International Renewable Energy Agency

Overcoming challenges related to the development of renewable energy based heating and cooling projects

- Established in 2011
- Headquarters in Masdar City, Abu Dhabi, UAE
- IRENA Innovation and Technology Centre – Bonn, Germany
- Permanent Observer to the United Nations – New York, USA

Mandate

To promote the widespread
adoption and sustainable use of
all forms of renewable energy worldwide

IRENA helps to increase financing flows towards RE projects, strengthen the national project development base and disseminate best practices

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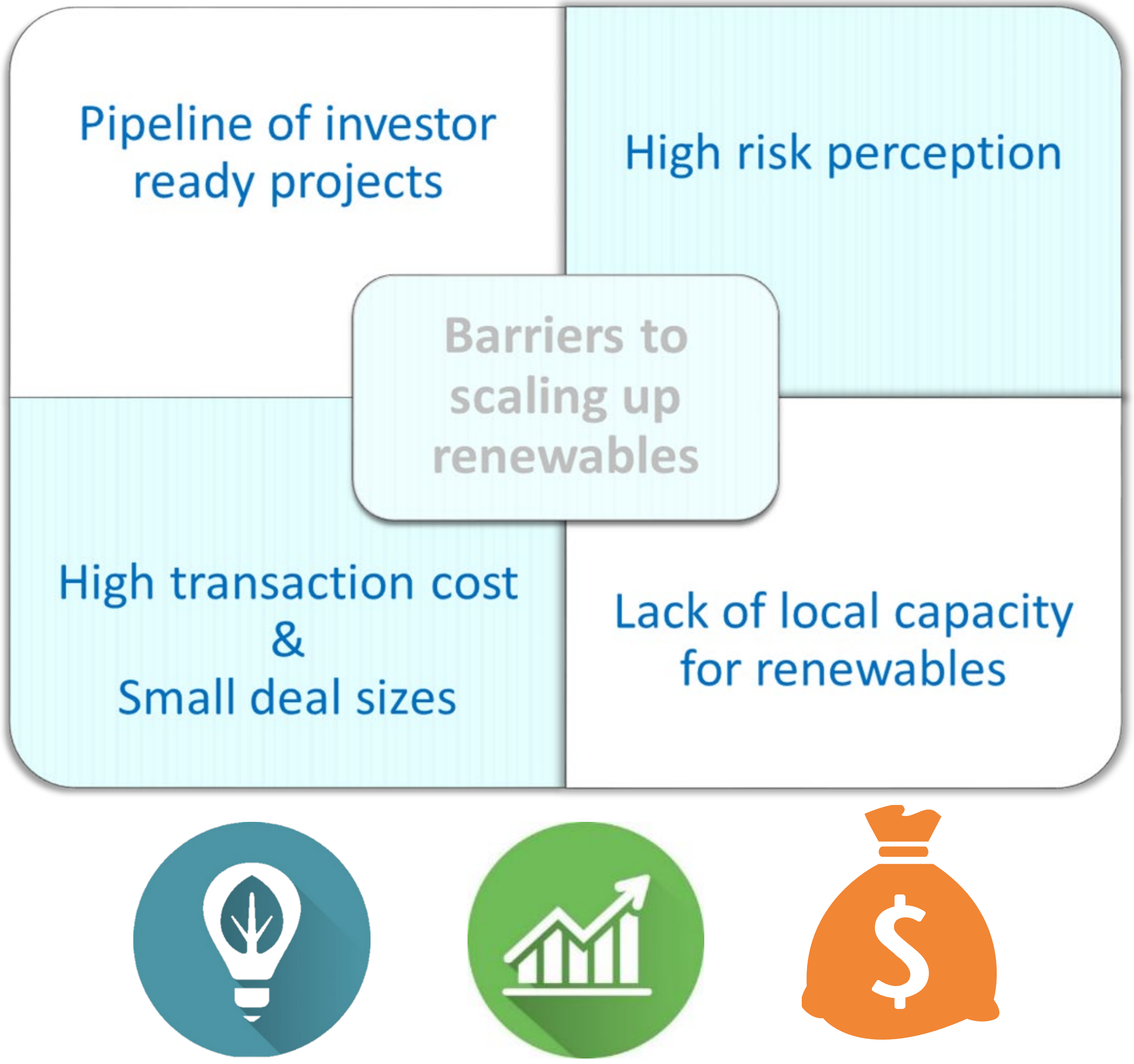

- Most countries know they have RE potentials. However, they lack the projects to achieve the desired deployment,
- Conditions inherent to certain countries/regions translate into high costs and financial risks,
- Stakeholders involved in a project often lack the know-how to complete a bankable project proposal,
  - This leads to higher project development costs and risks,
- Fund securement process and financing options themselves aren’t transparent.

Source: IRENA (2019)

Project Navigator – an open platform supporting bankable renewable heating and cooling energy projects

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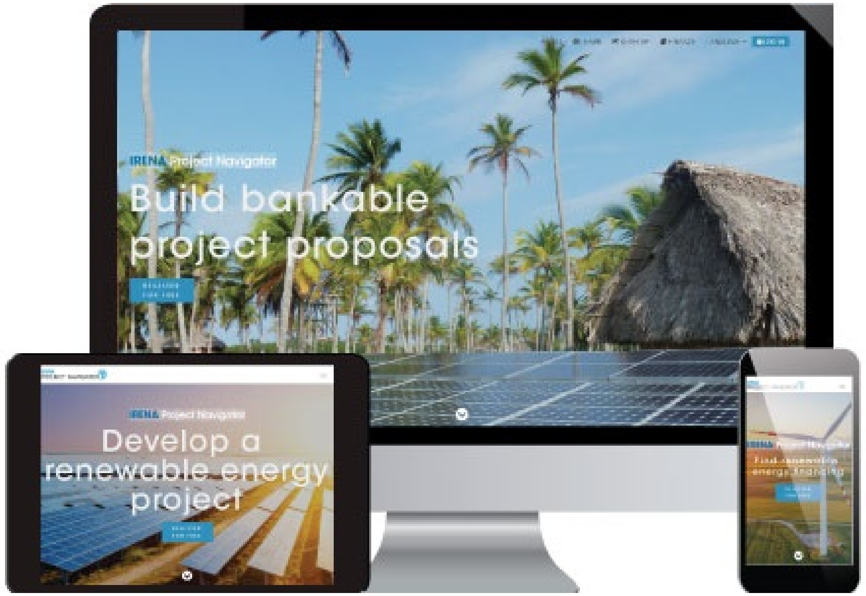
- A platform providing information and guidance to assist in the development of bankable renewable energy projects including heating and cooling solutions.
- It features project development guidelines with best practices and tools covering the lifecycle of renewable energy projects building on IRENA technology expertise & networks.



irena.org/navigator

Project Navigator supports project developers in applying best practices and addressing the challenges of affordable energy and climate change

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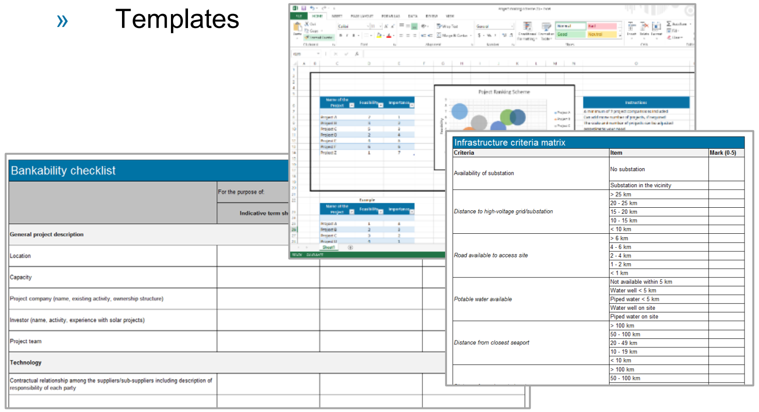
Learning Section

Project Development Guidelines

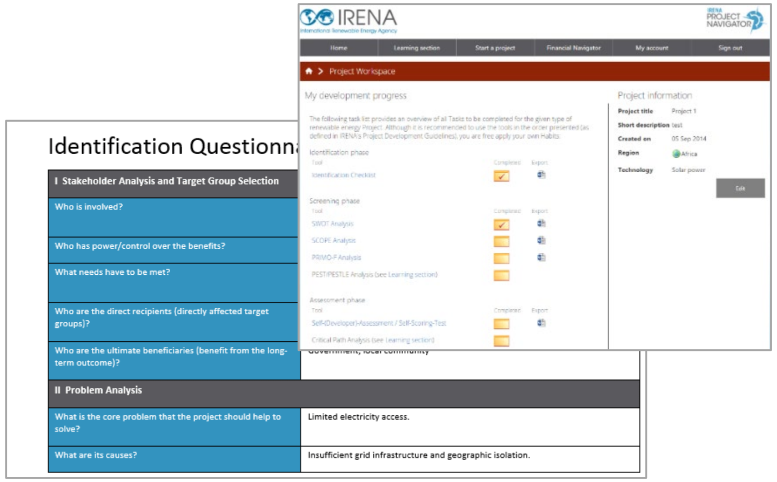
- » Clear project development process
- » Tools
- » Key Actions
- » Control questions and deliverables
- » Contract templates
- » Land and resource assessment
- » Technology selection and sizing
- » Contractual aspects
- » Lessons learned from previous projects

How others did it

- » Find examples
- » Case studies
- » Templates



Interactive Workspace



Create your own workspace

- » Password protected workspace
- » Interactive tools
- » Store up to three projects

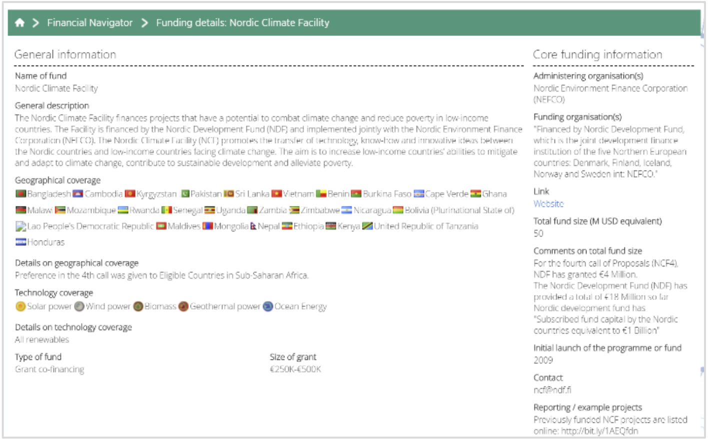
Follow a clear project development process

- » Clear objectives
- » Interactive tools
- » Control questions to ensure that nothing important has been overlooked
- » Store your data
- » Keep track of your project
- » Export and download reports

Financial Navigator

Detailed database of funds that actively provide finance to renewable energy technology projects.

It increases the transparency of the funding process and helps project developers identify potential funding opportunities



- » Name of fund
- » General description
- » Geographical coverage
- » Technology coverage
- » Type of funding
- » Size of fund
- » Applicant requirements
- » Cofunding requirements
- » Contact details

Source: IRENA (2019)

Project Navigator Technical Guidelines for Heating and Cooling systems

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Objective

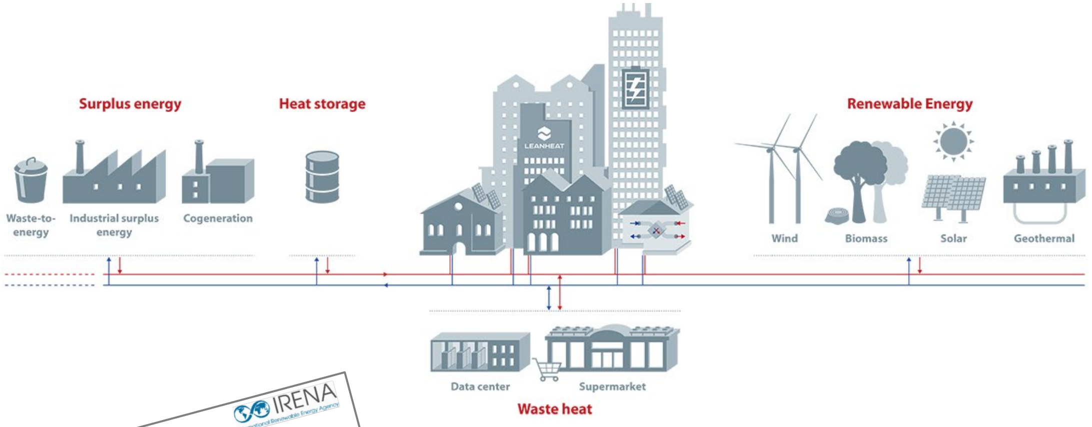
- Support the development of renewable energy heating and cooling solutions for cities-related applications including residential, industrial and commercial end-uses

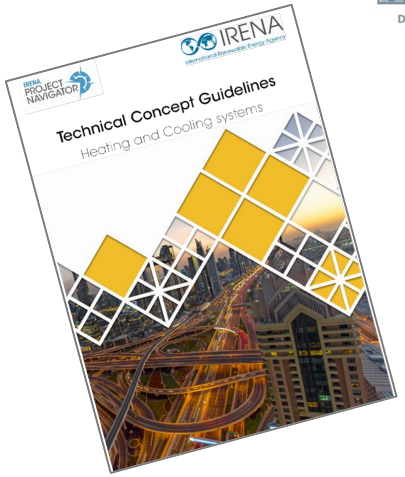
Scope

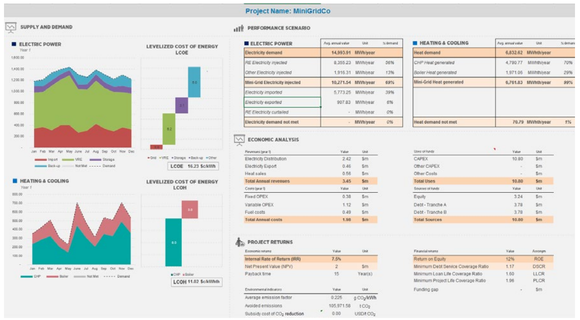
- Small and medium scale projects in the context of urban development that improve the dynamic behavior of thermal systems to match user requirements in terms of supply volume, time of day, resource efficiency.

RE Technology

- solar (solar photovoltaics, thermal and concentrated), biomass (cogeneration), biogas, geothermal and heat pumps combined with storage technologies







Focus on bankable project alternatives for each configuration and load requirement with practical details such as energy audit, process integration, technology selection, technical design, cost estimation or financial modelling.

Evaluation of district energy suitability and identification of heating/ cooling supply and demand factors

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- Starting points
  - There is a large heating or cooling demand
  - There is an affordable source available, typically surplus heat from electricity production or industries
- Reviewing energy plans that may act as barriers or enablers
  - Evaluate key national and city energy priorities, timelines and upcoming policies
  - Analyze local energy plans, legislation and develop initial stakeholder analysis

Source: IRENA (2019)

A project developer should unlock district energy barriers & identify risks

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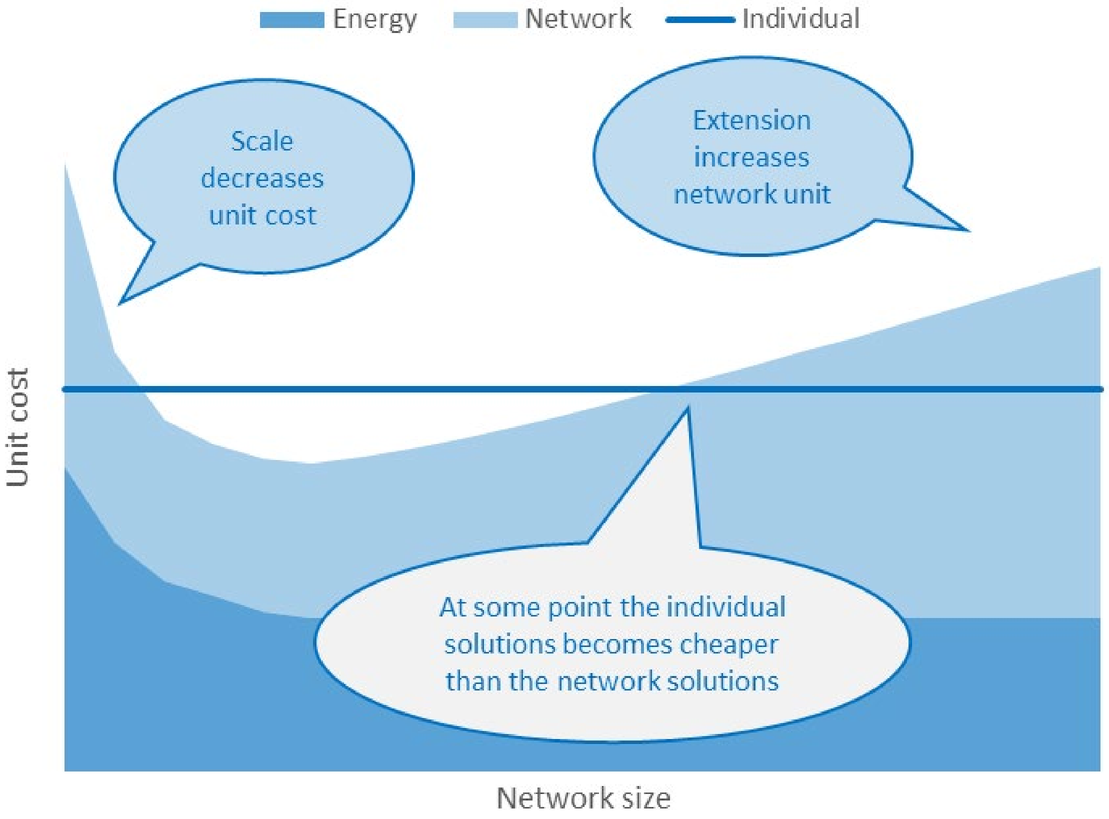
- Costing estimation
  - Payback can be long: systems lifetime is 40-50 years but loan repayment will typically be 20-30 years
- Policy environment
  - Customers: possibility of disconnection / mandatory connection
- Local terrain characteristics can complicate engineering and increase costs
  - Terrains with hills, rocky areas, complicated topography, others
- Fuel availability and cost
  - Base heat production on several technologies/fuels
- Potential leverages
  - Existence of a running thermal power plant in the city (surplus heat)
  - Areas next to the sea (seawater use for district cooling)



Scale of the system often is the main variable in network design

Screening is about understanding relevant production technologies, synergies and potential storage solutions

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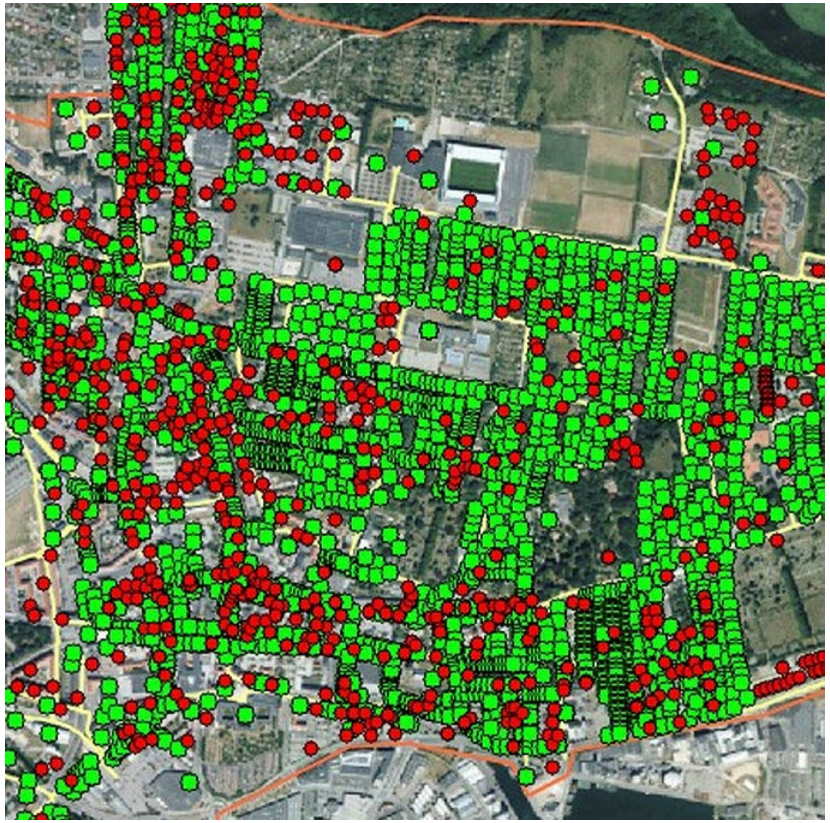
Identification | **Screening** | Assessment | Selection | Pre-development | Development | Construction | Operations | Decommissioning

- Generate a shortlist of all **resources available**
  - solar (solar photovoltaics, thermal and concentrated), biomass (cogeneration), biogas, geothermal and heat pumps combined with storage technologies
  - Natural gas is often used as peak load and back-up capacity
  - Power to gas will get more relevance due to the increase in fluctuating power production from wind and solar
- Evaluate feasibility by the projected **energy density** demand. As a rule-of-thumb:
  - Energy density > 10 kWh/m² indicates that cost of building and operating the network is reasonable
  - Densities between 5 and 10 kWh/m² need deeper evaluation
  - Densities < 5 kWh/m² are unlikely to be feasible for district networks



GIS image of district heating system in Denmark

Source: IRENA (2019)

To gain acceptance among stakeholders, screening project options from a long- to a short-list is a crucial step

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- Evaluate different technology alternatives
  - Base-load and peak-load units are necessary to ensure the economic advantages of the system
  - Base-load units have high/moderate CAPEX and low OPEX (geothermal or heat pumps) while peak-load units have low CAPEX and high OPEX (biomass boilers)
- Assessment of heating and cooling temperatures profiles
  - Traditional district heating systems usually supplies temperatures from 70 to 90 °C
  - For district cooling systems, temperature ranges from 6 to 12 °C

Source: IRENA (2019)

A quantitative assessment of relevant assumptions will be the basis to select the best system option

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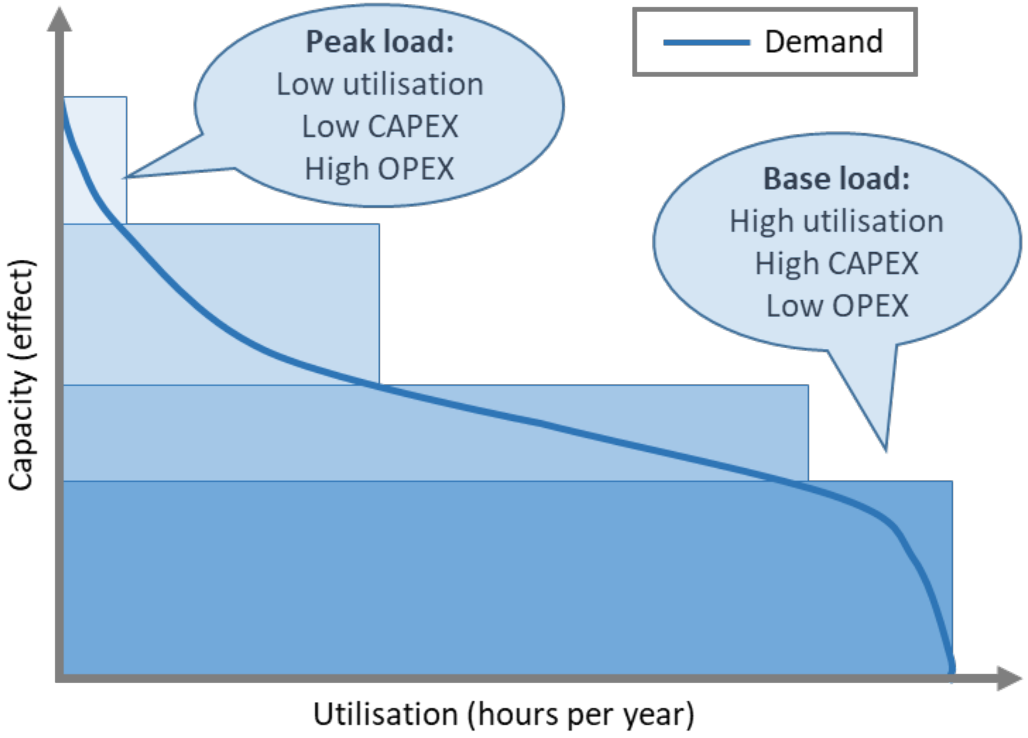
Identification | Screening | **Assessment** | Selection | Pre-development | Development | Construction | Operations | Decommissioning



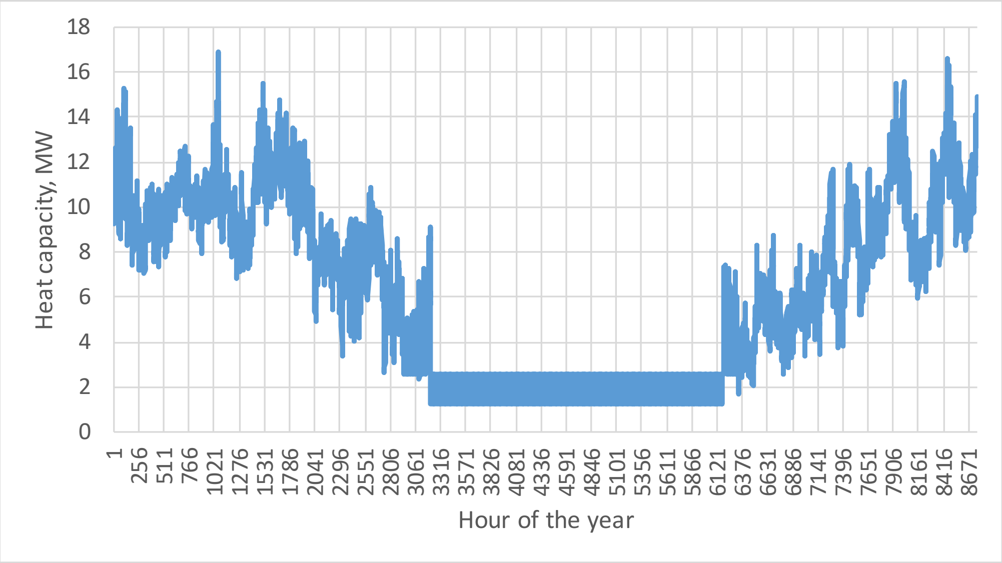
Relationship between utilization, capacity and cost

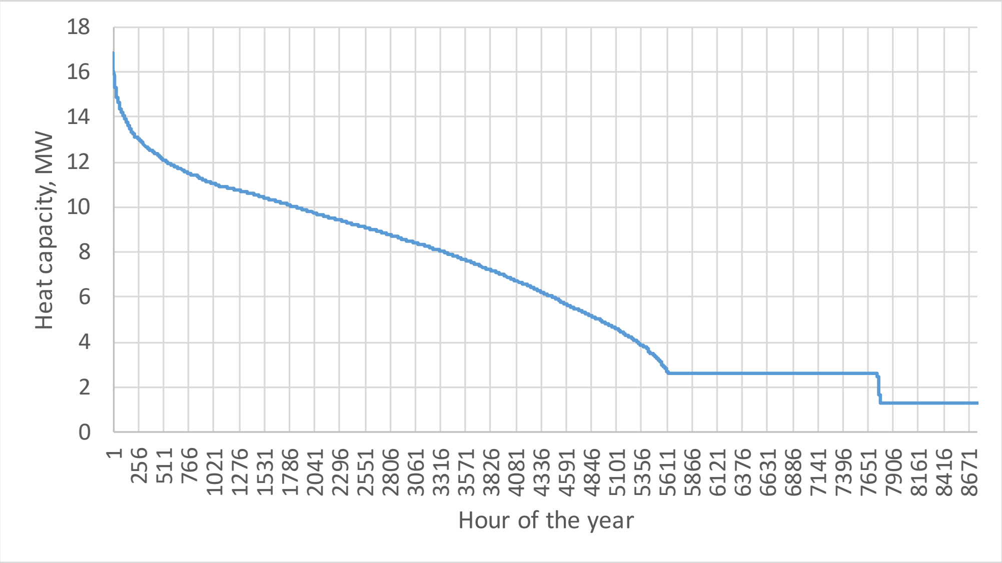
- Assess availability and estimate cost for energy resources
  - By evaluating specific project CAPEX and OPEX data
- Analyze equilibrium between production capacity and energy utilization
  - If the energy generation assets is expensive, it should probably have a very high utilization to be feasible
  - Exceptions may arise, such as economy-of-scale in which for some technologies (especially thermal power plants) the specific cost will decrease when the capacity increases

Understanding the demand and its variation across the year are key inputs for the planning and feasibility process

Identification | Screening | **Assessment** | Selection | Pre-development | Development | Construction | Operations | Decommissioning

- Duration curves provide an overview of the peak and base load demand
- Demand curves provide a picture of the energy demand variable within a year (seasonality for example)
  - Screen for storage solutions to balance production and demand, for example within a 24 hours range.

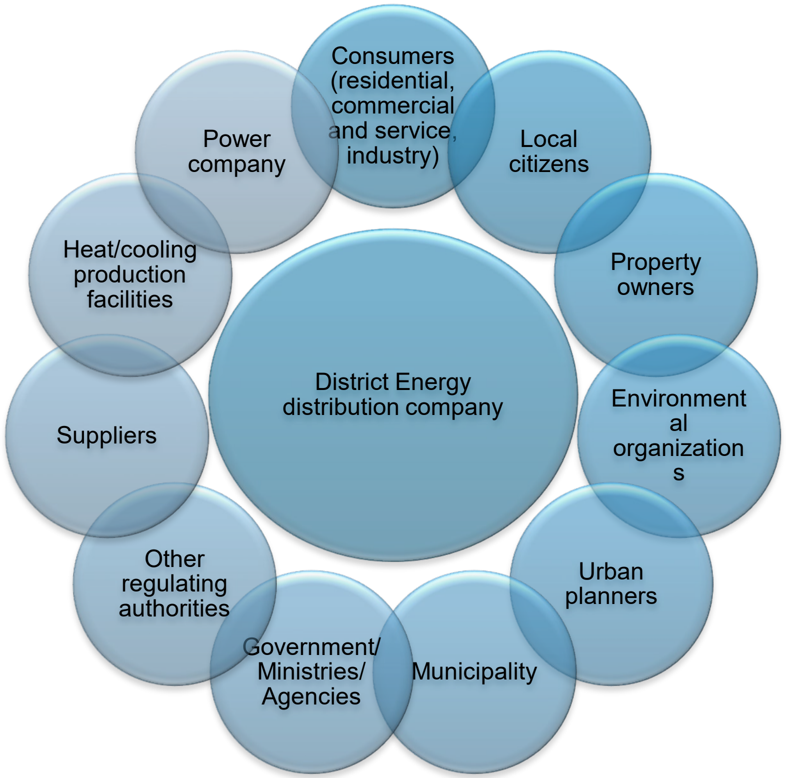




Heat demand curve examples

Along assessment technology parameters, stakeholder analysis will ensure that relevant parties are on-board in the project structure

Identification | Screening | **Assessment** | Selection | Pre-development | Development | Construction | Operations | Decommissioning



Stakeholder overview

- Analyze network size, costs and district inclusions
  - initial Cost assessment by heat density (MWh/km²) and typical network's cost per km²
- Suggest different plant technologies and sizes
  - An initial approach is to compare short-term vs long-term cost and benefits of different production units to match values in the demand duration curve
- Suggest other technologies to be incorporated in the DH/C system
  - Highly dependent on project and geographic specifics considering resources available and needed solution (for example storage, heating and cooling complementarity, industrial surplus heat use and geothermal solutions)

Source: IRENA (2019)

Selecting the best alternative of DH/C system, network and technologies

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- Review methodology and prepare scoring matrix
  - Key criteria: System costs, Financial evaluation, Environmental benefits, Mitigation potential, others of interest
- Develop supply plan including selection of market segments, resources and technologies based on the system pre-feasibility analysis
- Optimization screening (for example, using PV's for heat pumps' electricity consumption or similar)
- Preliminary time schedule:
  - Focus on system commissioning date typically just before the heating/cooling season begins or when new buildings are inhabited
  - Taking into consideration permits, contracting schedules and construction phase

District heating pipes in Gentofte, Denmark

Typical technical project development studies will provide inputs to prepare a credible business plan

Identification → Screening → Assessment → Selection → **Pre-development** → Development → Construction → Operations → Decommissioning

- Perform major engineering studies
  - Pipe network: design pipe diameter, isolation level, pump stations, wells
  - Production technology: flue gas cleaning and absorption heat pump for biomass boilers or refrigerant for heat pumps
- Launch permits, licenses, authorizations (excavation, building/installation design, environmental, management of archaeological and historical heritage, among others)
- Prepare procurement plan and strategy
  - DH/DC network installations have multiple interfaces which favors construction management by one single entity (turn-key EPC)
  - Construction management that relies on the experience of the bidder will often be successful

Source: IRENA (2019)

Once the business plan has reached a sufficient level of detail, potential investors and lenders will be approached with high success rate

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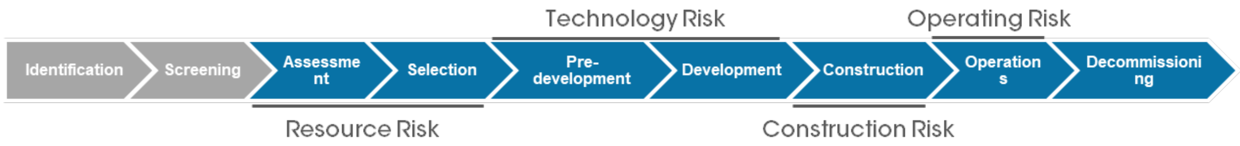

- Evaluate Project financing options:
  - Assess available financing instruments (public and/or private funding)
  - Prepare risk management plan (even a project with high subsidies may entail significant residual risks for an investor)
- Economic and financial evaluation
  - Demonstrate bankability (ability to deliver returns)
  - Show reliability, safety and good performance potential
  - Substantiate how identified risks are appropriately mitigated so that residual risks can be accepted by the relevant party
- Bankability perception from investors and lenders will be affected by the risk identification, evaluation and mitigation measures

Source: IRENA (2019)

A development cycle concludes with a project's financial closure where all agreements are signed to prepare implementation

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- In this critical phase final technical decisions are taken, affecting the project's future performance
- A project developer will prepare procurement and construction with pre-negotiation of key terms according different contracting strategies:
  - Turnkey approach: the whole DH/DC system, including energy generation assets providing heat or cooling, the distribution network and the interface towards the end-users/consumers
  - EPCM approach where each sub-systems are contracted separately with some interface management requirements
- Signing of all applicable contracts: EPC, O&M, fuel supply agreement, consumer contracts
  - Financial investment decision and definition of amount of funds to be mobilized
    - Legal and technical due diligence

Source: IRENA (2019)

It is crucial that investors and lenders are informed about construction activities leading to system commissioning

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Identification → Screening → Assessment → Selection → Pre-development → Development → **Construction** → Operations → Decommissioning

HOFOR's District Cooling Plant in Adelgade Copenhagen – sea water free cooling and compressor cooling. The system is operated at delivery temperature 6 oC and return temperature 16 oC.

- Review of budget and project master plan upon which the construction will be based
- Progress / status reports to monitor progress against the project master plan
- Commissioning report is performed to certificate that construction was developed according to plan and all contracts specifications
- Manuals, training and safety procedures documents
  - Safety equipment and procedures, Quality control, Equipment operation, Receiving feedstock, Explosive material handling and Emergency procedures
- Construction risk management
  - Risk management plan needs to be constantly monitored, assessed, and updated when necessary

Source: IRENA (2019)

Complex sub-components of the DH/C system need to operate as expected and match guaranteed energy generation values

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Identification → Screening → Assessment → Selection → Pre-development → Development → Construction → **Operations** → Decommissioning

- Operation
  - Permanent adjusting of energy production and temperature levels
  - A full back up production facility should be in place, such as an existing power plant onsite with at least the same capacity of the largest demand unit
  - Networks: hydraulic software will monitor the forward and return temperatures and will flag any possible leak in the system to prevent failure
- Maintenance plan: reports should be on a monthly and annual basis
  - For DH/C production facility maintenance will broadly depend on the energy supply asset (PV-based, biomass, others)
  - For DH/C network, maintenance is largely focused on repairing leaks and other system failures.

District heating tunnel under the Copenhagen Harbour
Two sets of forward and return pipes

Source: IRENA (2019)

Given the increased efficiency and the reduced installed costs of RE district systems, most end-of-life processes consist of upgrades

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Identification → Screening → Assessment → Selection → Pre-development → Development → Construction → Operations → **Decommissioning**

- A developer will perform a cost-benefit analysis comparing decommissioning versus refurbishment value
- End-of-life
  - Technologies, equipment, machinery, and systems reach the end of their useful life and need to be replaced or upgraded
  - Newer technologies or materials are more efficient than those in use and it is more cost-efficient to replace these before the end of their useful life
  - Energy resources, either fuels or renewable sources, are no longer available
  - Unplanned, catastrophic system failures that require repair or other solutions
- Decommissioning report
  - Evaluate the most cost-effective way to dispose of materials
  - Evaluate regulations and guidelines to be followed during this phase

Source: IRENA (2019)

Case study 1 - District Heating project in Denmark

- District heating project in **Denmark**
  - More than 60% of households are connected to a district heating system. In Copenhagen the connection rate is approx. 98%
  - Historically, heat was based on CHP plants and waste incineration.
  - In Elsinore, heat demand is above 200.000 MWh annually. Supply comes mainly from a CHP plant (+20 years old)
- Transition to renewable energy
  - Predicting a future increase in natural gas prices and OPEX costs for a plant over 20 years old, a fuel switch was proposed
  - A new biomass fired boiler using wood chips as fuel of 18 MW electricity and 61 MJ/s district heat with reuse of the existing network was approved
  - Engineering and construction 2,5 years. Total CAPEX 110 MEUR

Plant architecture
Left: old plant (triangle). Right: new plant.

Case study 2 – District heating project in Shangri-La in southwest China

View of heat air-water heat pumps in the year of Shangri-La Boiler House No. 5. Photo: Shangri-La. 2018 03 13,Andrew Christensen, COWI A/S.

- **District heating project in China**
  - Roughly 55% of heated space is served by DH in Northern China
  - Above 90% of the district heating systems apply coal as the primary fuel
  - Given the abundance of hydro power plants in Shangri-La's region, its DH system is uniquely heated by electric boilers
  - Shangri-La makes use of small stoves burning coal and wood biomass for heating in the non-district heating areas. Authorities interest in DH intends to improve air quality by extending the infrastructure
- Modernizing the district energy system
  - Constructing of five boiler houses with a total of 17 electrical steam boilers, of 7.5 MW each. The 128 MW electrical boiler capacity is supplemented with 15 MW electrical driven air-water heat pumps

Success factors for RE project development – key takeaways

- Provide proven and credible RE solutions for district energy systems
- Identify, assess, district energy risks early in the planning
- Enhance capacity and knowledge on the ground
- Inform city-level decision makers towards RE Heating and Cooling benefits
- Strengthen institutional mechanisms across similar cities
- Facilitate access to predictable and sustained climate financing
- Measure, evaluate and share results

Source: IRENA (2019)

Thank you for your attention

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