Research on the Planning Framework of Renewable Energy for Heating in China Based on Danish Experience

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Abstract

Building on Denmark's long-term experience, this paper explores district heating as a key pathway for integrating renewable energy and improving energy efficiency. The study points out that district heating can collect waste and ambient energy from various sources and deliver it for building heating, hot water, cooling, and sometimes industrial use. It supports decarbonization, energy security, flexibility, and electricity storage, while reducing primary energy consumption and costs. For governments, it is a key technology for achieving environmental, efficiency, and decarbonization objectives. To fully realize these benefits, comprehensive energy planning is essential. Planning goes beyond connecting buildings—it includes designing infrastructure to use surplus heat, heat from waste incineration, and local energy sources, as well as embedding storage and flexibility mechanisms across energy systems. Effective planning requires reliable heat load and source data, targeted incentives, systematic heat source mapping, multi-dimensional scenario analysis, standardized approval processes, and coordination among stakeholders such as governments, local authorities, companies, advisors, and consumers. If the government leads the process, removes barriers, sets requirements, and adjusts incentives, energy planning becomes a critical tool for achieving policy goals and reducing investor risk. This paper explores how a systematic, holistic energy planning approach can help China transition from a fossil-based to an efficient, renewable energy system, with recommendations for government action.

Key words:

Energy planning, Scenario investigations, socio-economy, Ambient heat sources, Low and high-grade excess heat sources, Multiple heat source design.

0 Introduction

Buildings in cold climates require heating, which can be supplied via various networks and local infrastructure. These systems must be coordinated within urban development, with planning approaches depending on the distribution of responsibilities among government, regional, and local authorities, as well as stakeholder involvement.

New infrastructure planning is often triggered by objectives such as urban development, climate and emission targets, energy resource goals, or transition strategies. Therefore, whether through district heating or individual systems, heating solutions must be deeply integrated with urban development planning and distribution networks to meet these diverse driving objectives.

This paper, a collaboration between the China Renewable Energy Engineering Institute (CREEI) and the Danish Energy Agency (DEA), compares Danish and Chinese heating system planning and explores solutions to accelerate China's transition from a fossil-based to a renewable energy system.

1 Denmark

Fundamentally the Danish society and the political system regarding energy solutions are based on consensus. When government make decisions on Energy policy most parties in parlement participate in the decision making and decisions rarely are changed. Government decides objectives. The Energy sector then immediately starts to find solutions fitting to objectives. Often, the Energy compagnies adjust their own objectives, focus on new solutions, change behavior and start implementing those solutions that can be established without further actions from Government. Heat storage systems, 4th generation district heating and smart meters are examples of implemented solutions developed by district heating sector without Government interference. In other cases, the solutions needed for fulfilling the objectives meet barriers. Government then often has to implement new legislation for removing barriers, making guidelines or introduce tax on unwanted emissions and subsidy for wanted solutions.

Denmark's heat planning strategy has evolved from a focus on district heating in cities with waste heat from power production to an emphasis on flexibility, storage, and integration with other energy sectors to enhance efficiency and reduce emissions.

Heat planning was initiated in Denmark more than 40 years ago. The purpose was to reduce dependency on oil. The 1973 oil crisis demonstrated that total reliance on imported energy could lead to economic crises and massive unemployment when prices increased rapidly within short time intervals. To reduce dependency on imported energy, the Danish government developed several objectives, one of which was energy planning, including heat planning.

（1）One of the first key insights Denmark recognized when planning to minimize oil consumption was the importance of energy conservation. From the outset, it was evident that using waste energy from power production in large cities for heating was a cost-effective solution that significantly reduced primary energy consumption in both the heating and power sectors. As a result, combined heat and power (CHP) systems were established alongside urban district heating networks. To ensure the technical feasibility and achieve economies of scale, citizens were required to connect to these heating networks. Following the liberalization of the power market, the design of new CHP capacity in Denmark changed. New plants are today designed based on heat demand in the heating network, thereby eliminating heat loss from power-only production. This is the first reason for heat planning—energy conversation by utilizing excess heat from CHP plants to heat buildings.

（2）Additionally, Denmark has established district heating in areas without available excess heat from power plants. Large-scale district heating systems are more efficient and cost-effective than individual heating technologies, even when network heat losses and additional investments are considered. In extensive heating systems, efficient base-load equipment can be combined with cost-effective peak-load equipment, leading to lower total investment costs compared to individual heating solutions. Moreover, large district heating systems enable the utilization of locally available heat sources, such as surplus heat from industrial production or cooling processes—something not possible with individual heating solutions. This is the second reason for heat planning—cost efficiency and the economic advantages of district heating compared to individual solutions.

（3）In the 1980s, Denmark began producing natural gas and oil from domestic fields to reduce dependence on imported fossil fuels. At the same time, Denmark needed to determine the best use for the natural gas extracted from these fields. A key realization was that CHP plants can only co-produce heat and power when sufficient heat demand exists. However, heat and power demand do not always coincide. This asynchronicity can occur on a daily basis, with high power demand during daytime hours, or on a seasonal basis, with low heat demand during summer. To address this issue, Denmark adjusted its heat planning approach in the 1990s. The construction of power-only plants was no longer permitted, and new CHP capacity was built as smaller, decentralized plants using natural gas turbines and engines incapable of power-only production. These CHP plants were integrated with heat storage tanks and peak-load natural gas boilers. As a result, natural gas-based CHP plants operated only up to 12 hours per day from Monday to Friday during periods of high and peak electricity demand. By employing this planning approach, Denmark successfully avoided power-only production during daytime hours and reduced the need for summer power-only generation where heating isn't necessary. The focus of heat planning thus shifted toward district heating and meaningful integration with power production. This is the third reason for heat planning—providing flexibility to the energy system through storage solutions.

（4）In recent years, the share of electricity generated by wind turbines and solar photovoltaics (PV) has increased, replacing much of the electricity previously produced by CHP plants, particularly in the summer. Large base-load CHP plants have reduced their power output and installed heat storage tanks, enabling them to operate at full load when electricity prices are high, regardless of heat demand. CHP plant owners have also invested in electric boilers to generate additional heat when electricity prices are very low. Large heat pumps have been introduced to compensate for the reduced heat output from CHP plants when electricity prices are moderate. Today, CHP plants only operate when electricity prices are exceptionally high—typically when there is little wind or sunshine. Storage systems are used to store heat from electric boilers and heat pumps when electricity prices are low and to store heat from CHP plants when electricity prices are high. This demonstrates that a coordinated mechanism combining CHP plants on the power generation side with electric boilers, heat pumps, and heat storage systems can play valuable roles in energy systems with high shares of fluctuating renewable electricity production. This is the fourth reason for heat planning—utilizing surplus electricity that would otherwise be curtailed. Heat planning leverages district heating's flexibility, energy storage capabilities, and ability to integrate various technologies based on electricity market conditions, energy prices, and the demand for flexibility.

（5）One of Denmark’s only mistakes in this process was the establishment of individual natural gas boilers in areas where district heating would have been more suitable. This decision was made to ensure the financial viability of the natural gas network but ultimately proved suboptimal, as it failed to support flexibility and efficiency. Consequently, Denmark is now reversing this decision. This is the fifth reason for heat planning—district heating can integrate with all other energy systems and provide flexibility.

（6）Finally, Denmark’s heat planning approach aligns well with the climate objectives of the past two decades. The primary focus is on renewable heat sources while simultaneously reducing dependence on imported energy. When renewable energy resources are limited, energy conservation becomes even more critical, emphasizing the importance of utilizing excess heat from waste, industry, the power sector, cooling processes, and other residual energy sources. The utilization of ambient and low-grade heat sources requires advanced district heating networks; after these low-grade heat sources are delivered to heat pumps, their temperature is raised to a usable level before being supplied to the heating network. Most Danish district heating compagnies have begun the transformation of the networks to 4th generation. This is the sixth reason for heat planning—district heating can capture ambient and waste energy from multiple sectors, making society more efficient and competitive.

The Danish energy planning process, designed by the government, prioritizes the use of local renewable resources. This is why local authorities are responsible for the actual planning and approval, while the government's role is to set the framework, establish regulations, remove barriers, and determine incentives.

The district heating compagnies are active when Government decides new objectives. They lobby for removal of barriers and for incentives that help them to implement the wanted solutions. Sometimes solutions create conflicts between for example power and heating sector, and then government needs to evaluate which solutions serves society best by adjusting legislation or guidelines.

It is the main principle in the Danish energy planning system, that multiple scenarios have to be investigated. The best and most feasible solution for district heating company, consumers and even society has to be preferred. The socio-economic evaluation includes pollution costs, which gives incentives for choosing low emitting solutions.

2 China

For decades, China has used the same strategy as Denmark by utilizing waste heat from power production in CHP plants for district heating in cold and severely cold urban areas. In urban areas without available heat from power production, coal or natural gas boilers are often used, both in district heating networks and for individual boilers/stoves. Waste heat from power plants is not utilized outside the 4-5-month heating season and is, therefore, wasted. China has similar climate objectives to Denmark e.g., carbon neutrality. The current dependency on imported fuels is low, and China does not wish to increase reliance on imported natural gas or oil.

In China, urban district heating planning is closely linked to local territorial spatial planning. When a city's spatial plan is updated, the heating system—as a key part of urban infrastructure—also may be adjusted accordingly to align with the revised city master plan. In practice, heating plans are often developed at the project level, focusing on specific areas within a city. These localized studies aim to design tailored heating solutions based on the characteristics and needs of the area. Additionally, national Five-Year Plans, which outline priorities in economic development, public welfare, and other sectors, may not include explicit directives on district heating. However, their overall goals and policy orientation, such as carbon reduction, energy efficiency, energy security, and energy efficiency improvement, can still influence the direction and priorities of local heating planning efforts.

Currently, in China, heat planning focuses on building district heating networks in areas with available and low-cost excess energy from power plants. In urban areas north of the Yangtze River, planning for new large district heating zones is typically included in government objectives when five-year plans are developed and implemented. Final investment decisions are made in cooperation between local authorities and the government, which often subsidizes investments due to a financing system that does not support long-term investments, such as district heating networks, without subsidies. South of the Yangtze River, local municipalities often independently take responsibility for energy planning for district heating. In some cases, district cooling is also considered, and several innovative solutions have been implemented.

District heating network owners in China have incentives for expanding the supply to new buildings with known insulation and predictable heat demand, but the fixed pricing system does not incentivise for expanding the networks to existing buildings with unknown heat demand. The economic risks are too high.

This is a barrier for expanding networks that needs to be addressed. The pricing system in China give district heating compagnies incentives for energy conservation in networks, sub stations and inside buildings, but the temperature requirements inside buildings (> 18 ˚C) is a barrier. Building owners does not face any requirements regarding the installations inside building and consumer behavior have no consequences when it results in inefficient operation of the system. This reduces the district heating sector incentive for energy conservation and planning for expanding networks in China. Currently, for power plants, because power demand dictates plant operations, whether generation costs can be covered mainly depends on the electricity price, and waste heat utilization is not a critical factor. However, the pricing system is undergoing changes, and future reforms will likely result in electricity market prices that make plants more dependent on revenue from heat sales. In a more competitive power market, power-only plants will be the first to reduce production when electricity prices drop. Introduction of capacity payments for ensuring power-only plants stay ready for operation may delay the phase out of power-only plants, but will ensure sufficient capacity and security of supply. In contrast, CHP plants will remain more competitive due to their additional income from heat sales.

In the future, however, the role of heat from CHP plants will decline due to the government's objectives of continuously increasing wind, solar PV, and hydropower generation. Over time, this will lead to a situation where heat output from CHP plants no longer aligns with heating demand. This necessitates a shift in district heating planning regarding heat sources. At the same time, China is at a crossroads. Should China aim for 100% electrification, which could ultimately phase out and replace district heating solutions with building-level electric heat pumps and coolers? Should China instead plan for a flexible and integrated energy system similar to the Danish model? Or should China allow for both solutions, depending on local circumstances, to determine the most suitable approach? These core questions need to be addressed in the planning methodology, taking into account regional characteristics such as climate differences, urban density, and energy resource endowments.

The chosen solutions require a roadmap guiding the transition from the current energy system to the future system. This means strategic energy planning and adjustment of incentives. Future infrastructure networks and heating systems may need to be integrated with broader urban planning, requiring a carefully structured planning process that outlines the necessary steps for the transition—regardless of the final choice. These are the key issues discussed in this paper.

2.1 Stakeholders

The central government sets the legal and policy framework through national five-year plans, which define climate, energy efficiency, and environmental goals. Provinces develop corresponding regional plans aligned with national targets. Subsidies are often included to support implementation.

Provincial and local authorities conduct energy planning but face financing constraints due to short loan repayment requirements. When subsidies from the central government are needed, planning becomes more centralized, especially for district heating projects.

District heating compagnies purchase or produce heat and transport it by a heating network to buildings.

CHP plants are built mainly to meet power demand, with heat as a secondary product. Heat revenue improves competitiveness but does not drive plant development. The transition to renewable heat sources will significantly impact the CHP sector.

Currently, industrial production is developing toward the use of industrial surplus heat as a resource. In the future, industry may play a larger role as both heat consumers and suppliers.

Heat supply companies and energy pricing mechanisms have traditionally relied on fossil fuel-based heating, cooling, and electricity services. The transition to renewable energy must ensure affordability for residents—meaning that heating costs after the transition should not be significantly higher than current fossil-fuel-based heating levels. The current heating fees (yuan/m^2) provide no incentive for energy-saving behavior. Metering and billing could change this.

Universities can provide technical R&D and data support; consulting institutions participate in planning formulation and feasibility analysis; financial institutions influence project direction through financing policies; and landowners affect heating network layout. All these actors may have a significant impact on energy planning in the heating sector.

2.2 Energy planning level

In China, energy planning can involve multiple government levels, from the Central Government down to provinces, prefectures, counties, and townships (subdistricts, towns, and county-controlled districts).

The appropriate planning level depends on the plan's scope, scale, and whether it involves neighboring areas or resources unavailable locally. Provided that a unified planning process is followed, all relevant stakeholders are fully engaged, and cross-regional coordination mechanisms are clearly defined, planning can occur at any level.

Energy planning is commonly used for new urban developments but is also needed for decarbonizing existing district heating systems. This includes replacing fossil-based individual heating with renewable or district heating solutions, and replacing fossil CHP or boiler units with renewable or surplus heat sources.

2.3 Purpose of the energy planning

Energy planning must align with government and provincial objectives, ultimately supporting policy goals such as: （1）Peak carbon emissions by 2030 and carbon neutrality by 2060, without compromising energy security. （2）Modernizing the energy system, including digitalization. （3）Upgrading coal power plants.

These objectives drive local initiatives, like phasing out coal boilers, using waste heat, or renovating heating systems, often led by public bodies, state-owned enterprises, design institutes, or consultants. Feasibility studies typically rely on simplified assumptions, which may cause deviations. Using standardized assumptions and cost-benefit frameworks enables identification of the most cost-effective solutions for carbon reduction.

However, studies are often shaped by pre-existing decisions, such as mandatory coal boiler removal, which can limit exploration of more efficient alternatives or local surplus heat sources. Coal-based CHP can be oversized, leading to waste heat emissions. Early planning at both the provincial government level or central government level may overlook local conditions, including combined heat and cooling, ambient heat, or residual energy sources from industry, farming or forests.

China's short-term funding system often requires investment subsidies to meet tight loan schedules. A more flexible, competitive funding model—prioritizing projects with the lowest cost per ton of CO_2 reduction—could improve efficiency and encourage innovative solutions.

Finally, heat planning should reflect local political and socio-economic priorities, including energy independence, urban livability, noise reduction, local business development, and fuel poverty alleviation, as these factors influence implementation even if not explicitly stated.

3 Energy planning steps

The following chapters will discuss how such a planning system could be designed based on Danish experiences and what regulatory framework would be necessary to support it.

3.1 Organizational setup

The organizational setup for the energy planning process works as a backbone for securing the integration of the plan with other authority plans and for securing acceptance by the politicians, the directly involved stakeholders, and the citizens. The transition of the heating sector from individual heating solutions to renewable distributed solutions or from fossil sources to renewable and/or surplus sources will result in radical changes in heat production, distribution, and consumption locally. Therefore, the Government needs to consider how the energy planning process for district heating solutions should be organized. Is a central approach appointing projects and responsible stakeholders participating in the planning process the best solution or should the responsibility and organizational setup be decentralized to an appropriate local level.

The role of the CHP plants in the organizational setup may be important, because the CHP plants cannot be expected to be the dominant heat supplier in future and may be looking for other ways to get involved in the coming energy system. It may be better to include the CHP plants in the organizational planning setup for getting acceptance and perhaps involvement in chosen solution than the opposite.

In some situations, it may be needed to rethink the ownership of CHP plant, transmission networks and the distribution system for preparing the heating sector to integrate with power sector. If for example the district heating system in the future setup both is going to deliver supply flexibility from CHP units as well as demand flexibility from electric boilers and heat pumps including storages to the electricity system, it is important that these supply/demand flexibility units are optimized together. If not - it can be difficult to realize all benefits from participating in power markets.

3.2 Kick-off event

The first goal is to ensure that all parties understand, agree, and accept the goals for the process and who is involved in the road toward a final energy plan. Everyone needs to know that an important process is starting and stakeholders need to have an opportunity to provide input.

Organize a major, carefully planned, and broadly announced kick-off event. In this event, you present the planning process, the involvement of citizens, stakeholders, and politicians, and provide everyone with the opportunity to get answers to their questions and share their ideas with you.

3.3 Heat Source Mapping

The mapping phase gathers all key information needed for scenario calculations. This includes heat use in housing, services, and industry, expected growth in built area, existing district heating and natural gas infrastructure, and local heat resources such as wind, solar, geothermal, biomass, industrial excess heat, and other low-grade sources usable with heat pumps.

High-quality data is essential. China’s planned heat-metering reform should be followed by public data collection to improve future energy planning.

Screening

Mapping can begin with a brief screening to gain a rough overview of potential district heating areas and identify "low-hanging fruits" based on heat density. This also includes a preliminary assessment of heat sources to estimate their potential scale—whether they can cover 20%, 50%, or even 200% of heat demand. Even small excess heat sources may be valuable as baseload, especially when storage is available, allowing electricity-using or electricity-producing technologies to operate more effectively.

Stakeholders such as consumer groups, housing companies, and utilities may already have relevant data. Excess heat can often be identified through public registers rather than relying solely on company-by-company inquiries.

The initial screening does not need to be included later if more accurate data becomes available, but it helps launch the planning process and identifies where further investigation is needed. Finally, decide which datasets to validate next, balancing effort and value, and determine what data you will collect yourself versus what requires external support.

Adapted mapping

A sufficiently detailed dataset is needed to support reliable calculations in the next phase. Based on the initial screening, it becomes clear which areas require more data and which information is still missing. This usually involves refining earlier data. For excess heat, nearby companies should be contacted directly, as on-site interviews are often necessary due to the process-specific nature of waste heat.

In China, where the heating season lasts only four to five months, renewable and flexible solutions can be challenging because of high peak demand and low annual utilization. To design a feasible district heating system integrated with the power sector, it may be necessary to consider extending the effective heating season by including industrial heat demand, domestic hot water, or even combined cooling-and-heat solutions.

At this stage, decisions are made about which demands and heat sources to include in the scenarios. The resulting adapted mapping must be reliable.

Excess heat survey

Excess heat from industrial processes is highly process-specific, so on-site data collection is essential to avoid overlooking important conditions. Mid- and low-temperature waste heat can be valuable for heat pumps when high-temperature sources are limited. However, efficient use of these sources requires 4th-generation district heating networks—a system equipped with metering devices, temperature control, and digital management capabilities. Without these, heat pumps cannot operate efficiently. Importantly, using excess heat must not replace necessary energy-efficiency improvements within the industry.

4th-generation networks reduce heat losses and allow more low-temperature waste heat to be used. This aligns with China's 14th Five-Year Plan, which emphasizes modernization and digitalization of the energy system. In large cities, such networks can be introduced locally behind the transmission network, with the main system supplying additional heat when local sources are insufficient.

Industries often hesitate to participate because they focus on core business operations and are reluctant to share sensitive data. To address this, it is recommended to establish a direct communication mechanism, clarify that the survey is intended solely for heat planning purpose, and implement a strict data confidentiality system.

3.4 Scenario analyses

The scenario analysis should follow a “from the inside out” method—first evaluating district heating feasibility in the densest urban areas, then expanding outward. The presence of nearby or strategic excess heat sources may justify adjusting this order. The scenario analyses have three main purposes:

(1) Determine heating method for each area.

The analysis identifies whether areas should use individual heating (e.g., heat pumps, biomass, solar thermal) or district heating. District heating is advantageous when using industrial waste heat or flexible electricity-based production, but in low-density areas it may be too expensive. The outcome is typically a three-category map: district heating / maybe / individual heating.

(2) Compare different supply solutions.

Individually heated areas mainly involve energy savings and heat pumps. District heating scenarios combine savings with efficient production technologies, excess heat, and renewables. Because district heating represents major change, it must expand gradually but with a long-term strategy.

(3) Develop the action plan.

The analyses define when actions occur and which stakeholders are responsible. For new district heating projects, responsibilities of local authorities, public companies, or private partners must be clear.

By this phase, much of the future heat-supply map is already drafted. The analyses validate realistic options and eliminate unrealistic ones. Results must directly support the heat plan’s objectives and be detailed enough for hearings and political approval.

Before constructing a district heating system, detailed feasibility studies—such as hydraulic modelling—are required. These should include both present-value calculations for company economics and average heat prices for consumer economics. The analyses should clearly indicate which areas receive which heating solutions, using an appropriate level of abstraction.

3.5 Choose scenarios

The purpose of this step is to decide what should be calculated in the scenario analysis, identify realistic scenarios, and eliminate impossible or undesirable options. Rejected scenarios should be documented to support later discussions and acceptance of the heat plan.

Based on data on heat demand, capacity needs, and available heat sources, areas are categorized according to heat density and distance from heat sources:

Based on data on heat demand, capacity needs, and available heat sources, areas are categorized according to heat density and distance from heat sources: (1) Green zone: suitable for district heating; (2) Yellow zone: has potential for district heating; (3) Red zone: suitable for individual heating.

Scenario analyses focus mainly on green and yellow areas, while outlining solutions for red areas. A common approach is to begin with green areas and assess how far district heating should expand, starting with the most feasible zones.

The aim—following Danish heat planning principles—is to find the socio-economically optimal heat supply. District heating should be used where it benefits citizens. In other countries, where commercial utilities dominate, decisions may focus more on profitability than on socio-economic value.

The heat plan must support China's target of CO_2 neutrality by 2060. Many pathways may exist, but the analysis should concentrate on the most promising options. Once scenarios are defined and data validated, detailed model calculations can begin.

Scenario results must be compared with governmental and company objectives, not only carbon neutrality but any broader goals. Where a power market exists, technologies that produce or use electricity (CHPs, electric boilers, heat pumps) interact with market prices and may receive payments for reserve capacity or flexibility. Scenario tools should account for variable power prices, storage, and technological flexibility.

3.6 Action plan

The action plan ensures that all stakeholders know what to do, when, and how in order to implement the heat plan. It translates the selected scenarios into concrete actions, specifying which areas of the city receive which type of heating, the reasons behind the choices, the timeline, and the responsible actors. The plan should be detailed enough to guide stakeholders and commit them to coordinated implementation. It should be included as a core chapter of the heat plan or as an updateable appendix.

A list of relevant technologies must be prepared to provide a consistent overview of possible solutions. Stakeholders can help verify this through a technology data catalog. For each technology considered, its applicability, capacity range, efficiency, and CAPEX/OPEX must be defined. These data form the basis for all steps of the scenario analysis.

3.7 The final heat plan and approval

The purpose of this step is to present the results of the heat planning process in a final document and to ensure that implementation of the actions will take place as approved.

The heat planning process will result in many documents. It is, therefore, important to have a short version of the plan and actions, but, at the same time, that all documents are available in their full extent.

The heating plan may be pre-approved in the municipal technical and environmental committee and, thereafter, be put to the citizens for a final chance for commenting. A public phase (and final iteration round) is preferable before the final political approval.

The next step after the heat plan should be an implementation phase, where district heating is established. At that stage, it is key that the politicians agree on the heat plan (both believe in it and stick to the action plan), as the project likely create resistance, and political agreement is a strong signal against the resistance.

Section 3.6 "Action Plan" has already defined most of the follow-up actions. In this phase, you design a framework for a) how the Action Plan is communicated, and b) how it is monitored to ensure that the Action Plan is carried out and projects are developed.

Implementation is up to the responsible stakeholders. Actions must be monitored both to ensure their implementation and to ensure their supervision. For this, it may be necessary to approve a follow-up process to ensure continuation and iteration of the heat plan.

The work in the heat planning process should be documented in the heat plan.

3.8 Approval process

The purpose of an approval process is to ensure that all stakeholders are heard and have the chance to express their views. Any implementation creates some resistance, but a good approval process makes the transition smoother. The draft heat plan must follow the work plan, be discussed politically, and then sent to public hearing before final approval.

After implementing stakeholders have reviewed the draft, the public is involved through a hearing phase. A broad and inclusive hearing allows new details and clarifications to be added. This step ensures the plan is understood, accepted, and supported. It also reveals whether the planning process has been sufficiently open and transparent.

When preparing the hearing, consider what feedback and resistance may arise. If strong public concerns are expected, communication should be open, with enough time for questions and dialogue. If the earlier information phase was well-handled, much of this groundwork is already done.

As the process began with a kick-off event, it should end with a “planning complete – now implementation” event. If the early work was solid, this event will focus more on solutions and less on public opposition.

To prevent the plan from being forgotten, continuous monitoring and evaluation are required. Government can enforce this by requiring data on fuel and electricity use, heat production and supply, and emissions.

The approval process also clarifies responsibilities for all actors. Once approved, various implementation activities begin: establishing companies, preparing and publishing tenders, acquiring land, designing and approving installations, and hiring staff or advisors. Stakeholders must be kept informed and must approve any major changes. If tendering shows major budget deviations, the plan must provide the opportunity to revise or stop the project.

4 Conclusions and recommendations

China’s current energy planning system is based on studies conducted before the drafting of the five-year plans, which define the actions and solutions that local governments can implement by applying for funding and subsidies. For decarbonizing society, China may need to implement a comprehensive planning system for heating that include planning new urban areas, planning for replacing individual fossil solutions and planning for upgrading existing solutions, and planning for flexible heating solutions. The most effective solutions often involve utilizing local heat from waste incineration, surplus heat, or ambient heat sources, which vary by province, region and city. China can enhance decision-making for the clean heating by implementing a formalized energy planning system based on scenario analysis, government assumptions, and policy guidelines. The methodology described in above chapter “Energy planning steps” may inspire Chinese Government and decision makers when designing future planning approach and when making planning guidelines. The main recommendations are listed below:

（1）China could implement a holistic strategic energy planning system based on scenario analysis, government-decided assumptions, and a cost-benefit (socio-economic) methodology to improve decision-making.

（2）China could require that expansion of heat delivery to other sectors are included in the planning process. This can give value for both heating, electricity and eventually cooling systems.

（3）China could require that heat source design includes multiple sources and heat storage options in scenarios. This can be achieved through socio-economic approval, by mandating the investigation of various scenarios, hereunder, requiring assessments of local waste and ambient heat sources, and by establishing guidelines for heat source design.

In summary, China's renewable heating planning can draw on Denmark's experience while being grounded in its own energy resource endowments and urban development characteristics. By establishing a government-led, multi-stakeholder coordination framework, supported by systematic heat source mapping and scenario analysis, coupled with flexible financing mechanisms and technical standards, a planning system that is both socio-economically viable and environmentally sustainable can be developed, providing solid support for achieving the "dual carbon" goals and ensuring energy security.

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