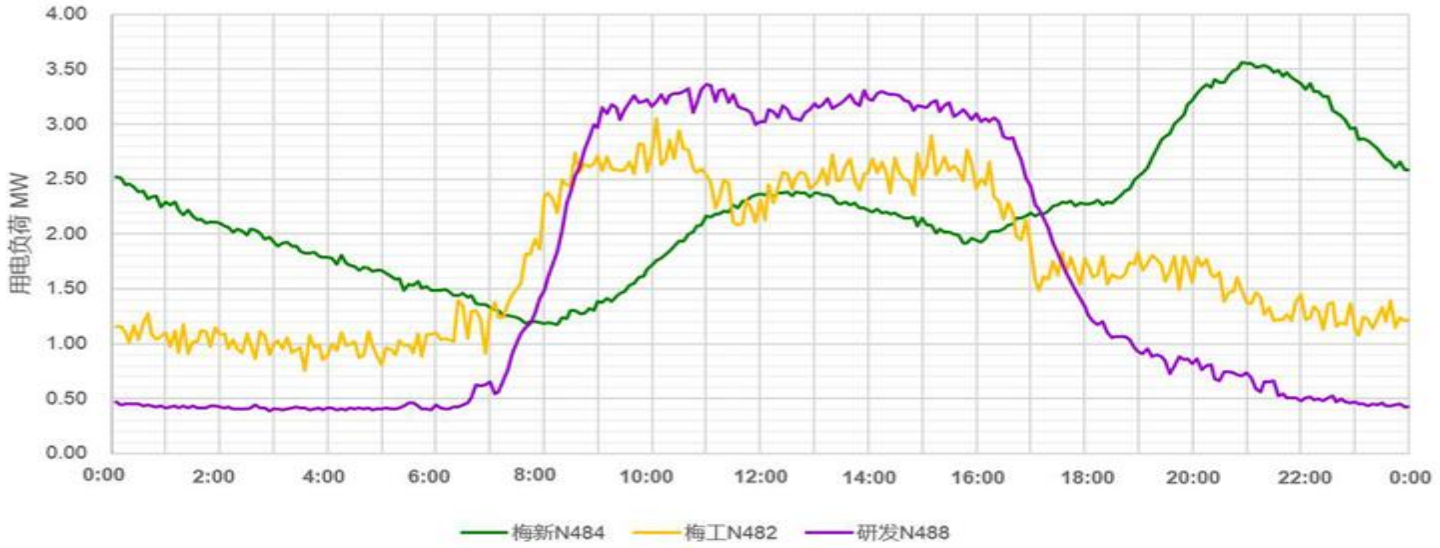
- 选取**2013**年华东电网碳排因子**0.8100**吨**CO2/MWh**，太阳能光伏发电首年减排**CO2**约**27953.1**吨，产生一定的经济效益和社会环境效益。

  If the carbon emission factor of 0.8100 tons of CO2/MWh of East China Grid is selected, the use of solar PV power generation can lead to the reduction of CO2 emission by approximately 27,953.1 tons in the first year, generating substantial economic, social and environmental benefits.

微电网概念区域能源管理中心
Microgrid Concept Distributed EMC

- 高新区典型日用电负荷曲线
  Typical-Day Load Profiles
- 高新区微电网概念区域能源管理中心架构 （三年后）
  NHTP Micro-Grid Distributed EMC Proposal
- 微电网概念区域能源管理中心功能
  Micro-Grid Distributed EMC Functions
- 分布式能源管理中心营运要点
  Distributed EMC Operations
- 微电网相关政策分析小结
  Policy Analysis of Micro-grid Development

高新区典型日用电负荷曲线 – 建筑、居民与工业
Typical-Day Load Profiles – Residential/Commercial/Industrial

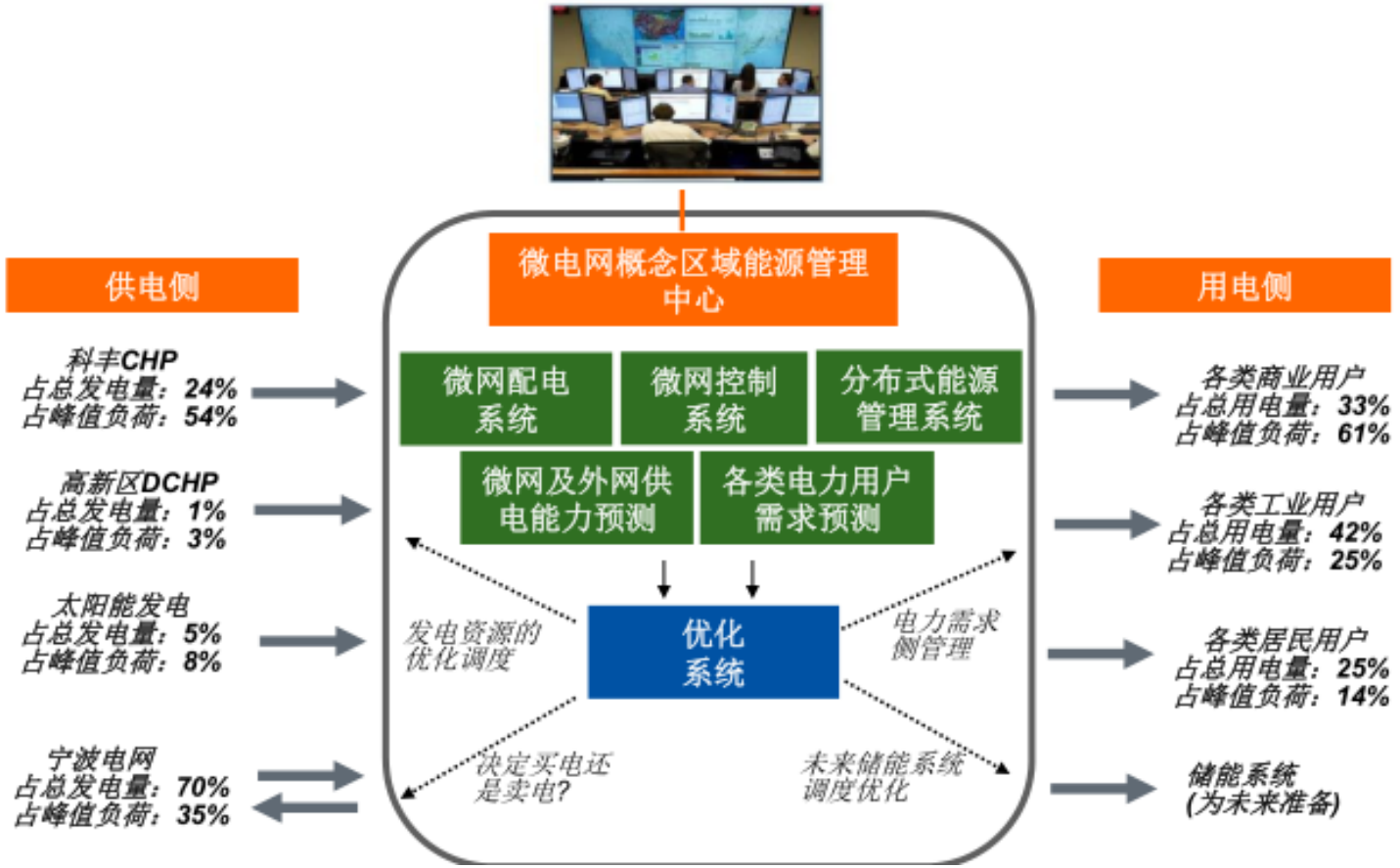


- 三类用电负荷互相叠加，上午9点到下午5点为第一高峰，晚上9点是居民用电高峰
- **With 3 types of typical users, the superposition results to 3 peaks, morning, afternoon, and evening**

- 上午用电高峰在11点左右，下午在3点左右，这与中国东南地区一致，也与美国纽约类似
- **The peaks appear at 11:00am and 3:00pm, similar to areas in southern-east of China and New York**

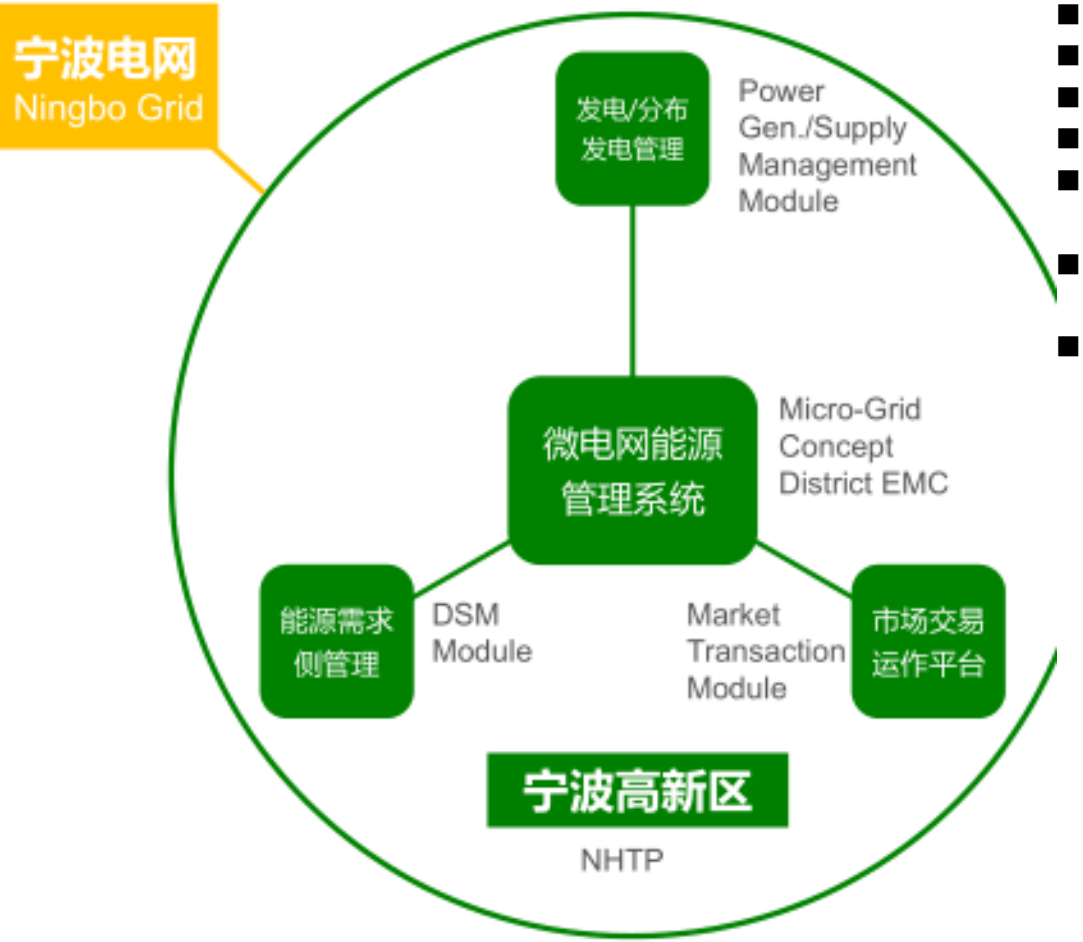
- 居民与商业建筑的逐日用电负荷变化具有很强的重复性，而工业企业变化较大
- **There are strong consistencies among day-to-day load profile for Residential/Commercial users, while the profile for Industrial users may vary largely.**

高新区微电网概念区域能源管理中心架构 （三年后）
Micro-grid Concept District EMC (In three years)



- **基本结论:** 高新区三年后供电需求的70%来自宁波电网，高新区不具备构建独立微电网的条件
- **建议方案:** 采用微电网概念的区域分布能源管理中心

微电网概念分布式能源管理中心功能
Micro-grid Concept Distributed EMC Functions



■ 核心功能 Core Functions：

- 实现碳排放削减8%、节电4%、高峰负荷削减23.44MW，实现办法如下：**Ensure CO2 red. 8%, kWh saving 4%, peak cut 23.4MW**：
- 分布发电状态监控、发电能力预测与控制
- **DG monitoring, pw gen. forecast & control**
- 需求侧管理，包括能效改善与需求响应
- **DSM, incl energy eff. & demand response**
- 区域内部发电与用电的动态优化平衡**Demand & Generation Optimal Balance**
- 区域外能源市场交易，区域作为整体买电、 卖电以及区域内部的高峰负荷竞价等
- **Internal/external energy trading/bidding**

创新要点 Innovations：

电网供电、分布发电、需求侧管理、市场化手 段统一在一个平台下营运 **Grid supply, DG, DSM, Market Mechanism in one platform**

微网概念，区域分布发电、用能、节能、碳排 放与调频/调峰优化平衡后再与大电网互动 **Microgrid concept, local balance then to bulk grid balance**

内部与区域作为一个整体与外部的市场化交易是营运效率改善的核心，例如区域作为整体直 接购电 **Market transactions drives efficiency, e.g. NHTP as an entity to purchase electricity**

发展智慧能源产业链

- Develop smart energy chain

分布式能源管理中心营运要点
Distributed EMC Operations

1. 区域低碳为主要目标的调度 – 不同发电资源以低碳为目标的调度方案实施 Low carbon orienteddispatching, selection of various energy resources

2. 基于需求侧管理节能减排最大化的调度 –通过分布能源管理中心进行“营运”，使得这些节能减排项目的状态得到监控与管理，并自我学习、改进提 Demand side EE/Emission reduction targeted dispatching, monitoring, control, management

3. 基于区域电力高峰用电优化调度– 根据区域用电特性，确定调度顺序，采用需求响应，确保区域高峰电力负荷的最大削减 Peak reduction oriented dispatching, to ensure grid safety and reliability, DR –Renewables – DG – Gas - Coal

4. 区域热电需求平衡的调度– 热的需求是随时间变化的， DCHP与CHP遵循以热定电的原则，通过调查系统确定热力生产与电力生产的数量与相关机组的运行参数； Heat demand and electricitygeneration optimal balance oriented dispatching

5. 能源采购成本最低的调度– 大客户直接供应与交易已经开始，未来将会出现许多独立的售电公司，区域能源采购成本最低的优化调度方法 low purchase cost

6. 基于交易的调度 - 获得最多的交易收益，例如碳交易、节能量交易，根据市场价格调度需求侧与供应侧的资源，即：价格高时多节省，价格低时多使用 Transaction based dispatching mechanism,internal and external energy demand transactions to generate benefits to the region

微电网相关政策分析小结 Policy Analysis of Micro-grid Development

有利方面 Pros：

- 宁波市低碳城市试点方案的通知（甬政办发〔2013〕 77号 Ningbo low carbon city guideline
- 关于做好浙江省电力行业节能减排监管系统测点整理和接入准备有关工作的通知 Gov. Notice toestablish energy saving & emission reduction monitoring requirements
- 深圳、内蒙电改试点的实施 Utility Reforms at Shenzhen/inner Mongolia in progress
- 电改9号文、于改善电力运行调节促进清洁能源多发满发的指导意见、完善电力应急机制做好电力需求侧管理城市综合试点工作的通知 Recent 3 key government policy releases: Utility reformpolicy #9, Use of renewables, DSM pilot guidance

不利方面 Cons：

- 国家电网设施的使用与价格核算，上网的限制 transmission charging fees, selling to grid
- 目前的《电力法》 不允许同一地区设置不同的供用电管理部门 limitation of additional utilitycompanies in the same region
- 如何平衡区域分布发电拥有者的利益，如何同一营运？ Balance of interests, consolidation of ops
- 区域系统性节能补贴限制 Gov. subsidy to aggregated EE not allowed

相关建议 Recommendations

1. 关注深圳电改 、争取宁波早日成为电改试点城市 To become utility reform pilot city
2. DSM 宁波自主开展需求响应试点 ， 负荷特性调整, To start demand response pilot
3. 关注9号文19个配套细则文件，早日在宁波建立售电公司 Following up with recent policies, try to establish independent electricity sales companies in Ningbo
4. 以工业4.0为手段， 推进企业数字化能源管理，推动区域分布能源中心客户增值服务 Develop industrial 4.0 infrastructure, add value to Distributed EMC

政策壁垒，建议及结论

Policy Barriers, Recommendations, and Conclusion

- **微电网相关政策壁垒与建议** Micro-grid related policy barriers and recommendations
- **合同能源管理相关政策及建议** EMC related policy barriers and recommendations
- **结论** Conclusion

微电网相关政策壁垒与政策建议

Micro-grid related policy barriers and recommendations

微电网政策壁垒 Micro-grid related policy barriers	供电营业机构相关政策缺乏 Lack of relevant policies for power supply organizations	《中华人民共和国电力法》和《电力法》中均有条款中均为规定电力公司是如何归属地方事业的，该如何管理，存在是否合法等。国家电网更趋向于利用现有的大电网的能力来管理调度，而微电网这种区域独立小电网一般下都不是电网投资建设的目的。
	微电网相关政策缺乏 **Lack of related policies and regulations for micro-grid**	目前没有微电网如何上网的规定，只有分布式发电上网的要求。但对分布式发电上网之定义了10kV及以下电压接入电网，但各网点总装机容量不超过6MW。
微电网政策建议 Micro-grid related policy recommendations	资产归属Asset Ownership	对于分配电网资产归属的问题，可以效仿深圳电网在开发售电分离模型来核算电网资产。
	政策补贴Policy subsidy	鉴于微电网模式能够更好地帮助政府完成节能减排的指标，政府可以通过法律或政策给出一定量的节能补贴给微电网公司，从而降低用电成本，降低电价。
	经营模式Operating model	对于营运者，可以允许未来独立的售电公司营运，不过需要有独家经营权，也可以让未来的售电公司与政府进行合作，采用PPP/BOT模式来运营。对于电力高峰削减成功所得潜在利益，需要政策来明确利益分配问题。

合同能源管理相关政策及建议

EMC related policy barriers and recommendations

相关补贴政策现状Current status of related subsidy policy		
时间Time	**政策名称Name**	**相关规定Description**
2010.4	《关于加快推行合同能源管理促进节能服务产业发展的意见》（国办发〔2010〕25号） 'Opinions on accelerating the implementation of energy performance contracting for energy services industry development'	规定了有关节能服务产业税收优惠政策。将合同能源管理项目纳入中央预算内投资和中央财政节能减排专项资金支持范围，对节能服务公司采用合同能源管理方式实施的节能改造项目，符合相关规定的，给予资金补助或奖励。有条件的地方也要安排一定资金，支持和引导节能服务产业发展。providing tax incentives for energy conservation service industry. The EPC projects are included into the scope of support from central within budget investment and the central government special EE funds. Qualified EE retrofit projects implemented by ESCOs in form of EPC mode will be subsided or rewarded. Local governments, if fiscally allowed, should set aside some funds to support and guide the development of energy service industry. After that, the Ministry of Finance arranged CNY two billion of special reward funds to support energy service companies to adopt energy performance contracting to implement EE retrofits in industry, construction, transportation etc. areas, and public institutions.
2011	《节能技术改造财政奖励资金管理办法》 'Management methods of fiscal incentive funds for EE technical retrofits'	明确提出，"十二五"期间，政府将对节能量在5000吨标准煤以上及年综合能源消费量在2万吨标准煤以上的节能项目，东部地区按240元/吨标准煤、中西部地区按300元/吨标准煤给予一次性奖励。made it clear that during the 12th five year period, the government will provide a one-time reward to energy saving projects with saved energy above 5000 tons of standard coal, and annual energy consumption over 20,000. The reward standard in the eastern regions is 240 CNY/ ton of coal, and 300 CNY/ ton of coal in the middle and western regions.
2011	《宁波市节能专项资金管理办法》 'Ningbo Municipal EE special fund management approach'	1) 由国家备案的节能服务公司实施的列入国家奖励计划的合同能源管理项目，以项目年节能量为依据、采取以奖代补的方式进行奖励。EPC projects implemented by ESCOs registered with the state and included in the national award plan will be rewarded rather than subsided in term of the project's annual energy savings. 2) 由宁波市级备案的节能服务公司实施的合同能源管理项目、或国家备案的节能服务公司实施的未列入国家奖励计划的合同能源管理项目等，以项目年节能量为依据、按300元/吨标准煤的标准进行补助。EPC projects implemented by ESCOs registered with Ningbo government, or implemented by state-registered ESCOs but not included in national award plan, will be subsided as per the standard of CNY 300/ton coal in term of the project's annual energy saving.

合同能源管理相关政策及建议

EMC related policy barriers and recommendations

	税收扶持政策 Tax policies to support the implementation of the current status	税收改革建议 Tax reform proposals
1	对节能服务公司实施合同能源管理项目，取得的营业税应税收入，暂免征收营业税，对其无偿转让给用能单位的因实施合同能源管理项目形成的资产，免征增值税。The revenues earned by ESCOs from its implemented EPC projects will be temporarily exempted of business tax. The free transfer of the EPC project assets by ESCOs to host companies is exempted from VAT.	EPC项目应纳税所得额的计算应符合独立交易原则。The calculation of taxable income of EPC projects should be consistent with the arm's length principle.
2	节能服务公司实施合同能源管理项目，符合税法有关规定的，自项目取得第一笔生产经营收入所属纳税年度起，第一年至第三年免征企业所得税，第四年至第六年减半征收企业所得税。If ESCOs have implemented EPC projects, the ESCOs, if qualified as per the regulation, shall be exempted income tax for the first three years starting from the year when the first operation revenue is obtained, and then shall be cut by 50% of income tax for the subsequent three years	成立合同能源管理专项基金，将事后补贴改为合同能源管理公司可申请的专项投资基金，从而缓解合同能源管理公司的融资成本。同时对该专项基金定期进行审计评估。To establish a special EPC fund, which will transform the ex-post subsidy into investment fund especially applicable for ESCOs so as to mitigate ESCO's financing cost, and meanwhile the regular audit of the special fund will be carried out.
3	用能企业按照能源管理合同实际支付给节能服务公司的合理支出，均可以在计算当期应纳税所得额时扣除，不再区分服务费用和资产价款进行税务处理。As permitted by the regulation, the reasonable payment made by the energy users to ESCOs as per EPC agreement can be fully deducted from the taxable income, with no need to further differentiate the service expense and asset price in the EPC payment.	对于实施企业，进行能源审计，实施奖惩制度。未达标企业在税收方面减免相应的优惠税收政策。对于达标企业设定不同的达标级别，鼓励不同等级的实施企业力所能及地开展合同能源管理项目，避免一刀切的政策。Organize energy audit for host enterprises and establish a correspondent reward and punishment system. Non-attainment enterprises will encounter reduction in the preferential tax policies. For attainment enterprises, different levels of benchmarks will be set up. To encourage companies to carry out what EPC projects within their capacity, they will receive more benefit if they can achieve higher benchmark.
4	能源管理合同期满后，节能服务公司转让给用能企业的因实施合同能源管理项目形成的资产，按折旧或摊销期满的资产进行税务处理。节能服务公司与用能企业办理上述资产的权属转移时，也不再另行计入节能服务公司的收入。After the expiration of the EPC agreement, the EPC project assets will be transfered by ESCOs to the host companies and they are allowed to be treated in tax application as assets with expired depreciation or amortization. And at the time when the ESCOs are transferring the ownership of these assets, there is no need to record revenues for the ESCOs separately.	对实施合同能源管理项目的用能企业可凭借其支付给节能服务公司的效益分享款中的增值税进项额来抵扣销项增值税。The host enterprises that adopt EPC model to implement EE projects shall be eligible to deduct the VAT in the savings-sharing payment made to ESCOs from the VAT in sales.

结论 Conclusion

- 建筑节能改造方案
  - 通过输配系统定流量泵改造成变流量水泵; 安装遮阳措施，配置自然采光控制;
  - 更换空调系统设备成**COP**较高的设备，使得综合节能达**11.94%**，相对于高新区需求侧现状
  - 应用各地块负荷分布及峰值时间达到自调峰功能，以及其他需求侧响应策略来削峰填谷，支持需求侧与供应侧的匹配。

- **Building EE renovation**
  - **Convert to variable flow rate pumps; Install sunshades daylighting control ;Replace to high COP AC system equipment ;**
  - **Overall energy conservation rate is 11.94%.;**
  - **Peak load management and load shifting**

- **CHP/DCHP方案一**
  - 方案一个是将现有机组扩容。只需要增添2台15吨/时的燃气锅炉，并考虑利用现有铺设好的东部新城的供热。

- **CHP/DCHP Option I**
  - **Option I is to increase the capacity of the existing units.**
  - **Add two 15 ton/hour gas boilers in order to meet the additional electrical heating demand of NHTP and the additional heat demand of ENT; Considers using existing pipeline in ENT.**

- **CHP/DCHP方案二: 使用分布式热电联产机组**
  - **配置5台单机为2MW合计10MW的DCHP机组;**
  - **CHP侧加上2台10吨/时的燃气锅炉;**
  - **增设蒸汽/热水转换装置以便DCHP和现有的CHP共同利用科丰已在东部新城铺设的母管。**

- **CHP/DCHP Option II: Add DCHP units**
  - **Add 5 DCHP units with a total capacity of 10MW ;**
  - **Add two 10 ton/hour gas boilers;**
  - **Add steam/hot water exchange device to enable the DCHP and the existing CHP units to mutual utilize Kefeng mother pipeline already installed in ENT**

- 分布式发电光伏系统
  - 总共有约**34.75**万平方米的楼宇屋顶适合安装太阳能光伏发电面板;
  - 最佳有效太阳能光伏装机容量为**35MW**，年度有效发电时间为**985.94**小时（已考虑损耗）;
  - 上网电量**34.51GWh**。

- **Distributed solar PV system**
  - **Total area of building roofs suitable for installation of solar PV panels is approximately 347,500m2.**
  - **Solar PV power capacity is 35MV , annual effective power generation time is 985.94 hours (loss already considered)**
  - **Total generation is about 34,510,000kWh per year**

- 微电网和能源管理中心,
  - 预计三年后高新区可实现高峰负荷削减**23.44MW**，约占总高峰负荷**203MW**的**11.5%;**
  - 与三年后不做任何变化相比，预计可以节能**8.53%**，碳排放削减可达**8.03%;**
  - 这部分的运行管理建议交由统一的能源管理公司来承担。政府提供特许经营许可权。

- **Micro-grid and energy management center**
  - **A peak load reduction of 23.44MW for NHTP in three years, accounting for 11.5% of total peak load;**
  - **This solution will save 8.53% of energy and cut carbon emission by 8.03%;**
  - **It is recommended to hand over the operation and management of this part to an energy management company under concession granted by the government.**

- **经济性分析**
  - CHP/DCHP方案一的投资为300万人民币，收益率为：118%，
  - CHP/DCHP方案二测算的总投资需求为1.23亿元，收益率为6.4%。
  - 光伏发电分布式能源系统总投资为2.98亿元，收益率为：11.3%。
  - 能源管理中心总投资为7575万元，收益率：16.6%。
  - 打包项目的静态总投资为4.96亿元， 收益率12.5(国内商贷)-18.6% (国际金融机构贷款）

- **Economic analysis**
  - CHP Option I –investment of CNY 3 million, IRR 118%;
  - CHP+DCHP Option II - investment of CNY 123 million, IRR 7.3%;
  - Solar PV - investment of CNY 298 million, IRR 11.3%
  - Energy management center - investment of CNY 75.75 million, IRR 16.7%.
  - Option II + solar PV system + energy management center, IRR 12.5-18.6%

财务分析 Financial Analysis

- 基本假设
Basic Assumptions

- 单项节能措施财务分析
Financial Analysis of Standalone Energy Efficiency Measures

- 打包项目财务分析
Financial Analysis of Bundled Project

- 实施主体问题
Issues Related to Implementation Entity

- 能源合同管理与营运模式思考
EPC & Operation Models

基本假设 Basic Assumption

		方案一 Option 1			方案二 Option 2		
投资范围 Investment Scope		新增2台15t/h燃气锅炉；利用现有冗余CHP机组发电供热能力 Add two 5t/h gas-fired boilers with utilization of currently redundant CHP capacity			配置5台单机为2M合计10MW的DCHP机组，CHP侧加上2台10t/h的燃气锅炉 Equipped with 5 sets of 2MW DCHP units and add 2 sets of 10t/h gas-fired boilers in CHP side		
总投资（万元） Total inv. (CNY 10000)				300.0			12,300.0
产出与投入 Output and input	能量来源 Energy source	DCHP	CHP	合计 Sum	DCHP	CHP	合计 Sum
	供热 Heat supply (t)	-	33,835	33,835	16,277	17,558	33,835
	发电 Elec. supply (10 MWh)	-	4,902	4,902	1,285	2,287	3,572
	天然气 Gas cons. (10k m3)	-	1,240	1,240	298	605	903
	消耗水 Water cons.(m3)	-	87,971	87,971	-	45,651	45,651
基本假设 Basic assumptions	供热价格 Heat price (CNY/t)	n.a.	285.17	/	320.00	320.00	/
	上网电价 Tariff (CNY/KWh)	n.a.	0.808	/	0.960	0.808	/
	天然气价格 Gas price (CNY/m3)	n.a.	3.22	/	2.90	3.22	/
	项目寿命期（年） Project life (yrs)	20			25		
	操作工 No. of operators	操作工2人，人均年薪6万元，社保福利为工资的45% 2 operators, average annual salary of CNY 60k, social benefit is 45% of salary			操作工3人，管理员1人，人均年薪6万元，社保为工资的45% 3 operators and 1 manager with average annual salary of CNY 60k, social benefit is 45% of salary		
	维修费 Maintenance	维修费：按投资的1%计提; 1% of investment			按总投资的1%计提; 1% of investment		
	房租 Rent	锅炉房土地1000平米，年租金180万元 1000 m2 of boiler house with annual rent of CNY 1.8 million			土地政府划拨，无成本 Government provided without cost		
	节能奖励（万元） EE reward (CNY 10000)	0			0		
	投资补贴 Investment subsidy	无			仿照北京，提供总投资10%的投资补贴 10% of total investment as subsidy in a similar way as Beijing		
	基准收益率 IRR benchmark	10%			10%（天然气发电项 gas to power generation project)		

方案二在供热价格、上网电价、天然气价格、投资补贴上需要政策激励

基本假设 Basic Assumption

太阳能光伏项目 Solar PV project

装机容量 Installed capacity	35.00	MW
年发电时间 Annual generation hours	985.94	hrs
上网电量 Electricity supplied	34.51	GWh
上网电价 Feed-in tarriff	1.00	CNY/KWh
电价补贴 Price subsidy	0.62	CNY/KWh
单位投资 Unit Investment	8,500	CNY/KW
项目寿命 Project life	20	years
年度衰减率 Annual degradation rate	0.80%	
年运行维护费 Annual O&M	1.50%	of investment
节能设备投资10%抵扣所得税 IT rebate	10.00%	of investment

能源管理中心 Energy Management Center

总投资 Total Investment	75.75	m CNY
项目寿命 Project life	10.00	yrs
节约电费-商业 Electricity cost saved	29.25	m CNY
节约供热费 Heating cost saved	0.10	m CNY
削峰量 Peak power removal	23.44	MW
削峰净效益 Net benefit of peak reduction	1,000	CNY/KW
节能效益分享率 Sharing ratio of energy savings	70%	
削峰效益分享率 Peak reduction benefit sharing ratio	25%	
节能率奖励 Energy saving reward	n.a.	
年运行成本 Annual O&M cost	6.46	m CNY

单项节能措施财务分析
Financial Analysis of Standalone Energy Efficiency Measures

CHP/DCHP		方案一 Option 1	方案二 Option 2
投资范围 Investment Scope		新增2台15t/h燃气锅炉；利用现有冗余CHP机组发电供热能力 Add two 5t/h gas-fired boilers with utilization of currently redundant CHP capacity	配置5台单机为2M合计10MW的DCHP机组，CHP侧加上2台10t/h的燃气锅炉 Equip with 5 sets of 2MW DCHP units and add 2 sets of 10t/h gas-fired boilers in CHP side
计算结果 Cal. Result	内部收益率 IRR	118%	6.4%
	简单投资回收期（年）Payback (years)	0.85	12.17

能源管理中心 EMC	
IRR	16.6%
简单投资回收期 Simple payback	4.73

Solar PV	
投资回收期 Payback	7.36
IRR	11.34%

打包项目财务分析 Financial Analysis of Bundled Project

融资计划

	权重 Weight	收益率 Cost of Capital	期限 Term（年/Year）	宽限期 Grace Period（年/Yr）
股权 Euity	30%	12.0%		
国内贷款 Domestic loan	30%	6.5%	7	1
IFI贷款 IFI loan	40%	3.8%	15	10

如果IFI贷款可获得，即使不要求任何新的激励政策，股权资本投资收益率仍18.4%.
If IFI loan is available, without requiring anyadditional incentives, equity IRR can still reach 18.4%

DCHP+EMC+Solar PV

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
静态总投资 Static total investment	496.3																		
股权 Equity	148.9																		
国内长期贷款 Domestic long-term loan	148.9	153.7	131.9	108.8	84.1	57.8	29.8	-0.0											
国际金融机构贷款 IFI loan balance	198.5	202.3	202.3	202.3	202.3	202.3	202.3	202.3	202.3	202.3	202.3	202.3	161.8	121.4	80.9	40.5	-		
净收入 Net revenues		114.5	114.1	113.7	113.3	112.9	112.5	112.1	111.7	111.3	110.9	84.1	83.8	83.4	83.0	82.6	82.3	81.9	81.6
附加费 Affiliated fees		1.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
燃料成本 Fuel cost		27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
运行维护费用 O&M costs		8.7	8.9	8.9	13.4	13.4	13.4	13.4	13.3	13.3	13.3	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
折旧 Depreciation		27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
国内贷款利息 Domestic loan interest	4.8	10.0	8.6	7.1	5.5	3.8	1.9	-	-	-	-	-	-	-	-	-	-	-	-
IFI贷款利息 IFI loan interest	3.8	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	6.1	4.6	3.1	1.5			
税前利润 Before-tax profit		31.9	50.1	49.7	44.9	44.5	44.1	43.7	43.3	42.9	42.5	29.8	29.4	29.1	28.7	28.3	28.0	27.6	27.3
所得税-激励前 Income tax-before incentive policy		8.0	12.5	12.4	11.2	11.1	11.0	10.9	10.8	10.7	10.6	7.5	7.4	7.3	7.2	7.1	7.0	6.9	6.8
节能投资抵税余额 Tax credit balance	29.8	21.8	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
所得税-激励后 Income tax-after incentive policy		-	-	3.2	11.2	11.1	11.0	10.9	10.8	10.7	10.6	7.5	7.4	7.3	7.2	7.1	7.0	6.9	6.8
税后利润 Net income		31.9	50.1	46.5	33.6	33.3	33.1	32.8	32.5	32.2	31.9	22.4	22.1	21.8	21.5	21.3	21.0	20.7	20.5
DCHP项目投资补贴 DCHP inv. Subsidy	10%		12.3																
国内贷款本金支付 Repaym't of domestic loan principal		21.8	23.2	24.7	26.3	28.0	29.8	-	-	-	-	-	-	-	-	-	-	-	-
IFI贷款本金支付 Repayment of IFI loan principal												40.5	40.5	40.5	40.5	40.5			
现金流 Cashflows	-157.4	37.5	66.6	49.2	34.7	32.7	30.6	60.1	59.8	59.6	59.3	1.7	1.4	1.1	0.9	0.6	40.8	40.5	40.2
累计现金流 Accumulated cashflows	-157.4	-120	-53	-4	31	63	94	154	214	274	333	335	336	337	338	339	379	420	460
IRR	27.8%																		
简单投资回收期 Simple payback	3.12																		

打包项目财务分析 Financial Analysis of Bundled Project

融资计划

	权重 Weight	收益率 Cost of Capital	期限 Term（年/Year）	宽限期 Grace Period
股权 Euity	30%	12.0%		
国内贷款 Domestic loan	70%	6.5%	7	1
IFI贷款 IFI loan	0%	3.8%	15	10

如果IFI贷款不可获得，则需要保持价格、减税政策优惠来确保15.2%的股权IRR（如果不考虑分享削峰效益及减税优惠，节能分享比例提高到80%，则股权IRR为12.5%）
If IFI loan is not available, price and tax incentives are needed to ensure 15.2% of equity IRR(12.5% if peak reduction benefit sharing or tax incentive not considered while energy savings sharing ratio is lift to 80%)

DCHP+EMC+Solar PV

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
静态总投资 Static total investment	496.3																		
股权 Equity	148.9																		
国内长期贷款 Domestic long-term loan	347.4	358.6	307.9	253.8	196.2	134.9	69.2	-5.2											
国际金融机构贷款 IFI loan balance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
净收入 Net revenues		114.5	114.1	113.7	113.3	112.9	112.5	112.1	111.7	111.3	110.9	84.1	83.8	83.4	83.0	82.6	82.3	81.9	81.6
附加费 Affiliated fees		1.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
燃料成本 Fuel cost		27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
运行维护费用 O&M costs		8.7	8.9	8.9	13.4	13.4	13.4	13.4	13.3	13.3	13.3	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
折旧 Depreciation		27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
国内贷款利息 Domestic loan interest	11.3	23.3	20.0	16.5	12.7	8.8	4.8	0.8	-	-	-	-	-	-	-	-	-	-	-
IFI贷款利息 IFI loan interest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
税前利润 Before-tax profit		26.3	50.1	49.7	44.9	44.5	44.1	43.7	43.3	42.9	42.5	29.8	29.4	29.1	28.7	28.3	28.0	27.6	27.3
所得税-激励前 Income tax-before incentive policy		6.6	12.5	12.4	11.2	11.1	11.0	10.9	10.8	10.7	10.6	7.5	7.4	7.3	7.2	7.1	7.0	6.9	6.8
节能投资抵税余额 Tax credit balance	29.8	23.2	10.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
所得税-激励后 Income tax-after incentive policy		-	-	1.8	11.2	11.1	11.0	10.9	10.8	10.7	10.6	7.5	7.4	7.3	7.2	7.1	7.0	6.9	6.8
税后利润 Net income		26.3	50.1	47.9	33.6	33.3	33.1	32.8	32.5	32.2	31.9	22.4	22.1	21.8	21.5	21.3	21.0	20.7	20.5
DCHP项目投资补贴 DCHP inv. Subsidy	10%		12.3																
国内贷款本金支付 Repaymt of domestic loan principal		50.8	54.1	57.6	61.3	65.6	74.5	14.0	-	-	-	-	-	-	-	-	-	-	-
IFI贷款本金支付 Repayment of IFI loan principal												-	-	-	-	-			
现金流 Cashflows	-160.0	2.9	35.7	17.7	-	-	-	46.1	59.8	59.6	59.3	42.1	41.9	41.6	41.3	41.0	40.8	40.5	40.2
累计现金流 Accumulated cashflows	-160.0	-157	-121	-104	-104	-104	-104	-58	2	62	121	163	205	247	288	329	370	410	451
IRR	15.2%																		
简单投资回收期 Simple payback	7.96																		

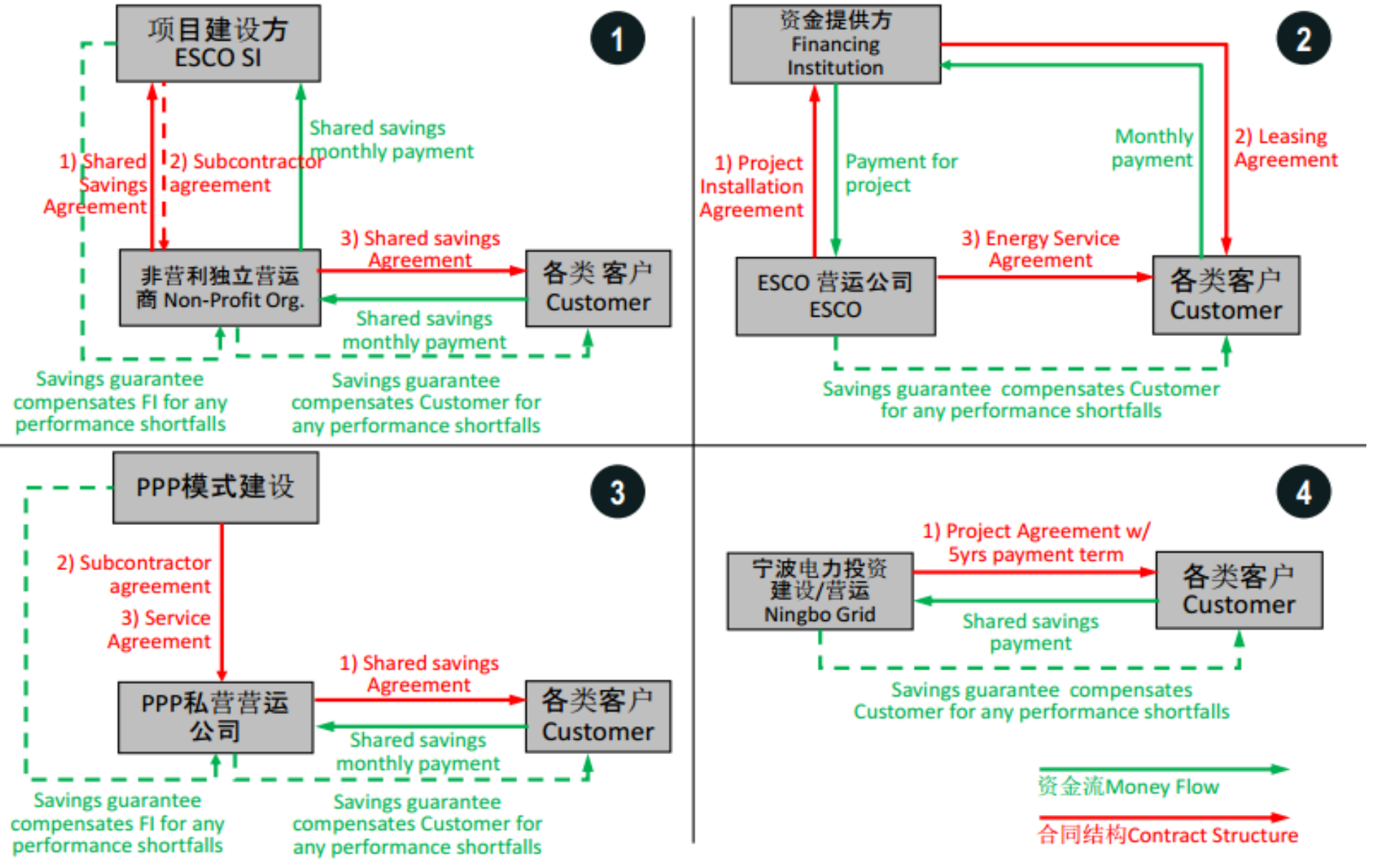
实施主体问题 Issues Related to Implementation Entity

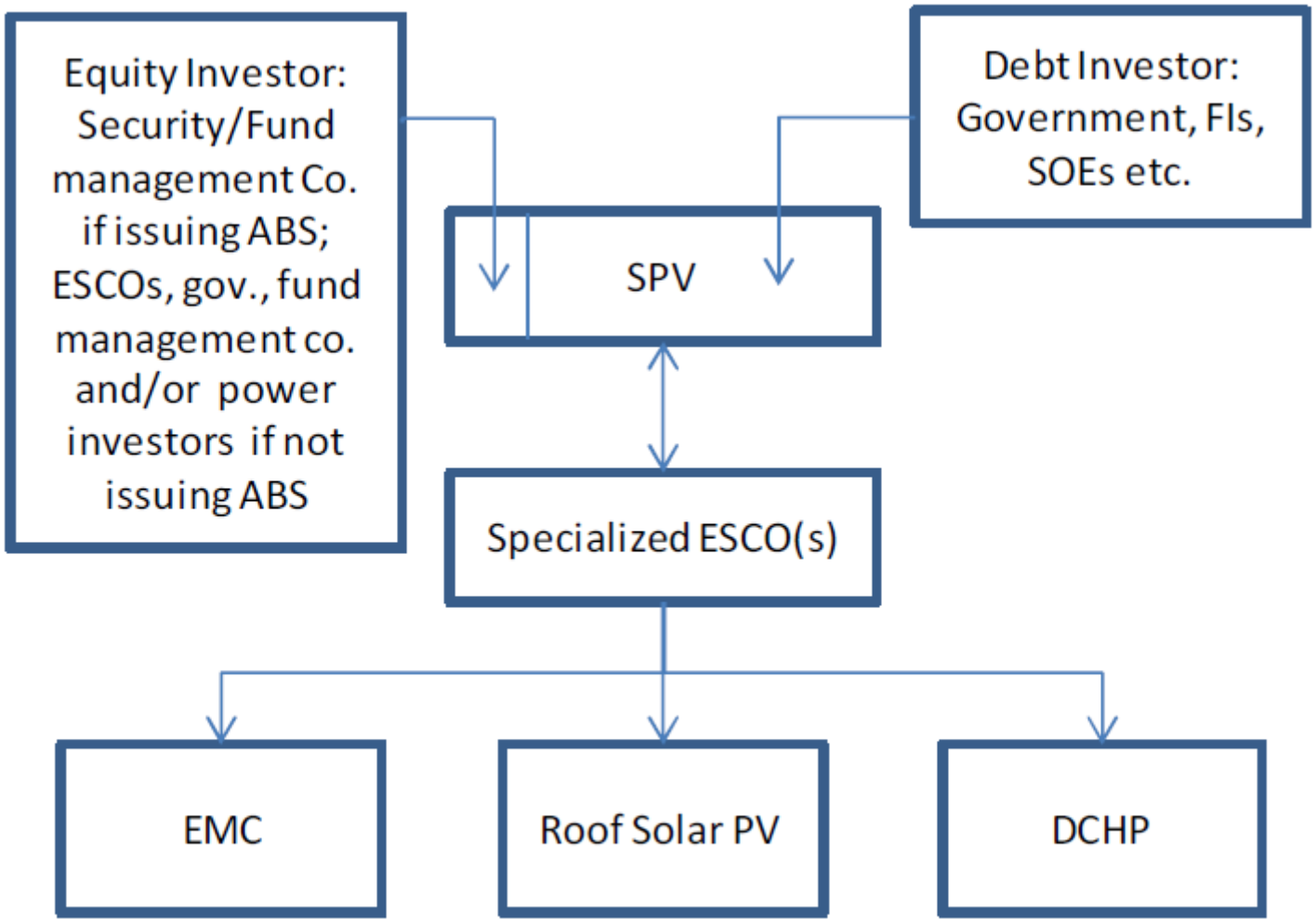
- 单独实施节能措施的话，无需**DCHP**。满足热需求方面实施主体是科丰热电 厂；能管中心可是专业**ESCO**；太阳能**PV**可招标确定行业投资者
  If EE measures are to be implemented separately, there will be no need for DCHP . Kefeng will be the entity to meet incremental thermal demand, professional ESCO could be the entity to invest on EMC, and sector investors could be the entity to implement solar PV through bidding procedure.

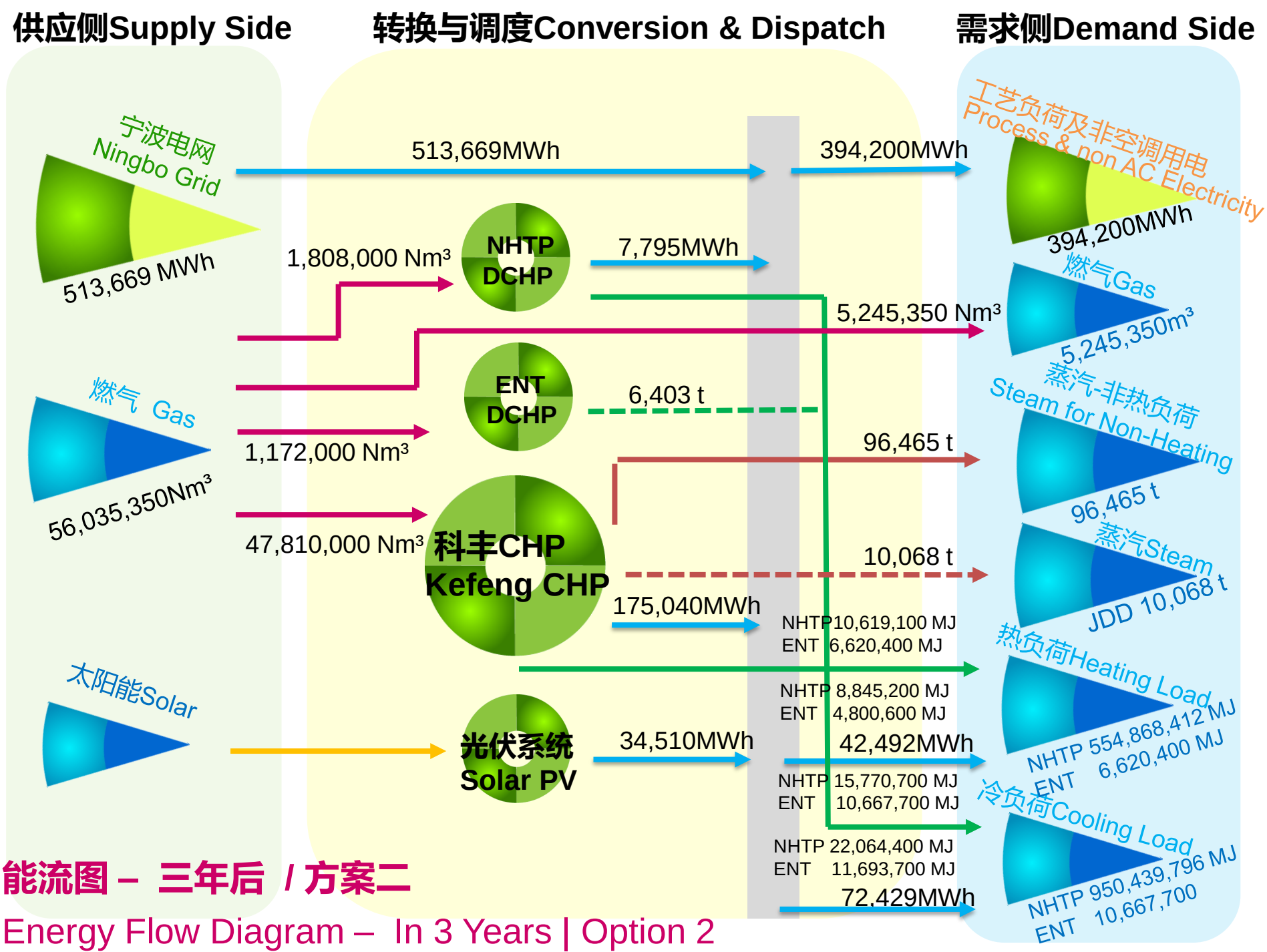
- 如果三项措施打包实施的话，实施的主体最可能是：科丰电厂（或其母公司投 资的关联企业）。候选可供考虑的其它实施主体有：电力投资企业或者少数有实力的**ESCO**公司（比如，电网成立的**ESCO**公司）
  If the three EE measures are to be bundled to implement, the most likely entity will be Kefeng (or its parent company affiliated subsidiaries). Other candidates include: power sector investors, or some large ESCOs (such as grid affiliated ESCO)

- 打包项目最好采用**ESCO**模式来实施。可采用**PPP**融资模式
  Had better to use ESCO model for implementation of the bundled project. PPP mechanism could be used for financing.

能源合同管理与营运模式思考 EPC & Operation Models




Equity Investor: Security/Fund management Co. if issuing ABS; ESCOs, gov., fund management co. and/or power investors if not issuing ABS
Debt Investor: Government, FIs, SOEs etc.
SPV
Specialized ESCO(s)
EMC
Roof Solar PV
DCHP



能流图 – 三年后 / 方案二

Energy Flow Diagram – In 3 Years | Option 2

Thank you!