

**REPORT ON THE BENEFITS  
INTEGRATED DISTRIBUTED ENERGY  
AND THERMAL STORAGE  
TECHNOLOGIES FOR DISTRICT  
COOLING IN THE ASIAN MARKETS**

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## Integrated Distributed Energy 综合性能源生产系统

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For the fast growing Chinese economy one challenge that must be met is the demand for generation and distribution of electricity, heating and cooling services to newly urbanized and industrialized areas or districts. In planning for meeting these demands governmental and regulatory bodies should consider technologies that reduce consumption of fossil fuel resources and also reduce the emission of atmospheric pollutants. Simply stated, the goal should be efficient energy supply with minimal environmental impact. One such technology offered today by forward looking companies is referred to as Integrated Distributed Energy (IDE).

在中国经济快速成长的各种挑战中“电力及冷热源”的生产及输送实在也是一不可低估的重要项目特别是在新城市的建立及大型工业区的开发上更是不可忽略的课题。在计划如何适当的解决这些必要的设施时, 政府及管理单位应该充分考虑可能适应的技术, 如何降低石化煤等燃料的消耗及减少其对大气的污染。简单来说, 主要的是在对大气最少的污染情况下有效的运用能源。一个现代最先进的考虑就是所谓“综合性能源生产系统 - Integrated Distributed Energy (IDE)- IDE 技术”。

For the purpose of this discussion IDE technology will be compared to the use of combustion turbine generators (GT) for electric power supply. Due to the relatively low cost for construction when compared to other forms of power generation, and a shorter construction time requirement, combustion turbine generators are frequently used when additional electric power is needed for a developing district. A combustion turbine engine burns a fossil fuel such as natural gas to run a generator that produces electric power at a full load output versus fuel input efficiency ratio of approximately 35%. Since electric loads in a district vary considerably from summer to winter and even within each day between day to night, the average annual efficiency of a gas combustion turbine can be expected to be lower than this full load value.

我们要首先讨论是 IDE 技术与一般燃烧涡轮 GT 发电系统的比较。与其他发电系统比较 GT 燃烧涡轮系统是比较便宜及所需建造的时间比较其他方式要短的系统, 因此 GT 发电系统常常在一开发地区需要更多电力时采用。燃烧涡轮一般多用天然气燃料来生产电力, 其需要燃料能源的消耗与真正电力的生产比较, 其效率在最高(最有利)负荷情况下约 35%。而一般城市小区冬夏季节及每天白天与晚上需求差别之差, 使得这样的电力生产的平均年效率更远远低过这全负荷状态。

Gas combustion turbine engines emit nitrous oxide and carbon monoxide as well as other pollutants to the atmosphere. The emissions are relatively low at full load

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operation but increase as the load factor on the generator is reduced. The annual electric load factor for most of the areas in China will fall between 45% and 55% and as a result, even allowing for the staging of generation equipment, the emissions from the combustion turbine engines become a major source for air pollution.

天然气燃烧涡轮在运转时会发放氧化氮及一氧化碳等不良污染物于大气间。但是在全负荷情况下其污染物的发散比较少,但在负荷情况降低时,发电机之“负荷系数”降低时逐渐增多。中国多半的地方其负荷系数在 45%之 55%之间,因此即使利用分段式来运转发电,这燃烧涡轮发电时的污染仍然是一大问题。

IDE technology integrates the electric power supply with the heating and cooling requirements for the district that is to be served. For this technology to be cost effective the location of the electric generating equipment will be near the district being served so that the heating and cooling pipes will not have long distances to run in order to serve the respective loads. This configuration of electric generation is considered distributed generation as opposed to centralized generation.

IDE 技术是将区域发电与供热供冷系统的联合运转。这系统最有效如果能够将发电设备能源中心设置在负荷需要的地方不需要做长程的输送。这种做法是所谓“分布”式而非“中央”式发电。

The basic design principle that is incorporated into IDE technology is the maximization of energy recovery from the flue gas that is discharged from combustion turbine engines. The first step taken to implement this technology is to run the flue gas through heat recovery steam generators (HRSG). A HRSG is bank of tubes that are mounted in the exhaust stack that is connected to a combustion turbine engine. Essentially, it is a boiler. Water is circulated to the tubes where heat from the flue gas (about 980°C) that surrounds the tubes boils the water and creates high pressure steam. The steam is then used to turn a turbine (STG, steam turbine generator) which generates electric power to add to the electric power generated by the combustion turbine.

IDE 技术的设计主要点是尽量利用燃烧涡轮排气余热的能源回收。第一部系统的增加是在燃烧涡轮排气上装置热回收蒸汽锅炉(HRSG)。HRSG 是许多排的钢管让高温的燃烧涡轮排气适当的流过。锅炉的热水进这些高温排气(约 980°C)排管而过产生高压蒸汽。再利用这高压蒸汽推动蒸汽涡轮(STG)而发电,这些电力再同时加入燃烧涡轮所发之电中。

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Steam then exits the turbine at a lower pressure and is used to provide cooling through mechanical or absorption water chilling equipment, and heating either directly or by converting to hot water through steam to water heat exchangers.

低压蒸汽在离开蒸汽涡轮後可以再被利用由机械式或者吸收式设备来制冷與直接利用低压蒸汽或者再进热交换器产生热水输送至负荷区供冷及供热.

Thermal storage is incorporated into both the heating and the cooling systems. This is done to allow maximization of the energy recovery during periods when the demands for electric power and thermal services are not well matched. Cool thermal storage is also used during warm weather periods to pre-cool the air which enters the gas combustion turbine engines. This process increases turbine output capacity by up to 25% over the capacity that would be available without the inlet air cooling.

热量储蓄设备可以再设计于供冷及热的系统中. 这样可以充分的利用特别是在冷热量與发电量不能相符对等时. 冷量的储蓄更可以运用来在夏季经济的降低蒸汽涡轮的进风温度. 这种方式较传统式蒸汽涡轮直接用外气进风的发电量提高至 25% 以上之多.

Figure 1 & 2 present the basic flow diagram and floor layout of the IDE power plant that has been described above. The configuration of cooling and heating plants that are part of the IDE technology vary with the specific applications and therefore is not shown in detail.

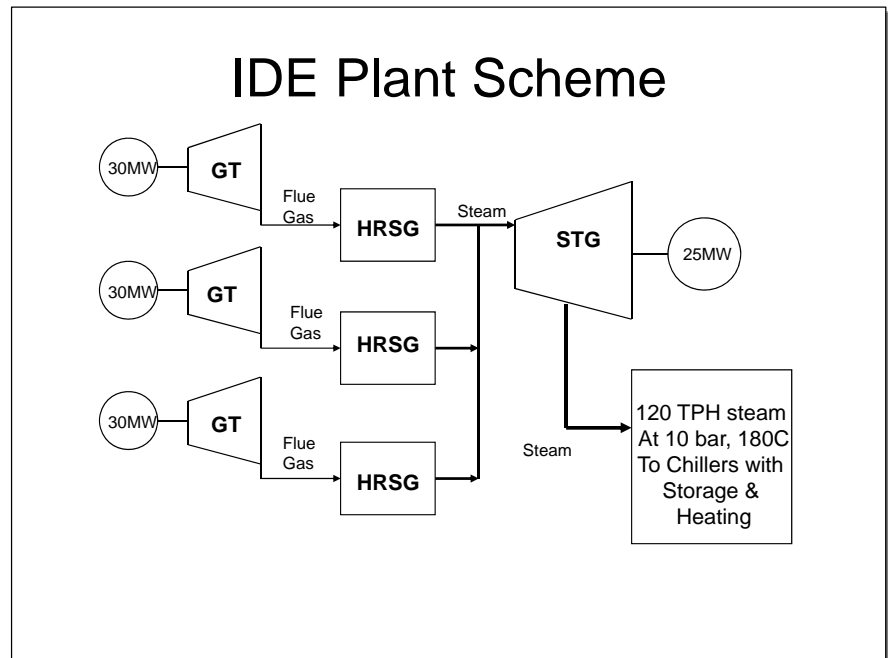


FIGURE 1

下面图式一及二是上面所叙基本 IDE 工程的程序图及机房布局. 有关供冷及供热系统没有表示因为这些系统要看下游的设备需要再为修改.

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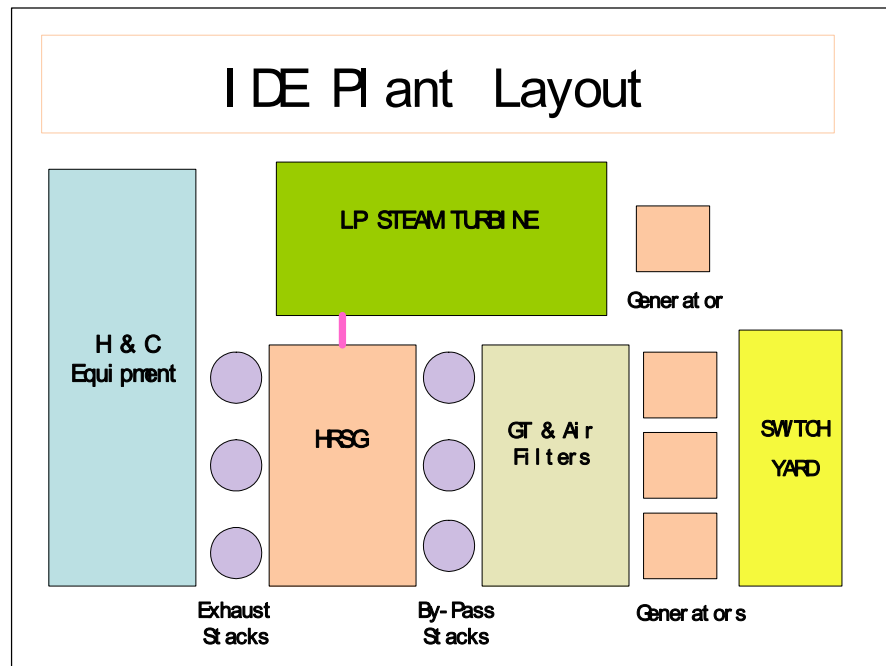


FIGURE 2

The energy recovery techniques, used to generate additional electric power as well as to provide heating and cooling, are part of IDE technology which increases the total plant energy output versus fuel input efficiency ratio. When using IDE technology up to 80% of the fuel consumed at the design rated capacity is converted into usable energy services. This is significantly greater efficiency than the 35% output versus fuel input efficiency ratio provided by conventional electric power generation without energy recovery.

这项能源回收技术产生更多的电力及冷热量也是 IDE 技术的一部分同时提高了全厂能源制造量与燃料比较的生产效率.利用这项 IDE 技术 80%燃料可以全部在这生产过程中变为有效的能源产品. 与传统式燃烧涡轮发电无回收系统的 35%效率比较, 这确实非常显著的增强了全程的效率.

Due to the incorporation of thermal storage peak use of electricity for summer-time air conditioning is reduced by 25% to 30% depending upon the particular application details. Since air conditioning makes up approximately 60% of the electric power requirements in a typical district, a total reduction in the installed electric generating capacity of 15% to 18% can be achieved. Reduction of the generating capacity while shifting the kWh consumption (required to store the cooling) to lower electric use hours

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improves the load factor of the generating equipment by a proportionate amount. Thus, an average annual electric load factor that had been 55% will be increased to 65% to 67% if IDE technology is selected. This will in turn mean better combustion efficiency and lower emissions of pollutants at the higher percentage of load.

因为增加了热能储蓄设备夏季空调尖峰负荷电力的消耗量在不同终端设计情况下可以降低到 25%至 30%之巨. 空调一般在现代区域用电量上占到 60%之巨,因此利用这项系统全部电力装置量也同时能够降低 15%到 18%之巨. 利用尖峰 kWh 转移到低谷时间(必须采用储冷技术), 电力生产量的需求也降低, 同时比例性的增强了发电设备的负荷系数. 因此一般“全年平均电力负荷系数”的 55%也因为利用 IDE 技术而可以增加到 65%到 67%左右. 这样同时也是增强了燃烧效率及降低了污染的放射

The key to maximization of total plant energy efficiency that is provided by IDE technology is the ability to balance demand for electric power with the use of thermal services. The components that are most important in achieving the necessary energy balance are the thermal storage and control and energy management sub-systems. IDE technology places emphasis on the proper design and selection of these components in order to meet the goals of efficient energy supply and minimal impact on the environment.

在 IDE 技术上最重要也就是能够提高全厂能源效率重要之处是能够适当的平衡电力及冷热量需求. 而最重要的一部分就是如何适当的运用储热系统及所有其他子系统设备能源的控制运转. IDE 技术特别讲究设计及选择系统设备尽量减少对外界环境的影响.

The total ownership costs for plant facilities that are constructed using IDE technology is lower than those same costs for plant facilities that do not integrate the supply of electricity with that of heating and cooling services.

IDE 技术的全部工厂设施及输送的营造价比较其他同样生产相等电量冷热能源的传统系统要便宜,

The construction costs for IDE technology, which include the generation and distribution of electric, heating and cooling services to a district that has at least 4 million square meters of building space, is approximately US\$80 per square meter. This is 8% lower than the construction cost of US\$87 per square meter for electric generation and distribution plus individual building heating and cooling facilities. The primary reasons for the lower construction costs are as follows:

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以一四百万平方米楼宇小区来计算,IDE 系统工程包括发电生产冷热能源及输送系统造价大约在美金八十元一平方米左右. 这大约比传统发电输送及冷热能源的输送同样的楼宇面积估计的美金八十七元一平方米要便宜 8%. 主要能够便宜是因为下列原因:

- ✦ The installed capacity of power generation is at least 38% smaller for IDE technology. This is due to 1) diversity of cooling loads among building in the district that reduces the installed cooling capacity, 2) use of thermal storage to reduce the connected chiller electric load, 3) use of inlet air cooling to boost outlet capacity of the combustion turbine engine.

IDE 系统设备的装置量至少要小 38%. 这是因为 1)各个楼宇相互间运用量的同时使用率的影响减低了中央装置量 2)利用储热设施降低了冷量装置的需要 3)利用燃烧涡轮进风降温技术大量的增加了燃烧涡轮电量的生产.

- ✦ The cost of electrical distribution is lower because the connected electric load at each building does not include electric service for cooling equipment.

电力输送的造价降低因为各个大楼电量的需求不包括制冷设施.

- ✦ The cost of heating and cooling equipment, as well as all building components required to support this equipment, for the individual buildings is eliminated. The cost of the heating & cooling equipment in a plant using IDE technology is less than the individual building equipment due to the diversity of building loads and the economies of constructing the cooling plant in one or two locations rather than at every building.

在各个大楼内无需设置制冷设备及装置设备的机房. 利用 IDE 技术生产冷热源的造价也比较在各个大楼内自己设置冷热源的设备要便宜多因为由于大楼间的同时使用率存在使其装置量的大量减少及在小区建造一两个能源中心比起在每一大楼建造有非常可观的经济性.

- ✦ The cost of distribution of cooling within each building is lower due the use of 1°C chilled water that is available from a plant using IDE technology.

因为 IDE 系统利用 1°C 冰水作为冷源的输送使得输送管道的造价减少.

The operation and maintenance costs for the electric, heating and cooling facilities using IDE technology are approximately one-half of the same costs for the facilities that do not integrate the supply of electricity with that of heating and cooling services. The primary reasons for this are:

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在电力及冷热源系统设备运转及维修保养方面利用 IDE 较传统式要节省一半以上, 主要因为下列原因:

- ✦ As detailed above the fuel consumption, and therefore the fuel costs, for a plant using IDE technology is at least 50% lower than conventional electric generating facilities.

如上述燃料的消耗, 也就是燃料的采购价值要比传统式低一半.

- ✦ The number and total capacity of the installed electric generating, heating and cooling equipment is at least 25% less than conventional electric generation equipment plus individual building heating and cooling equipment. The maintenance costs will therefore be lower.

装置电力及冷热源生产设施量较传统式要少 25%, 再加上各个大楼本来要装置的冷热源设施. 保养维修费用也跟作降低.

- ✦ The equipment will be installed in a few plants as opposed to at each individual building. As a result the number and cost of operators will be reduced.

因为能源站少, 运转人员也跟作大量的减低.

### Environmental and Societal Benefits.

#### 环境和社会效益

- ✦ Nitrous oxide, carbon dioxide and sulfur emissions from power generating plants are reduced as a result of the use of nighttime power to generate thermal storage. During the nighttime power plant efficiency is increased and losses in the electrical transmission grid and distribution systems are reduced. These factors combine to reduce the burning of fossil fuels at power plant sites and create the subsequent reduction in emissions resulting from the fossil fuel use.

利用夜间电力进行蓄冷, 可减少电厂一氧化二氮、二氧化碳和硫化物的排防量。夜间电厂效率提高, 电力变送损失减小, 这些因素综合作用, 可减少电厂原料燃量, 从而显著减低燃烧排防量

- ✦ The amount of iron ore for steel and other natural resources that have to be converted into cooling equipment is reduced through economies of scale that result from combining cooling plants in many buildings into one system. A net



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reduction in the use of materials for construction of a business district also result from the use of thermal storage to reduce the installed chilling and power generation capacity. While the amount of resources saved will vary depending upon the specifics of each project a conservative average value for the reduction is 45 kilograms of materials per 100 square meters of total developed space. Thus, using district energy technology in a 4 million square meter development will result in the savings of over 1,800 metric tons of materials.

将多个建筑物内的冷冻站合并并在单个区域供冷系统中，扩大供冷经济规模，可减少供冷设备的使用量，相应减少用于设备制造所需的钢铁用量，减少铁矿和其它自然资源的消耗量。采用储能系统，减小供冷和电力装机容量，可节约商业区域建设耗材。每个不同的项目，资源节约量不同，按照总体开发面积计算，每 100 平方米平均节约 45Kg 材料，在 400 万平方米的开发区域采用区域能源技术，可节约材料 1800 吨以上

The conservation of raw materials will be greater due to losses in processing. Further, the energy required for processing of those raw materials can be diverted to other uses.

考虑加工过程的损失，自然资源的节约会更大，而加工这些材料所需的能源，可满足其它需要

- ✚ The noise, vibration and the vapor plume that would be caused by refrigeration equipment at each of the buildings is eliminated. This allows for creation of an improved environment for the use that was intended for the building. This can be particularly important for building users such as cultural centers, libraries, television and radio broadcast studios, scientific research facilities, product research & development buildings, hospitals, and performing art centers.

消除每个大楼内制冷设备产生的噪声、振动和水雾，改善大楼的使用环境，这对于类似文化中心、图书馆、电视广播、科研设施、产品研发大楼、医院和文艺演出中心等应用场所尤其重要

- ✚ IDE relies on the use of HFC refrigerants in its cooling plants. The total amount of refrigerant installed in refrigeration equipment is 30% to 50% lower than would be installed with other water chilling technologies and 50% lower than would be used in the individual split system air conditioning that is prevalent in many area of China. As a result global warming and ozone depletion potential of all cooling

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plants using IDE technology will be significantly reduced when compared against these other cooling services.

IDE 冷冻系统采用 HFC 冷媒，与其它常规制冷系统相比，其制冷设备所需的冷媒用量低 30%~50%，而与目前中国普遍使用的分体空调相比，则低 50%。与其它供冷服务相比，采用 IDE 技术，对减低全球温室和臭氧消耗具有积极作用

Further, since all components that could potentially leak refrigerant to the atmosphere are contained within one to a few plants rather than in many different buildings, the risk for leakage is reduced ten fold.

此外，所有部件都存在冷媒泄漏的可能，与安装在许多大楼内相比，这些部件集中在一个或少数几个冷站内，泄露风险减低 10%

- ✦ Cities or large commercial development benefits from inclusion of district cooling and heating services as part of the infrastructure that they make available for prospective property developers. Such infrastructure services are not available in all locations and as a result including these provide those cities or developments with monetary advantages over areas competing for the same developers.

作为市政基础设施的一部分，区域供冷和供热服务如果可供房产开发商利用，城市或大型商业开发区可因此获益。相对于没有此类市政基础服务的所有区域，拥有该类设施的城市或开发区，与同类开发商竞争时，在投资方面具有优势

- ✦ In April 2001 edition of ASHRAE Journal, Wang Qingqin wrote the following regarding the need for the type of technology that Integrated Distributed Energy offers in the People's Republic of China:

ASHRAE2001 年 4 月刊中王清勤所撰写的文章，谈及了综合性能源生产系统在中国推广的该类技术的需求:

*“Preferential policies are needed to promote the widespread use of Thermal Energy Storage (TES) systems. Local governments should award the users who adopt TES technology to shift Peak power load to off-peak time. The preferential policies should benefit power companies, TES investors and users. It is necessary to import, assimilate and Absorb new and advanced technologies from abroad.*

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*We may first cooperate with TES manufacturers and companies, and set up some demonstration projects. For the advanced technologies suited to China, we should import or set up joint ventures. All types of TES systems should be studied and developed for different applications. The new TES system should shift peak load to off-peak time and reduce energy consumption. This would make it easy to extend a TES system. Air-cooled heat pump chillers are used in many small and medium buildings. There is a need to develop and install TES type heat pump installations to shift loads and save power*

*“蓄冰系统 ( TES ) 获得更广泛应用推广需要优惠政策鼓励，当地政府应对利用蓄冰系统 ( TES ) 将高峰电力转移到低谷时段的用户进行奖励，优惠政策应惠及电力公司、蓄冰系统 ( TES ) 投资方以及用户。有必要从国外引进、吸收和消化新的先进技术，首先应与蓄冰系统制造商和公司合作，建设一些示范工程。引进适用于中国的先进技术，或成立合资公司，应针对不同的应用研究并开发各种类型的蓄冰系统。新型蓄冰系统应能将高峰负荷转移到低谷，并能减少能耗，这有利于扩大蓄冰系统的应用。风冷热泵机组应用许多小型或中等规模建筑中，有必要开发并安装蓄冰类热泵系统，转移负荷并节约能源*

*The cold air supply system has the benefits of low investment, the reduction of peak electrical consumption and running cost, and the savings of building area and space. However, the design method and equipment manufacturing need to be studied and developed. The equipment related to cold air-distribution system in-April 2001 ASHRAE Journal 5.5 includes air-handling units, air supply outlets, heat exchangers, air terminals, etc. Codes and standards related to cold air systems need to be compiled. TES technology is unfamiliar for most engineers in China, so codes and technical measures for the design, installation, commissioning, maintenance of TES systems, and to strengthen the related technical exchange and training are needed”.*

*低温送风系统具有低投资、减低高峰电力用量和运行成本、节省建筑面积和空间等许多好处，但在设计方法和设备制造加以研究开发。在ASHRAE2001年4月5.5刊中介绍的低温送风有关设备包括空气处理机、送风口、换热器、送风末端等，应符合低温送风有关的标准和规范。中国大部分工程师对于蓄冰系统并不熟悉，需要引进有关蓄冰系统设计、安装、调试和维护的规范和技术方法，并应加强相关技术交流和培训。”*

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There are international companies who specialize in the financing, construction and operation of IDE facilities that will serve newly urbanized and industrialized districts. Due to the factors stated above they will provide these services to building customers at a lower cost than can be achieved from most conventional electric power, heating or cooling facilities. These companies provide the opportunity for districts to get the best energy efficient technologies with the associated lower energy cost but without having to pay for the upfront construction costs.

现在有一些国际公司专门愿意负责投资,建造及运转 IDE 设施. 也因为上述原因,它们可以供给同样的能源输送而能够比较传统式的系统便宜. 因此这些公司能够给予小区内客户们经济合算有效的能源而不需要在初期工程付出开发事业的费用.

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