Ea Energianalyse

Plan 4 District Energy

Webinar II: The modelling approach

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Agenda

Part 1 – Overall approach

Introduction to Plan4DE
Model purpose
Analytical approach
Main elements of district heating costs
Main elements of individual supply costs

Questions

Part 2 – Model application

Model structure
- Type of inputs
- Type of results
- How does urban planning affect results

Case example
District heating in Denmark

Questions

Part I

OVERALL APPROACH

Background for Plan4DE

- Land use as a consequence of urban planning can have a serious impacts on energy use and GHG emissions
- Most existing models focus on the relation between urban planning and transport
  - Very few deal with district energy
- There are a number of tools and models that can be used to evaluate the feasibility of district energy systems
  - However, these models don't consider the land use perspective
- The aim of this project is to develop a model that integrates the land use perspective with the feasibility of district energy systems

"OPTIMISE THE DISTRICT FOR ENERGY, NOT OPTIMISE DISTRICT ENERGY."

- The project is financed by IEA, Implementing Agreement on District Heating and Cooling, including Combined Heat and Power- ANNEX XI

Project purpose

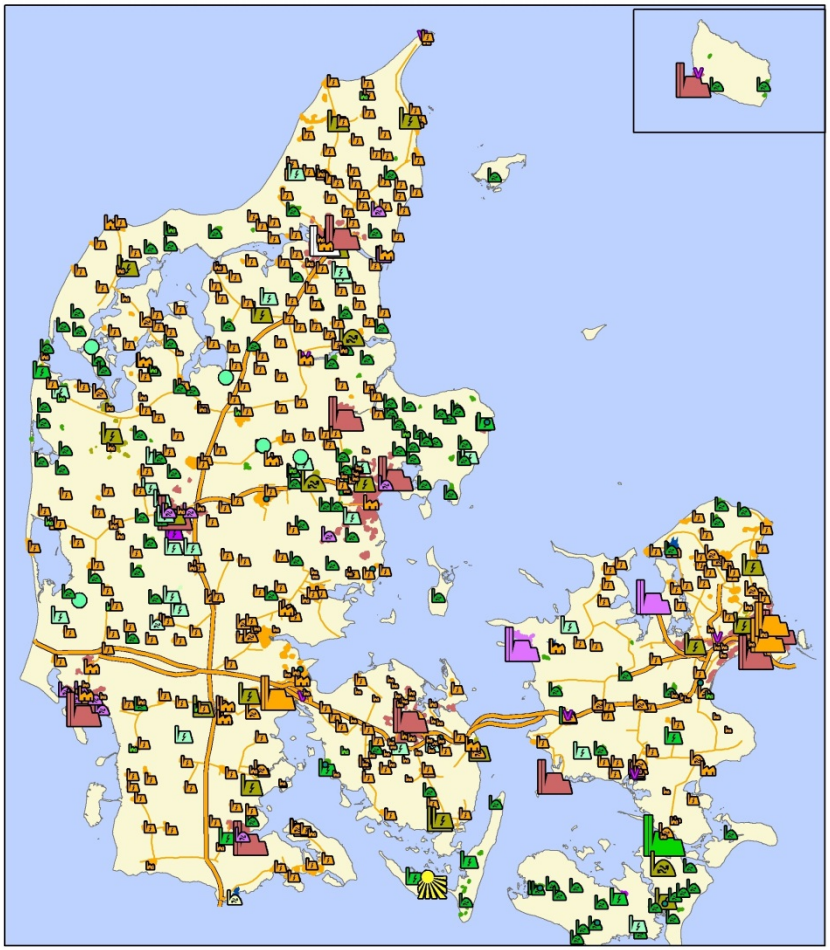
The objectives for this project are:

- Better understand the relationship between district energy and the built environment *from a planner's perspective*
- Develop an open source interactive model to allow planners to optimize urban form for district energy
- Enable planners to evaluate different scenarios and the resulting GHG emissions reductions, energy savings and other social and economic benefits as part of the development of municipal plans
- Develop easily recognizable district energy archetypes for different types of urban form that can be incorporated into municipal plans

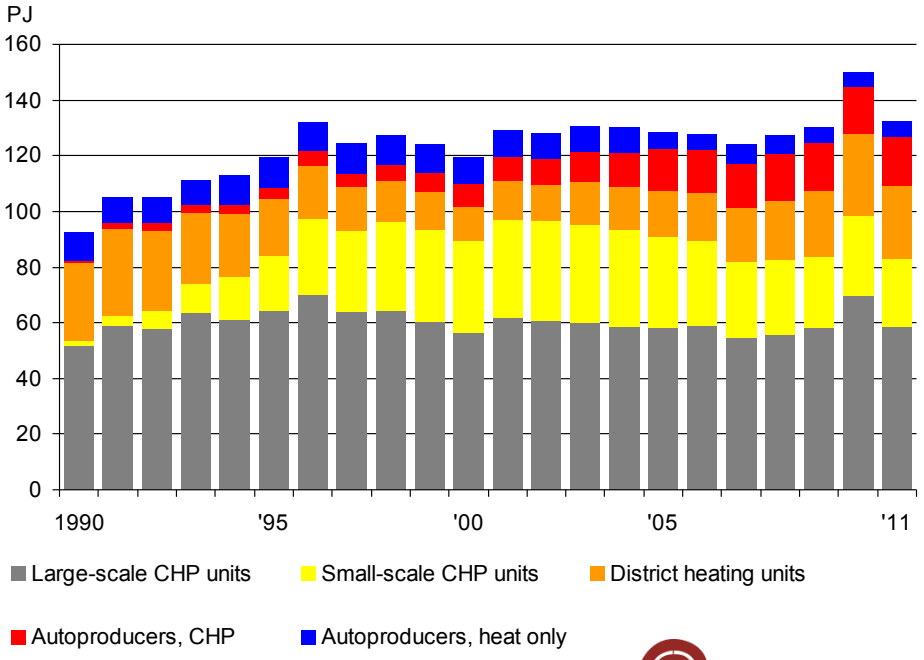
Project participants

- **Sustainability Solutions Group**, Canada
  - Project management, leads model development and testing and provides an urban planning lens.
- **GGLO Design**, USA
  - Applies the lens of urban design and architecture to the project and develops visualizations for the archetypes
- **Ea Energy Analyses**, Denmark
  - Provides expertise in energy modelling and district energy
- **International District Energy Association**, USA
  - Contributes to the guidebook and support dissemination efforts
- **Farallon Consulting**, USA
  - Provides expertise in industrial ecology and engineering
- **Government of BC**, Canada
  - Provides policy expertise and contribute to the dissemination effort
- **Mary Ellen Richardson**, Canada
  - Dissemination

District Heating in Denmark



- 60 % of heating is district heating
- 6 central areas: Aalborg, Aarhus, TVIS, Odense, Copenhagen, Esbjerg
  - Total heat production ~ 70 PJ
- 400 decentral areas
  - Total heat production ~ 60 PJ



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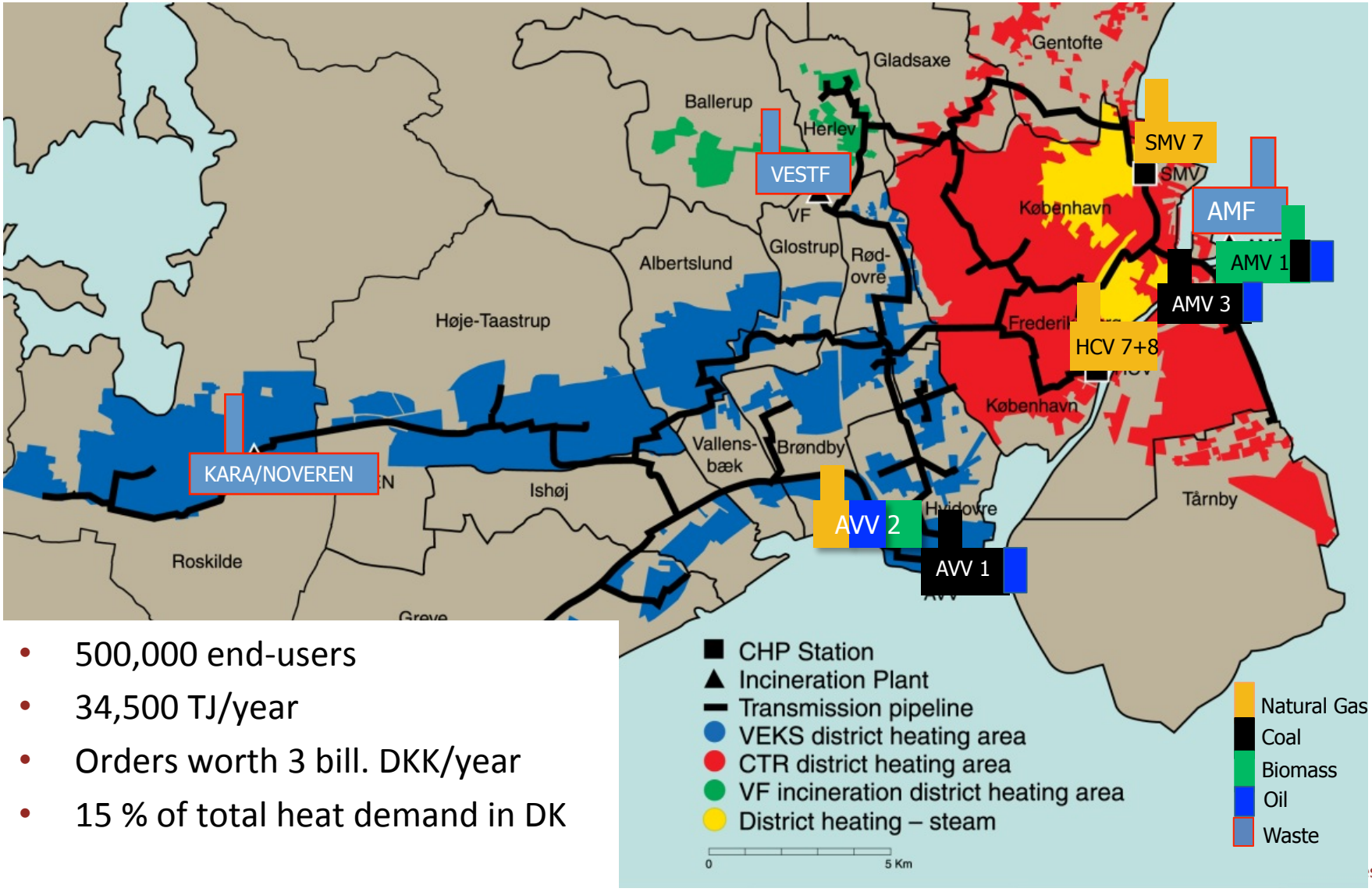
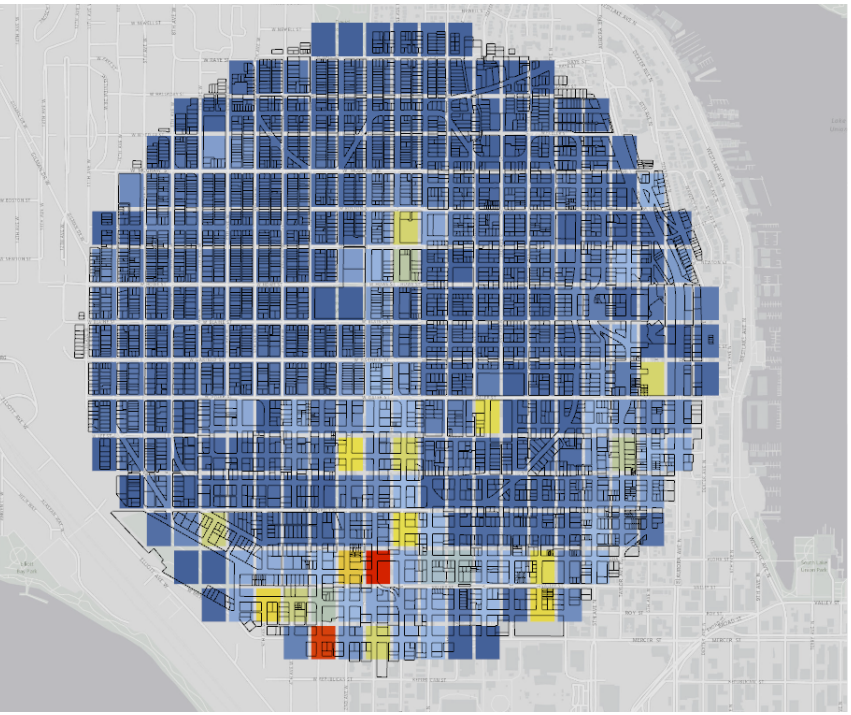
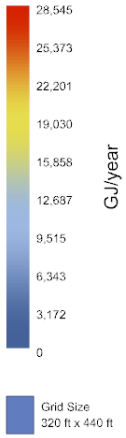
District heating in Greater Copenhagen Area

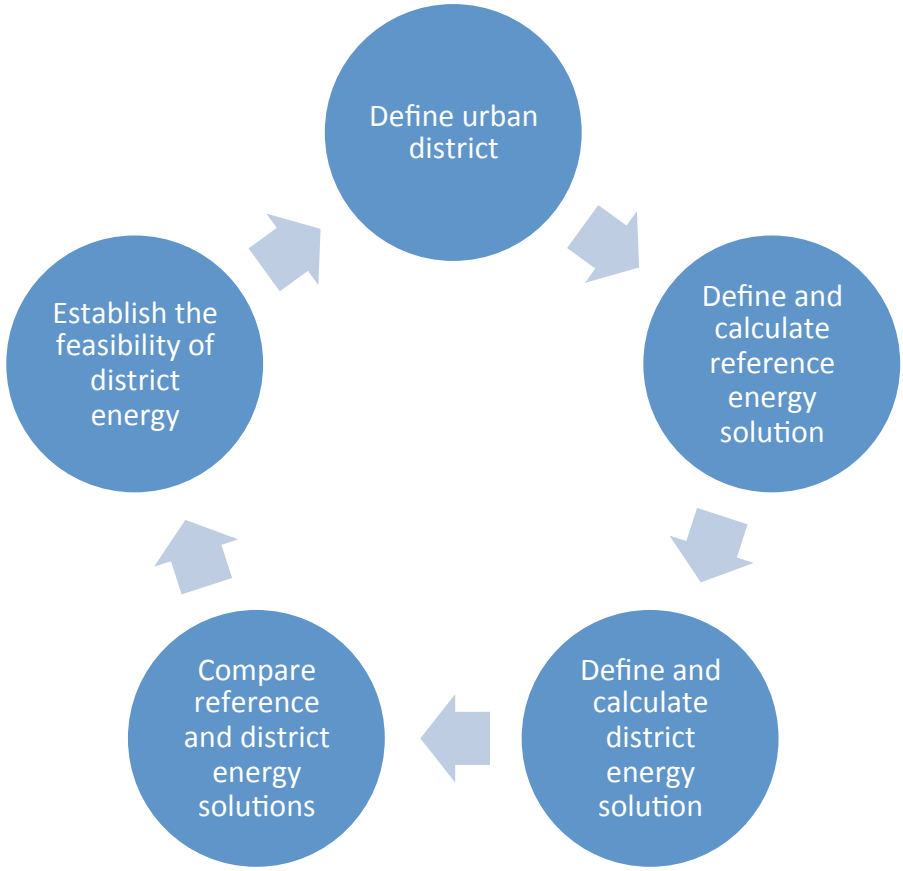


- 500,000 end-users
- 34,500 TJ/year
- Orders worth 3 bill. DKK/year
- 15 % of total heat demand in DK

Analytical approach







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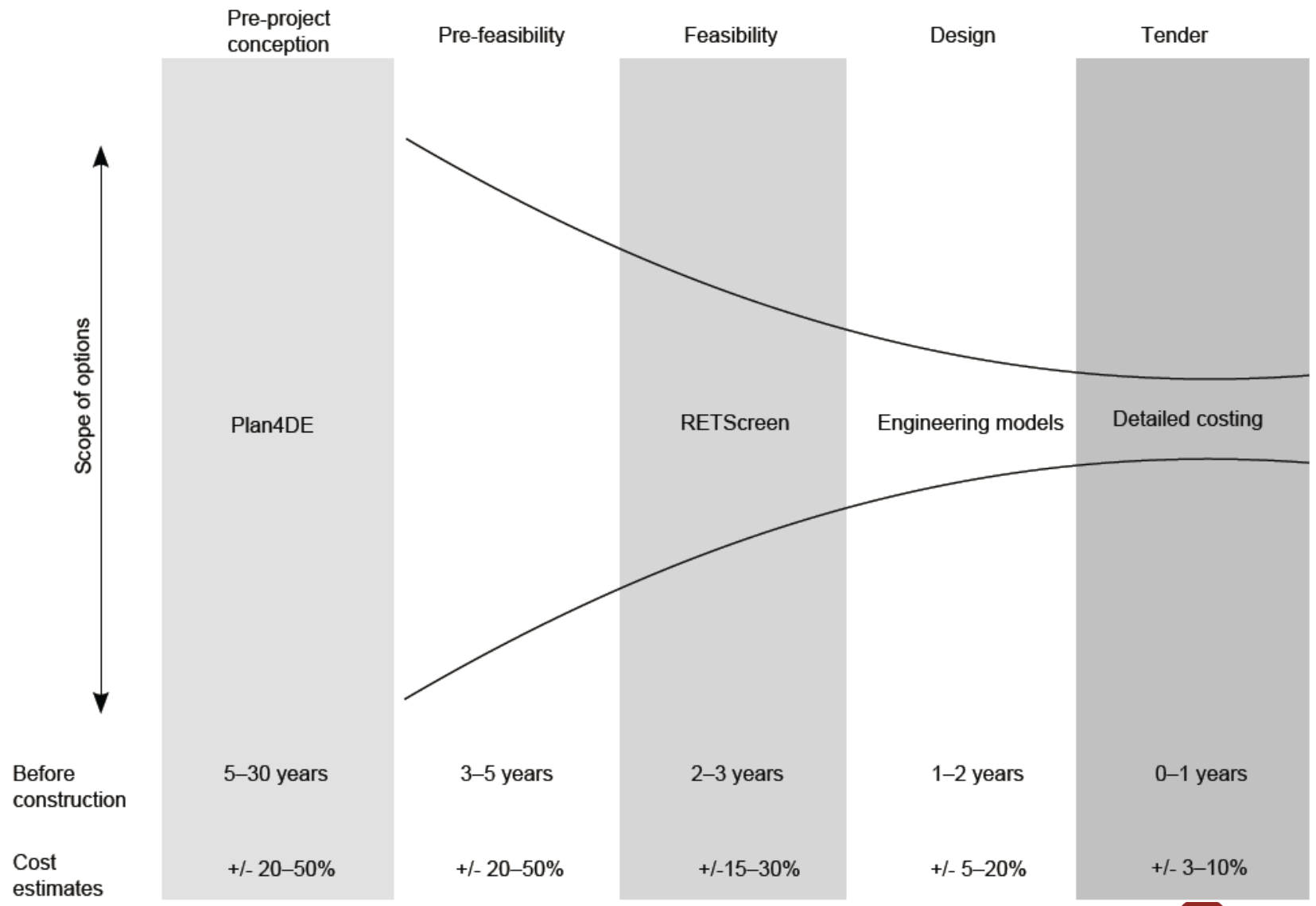
Position of model relative to the feasibility funnel



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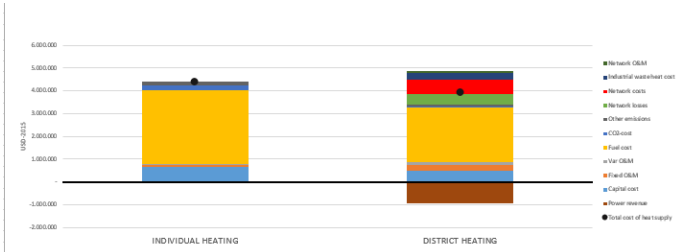
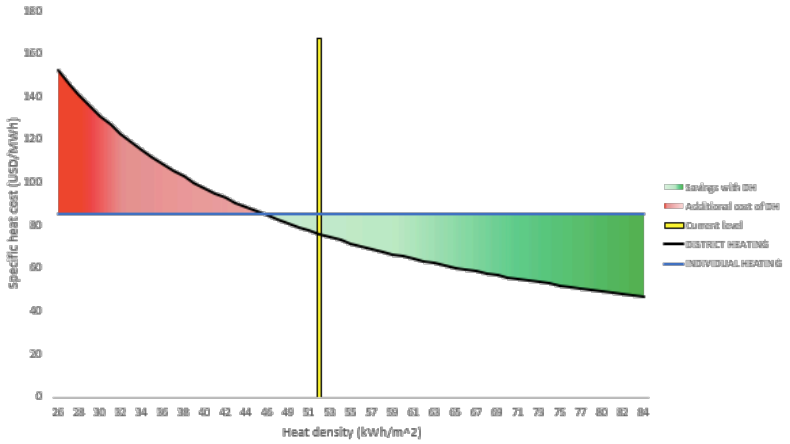
Desired principles for the model

- Pre-pre feasibility
- Exploratory rather than guidance
- Open source
- Transparent
- User friendly
- Cost-driven
- Locally relevant
- Online
- Heating or cooling
- Flexible level of analysis
- Data catalogues



		INDIVIDUAL HEATING	DISTRICT HEATING
Capital cost	USD	642.341	476.110
Fixed O&M	USD	122.617	289.877
Var O&M	USD	40.627	111.943
Fuel cost	USD	3.230.832	2.405.710
CO2-cost	USD	194.405	24.190
Other emissions	USD	172.682	99.447
Power revenue	USD	-	-934.254
Production cost	USD	4.403.504	2.473.029
Industrial waste heat cost	USD		299.801
Network losses	USD		436.417
Network costs	USD		652.355
Network O&M	USD		70.070
Total cost of heat supply	USD	4.403.504	3.931.671

NOTE
District heating costs shown are the selec
the optimized ones, depending on the ch



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Main elements of energy supply costs

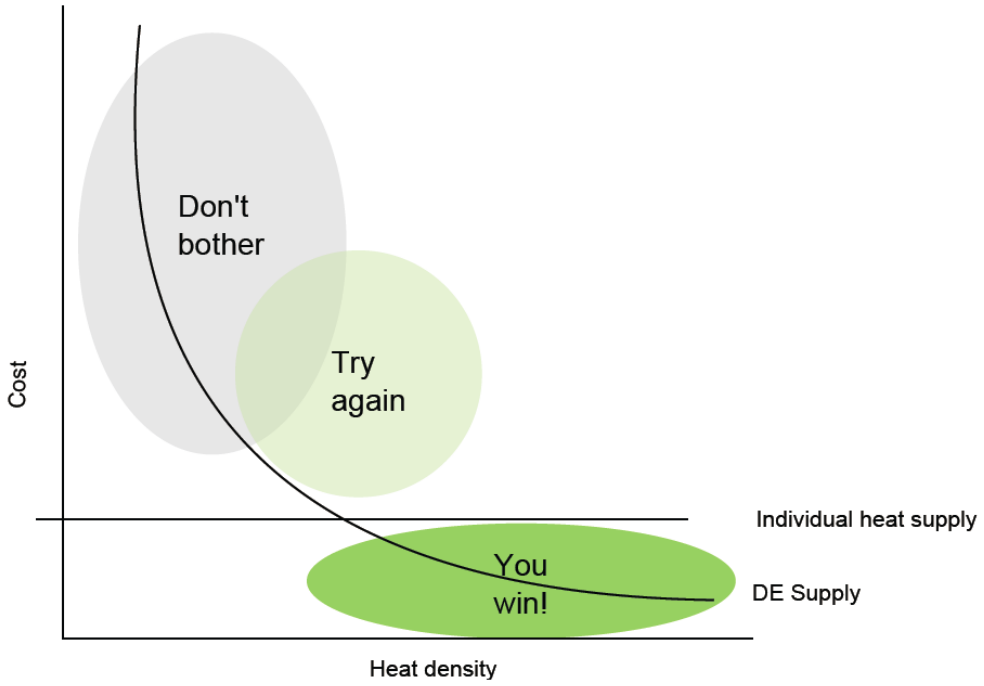
	District Energy	Individual supply
	Network	
	Environmental	Environmental
	Fuel	Fuel
	O&M	O&M
	Generation capacity (capital cost)	Generation capacity (capital cost)
	Electricity sales	

Part II

MODEL APPLICATION

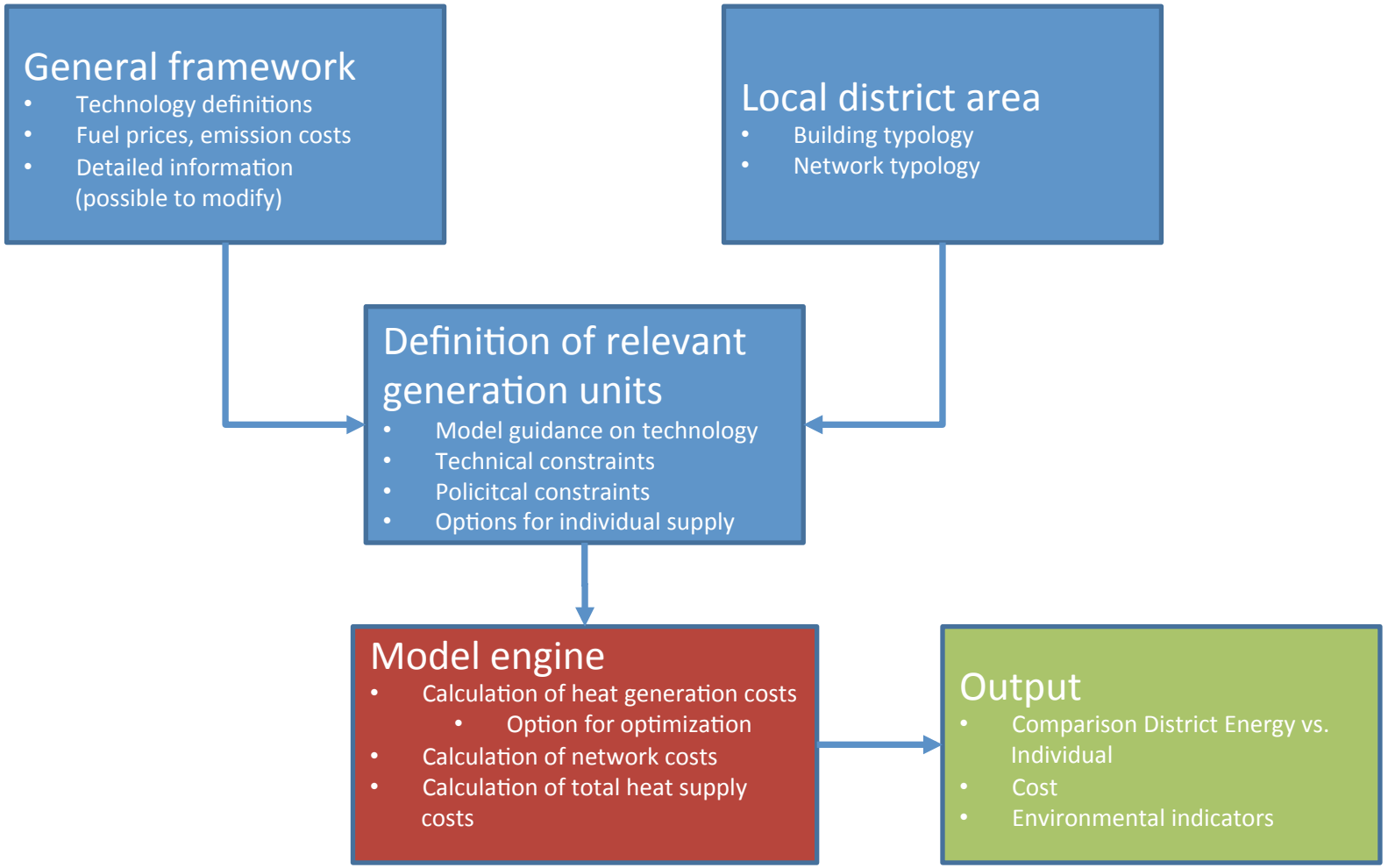
Main Idea

Comparing individual and district heating based on the heat supply costs



District heating cost decreases when heat density increases (kWh/m^2), therefore there is a certain heat density after which District heating becomes more convenient than Individual one.

Model structure



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Case example

Made-up district with a simple setup, to show how the model works

INPUTS:

- Simulated year: 2015
- Plan Area: 1 km^2
- Star topology, Energy center located in central position
- 4 clusters in the plan area

Buildings type	Number
Single-family detached	30
High rise apartment	8
Medium Office	15

Total area covered:
200,000 m^2

Case A example

District heating inputs:

- Manual input of the energy mix, no optimization
- No industrial waste heat
- Mix:

Baseload	Technology % of total demand	Large CHP - refurb. Wood pellets 50%
Intermediate	Technology % of total demand	Medium CHP - wood chips 35%
Peak	Technology % of total demand	DH boiler - natural gas 15%

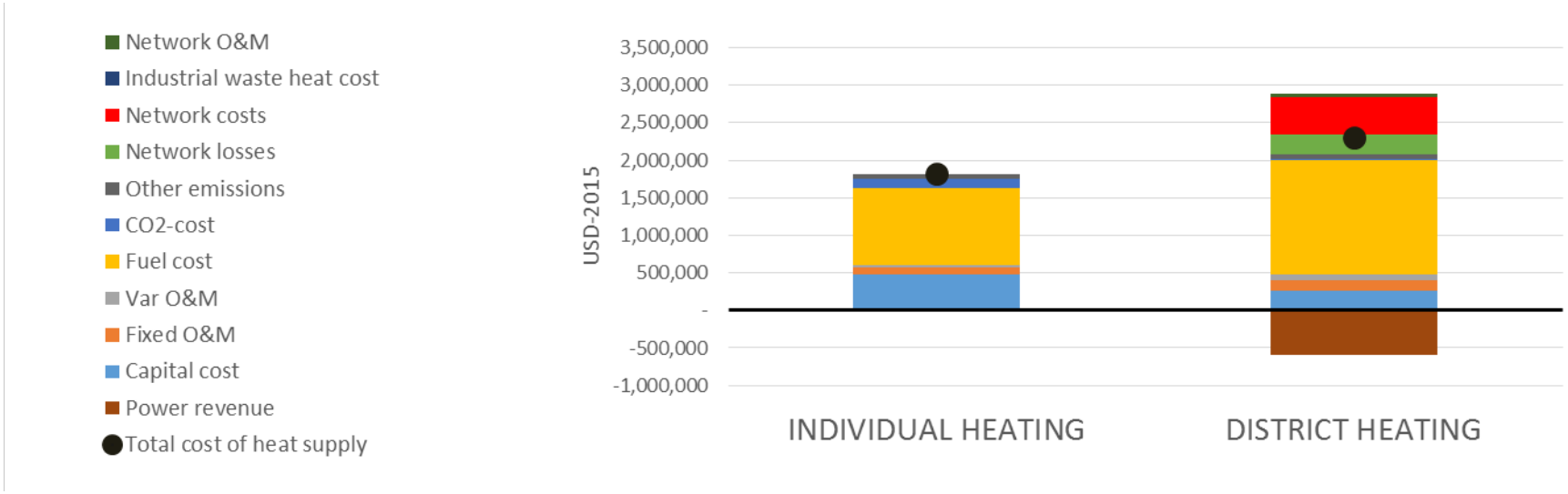
Individual heating inputs

- Same mix for every building type present:

IND ground heat pump 70%	IND boiler - natural gas 20%	IND electric heating 10%

Case A Results

			INDIVIDUAL HEATING	DISTRICT HEATING
Capital cost	USD		482,090	257,647
Fixed O&M	USD		85,776	145,538
Var O&M	USD		40,627	73,093
Fuel cost	USD		1,022,913	1,522,993
CO2-cost	USD		114,679	15,746
Other emissions	USD		67,890	63,298
Power revenue	USD		-	-586,767
Production cost	USD		1,813,976	1,491,548
Network losses	USD			263,214
Network costs	USD			491,663
Network O&M	USD			52,810
Total cost of heat supply		USD	1,813,976	2,299,235



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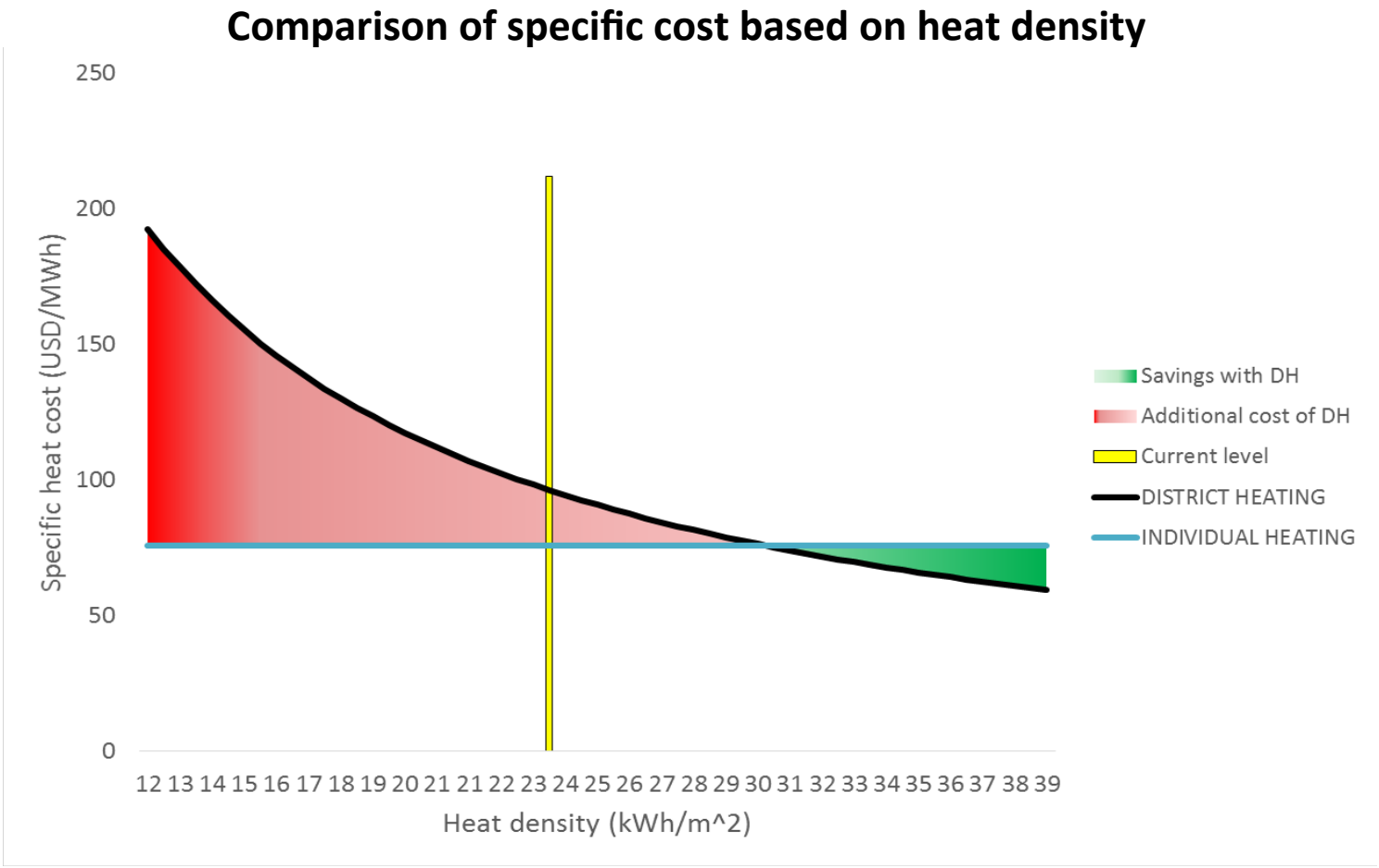
Case A Results



District heating is not feasible for this heat density!

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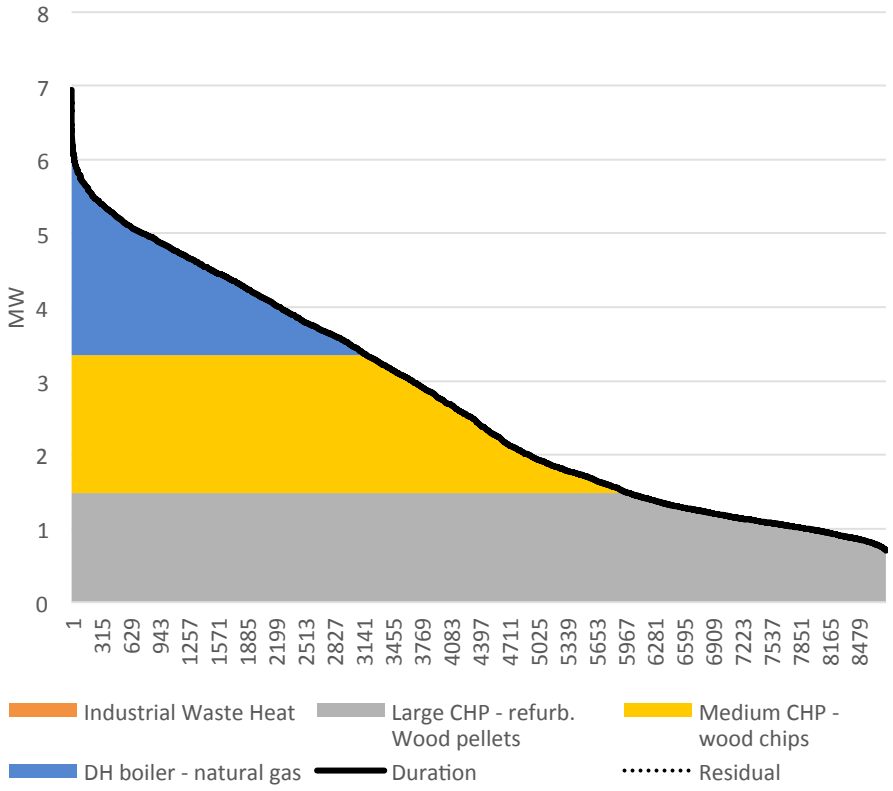
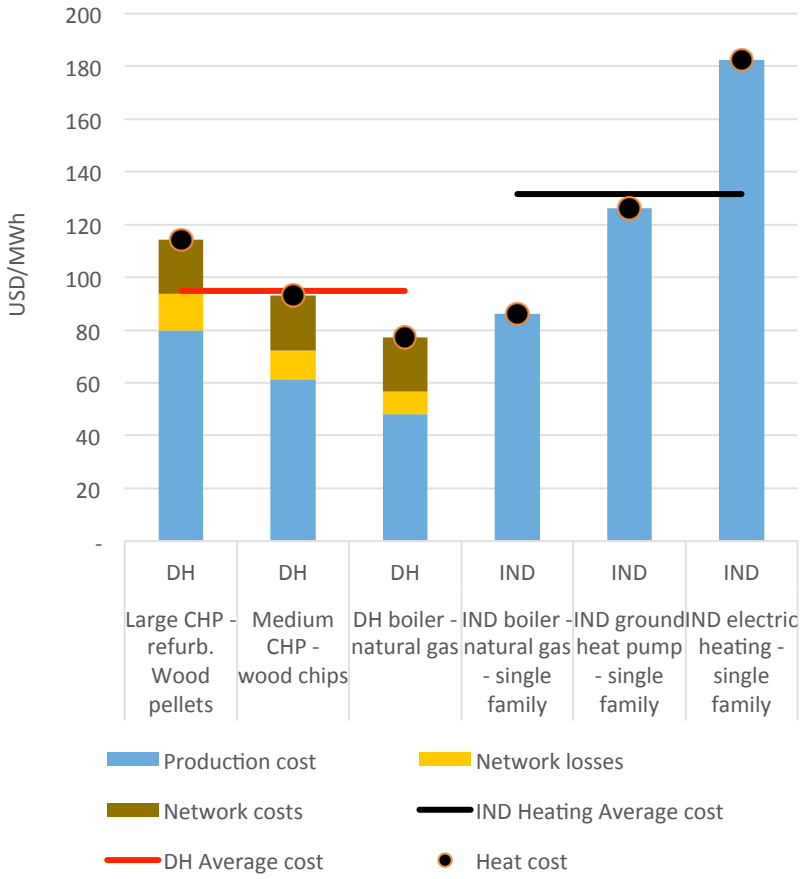
Case A results

Duration curve for DH



Heat cost comparison for different technologies



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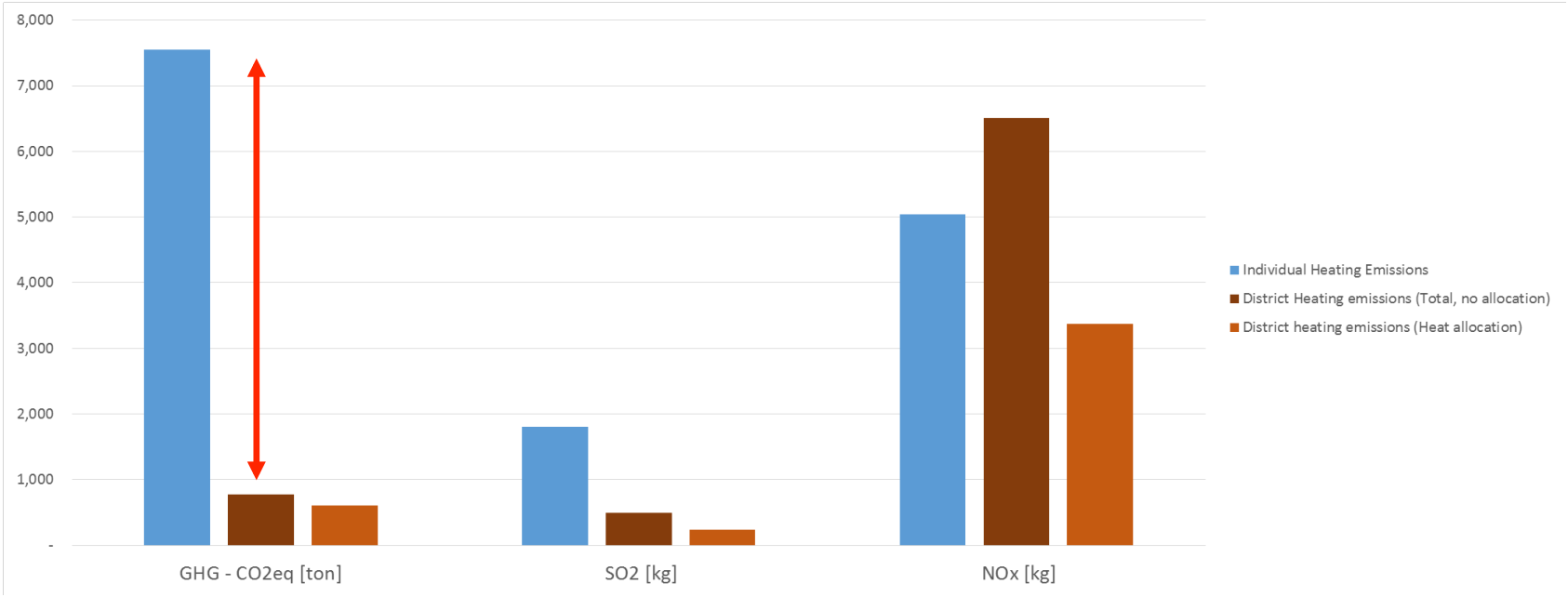
Case A Results

Emissions comparison



Results for District heating are shown both with and without emission allocation (relevant for CHPs)

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How can urban planning impact on results?

- Reduced district area
- Increased building number
- Increased demand

→ Heat density increases ↘

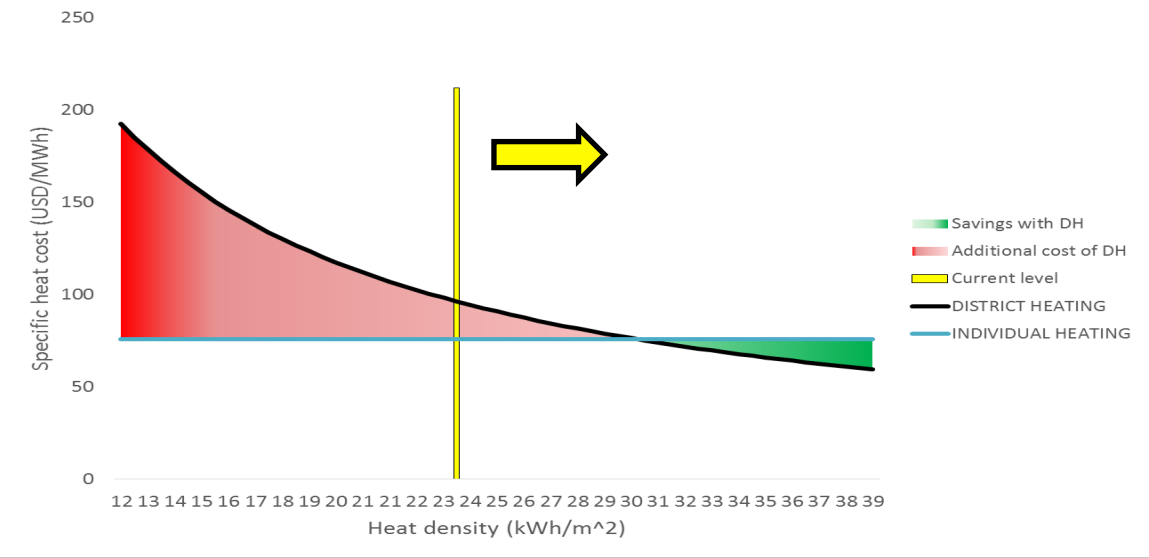
- Reduced district area
- Clustering of buildings
- Reduced pipe length
- Change network configuration

→ Network costs decreases →

- Find a source of waste heat (eg. industry)

→ Cheaper heat ↗

District Heating is more competitive!



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Case B adjustments

To make District heating more competitive compared to individual heating, the Urban Planner decides to:

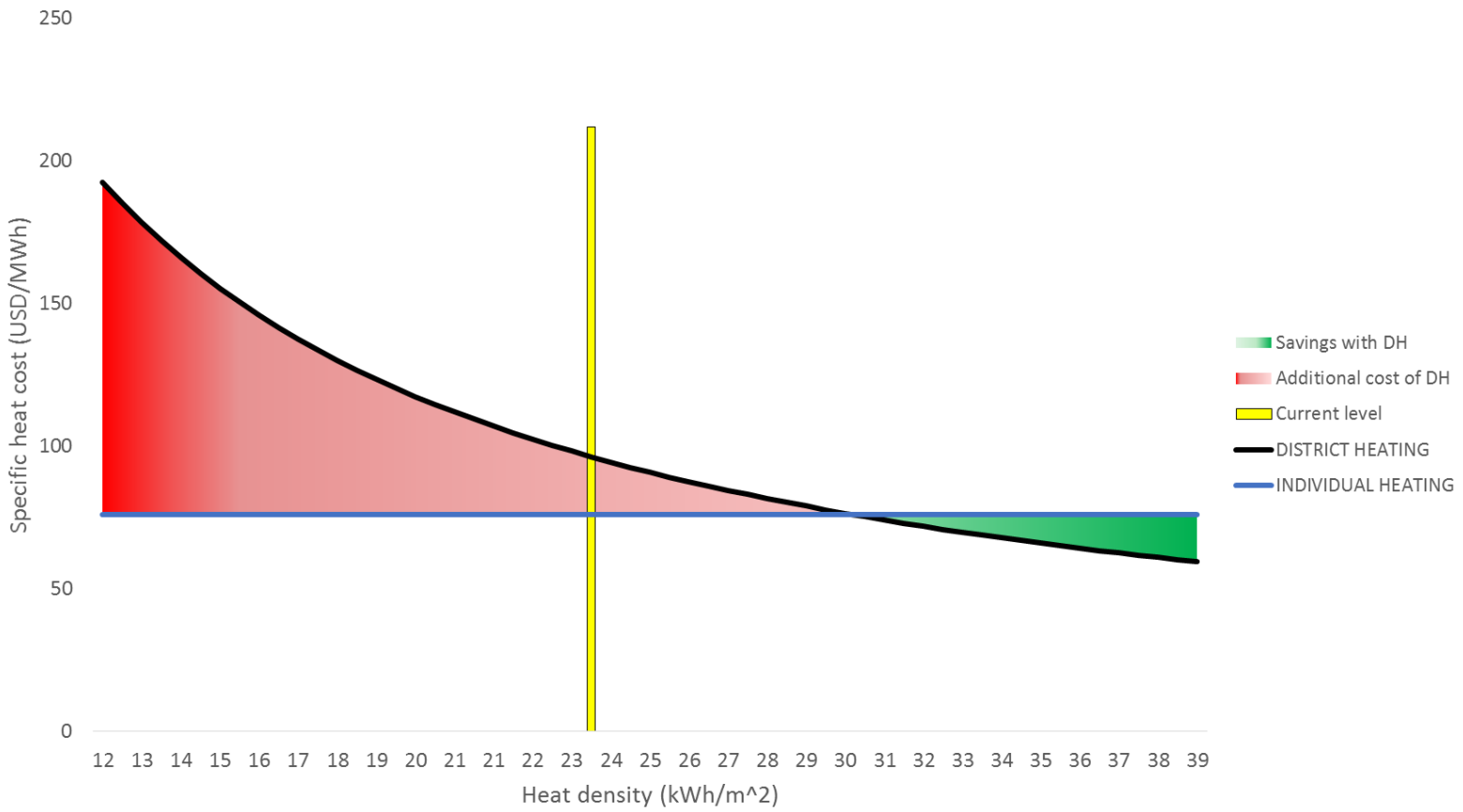
- ✓ **Increase the number of buildings in the area:** 10 Large offices added to the district

Buildings type	Case A	Case B
Single-family detached	30	30
High rise apartment	8	8
Medium Office	15	15
Large offices		10

Total area covered:
660,000 m^2

- ✓ **Use 15,000 MWh of waste heat (low price) from a near industry**

Case A Results – before adjustments



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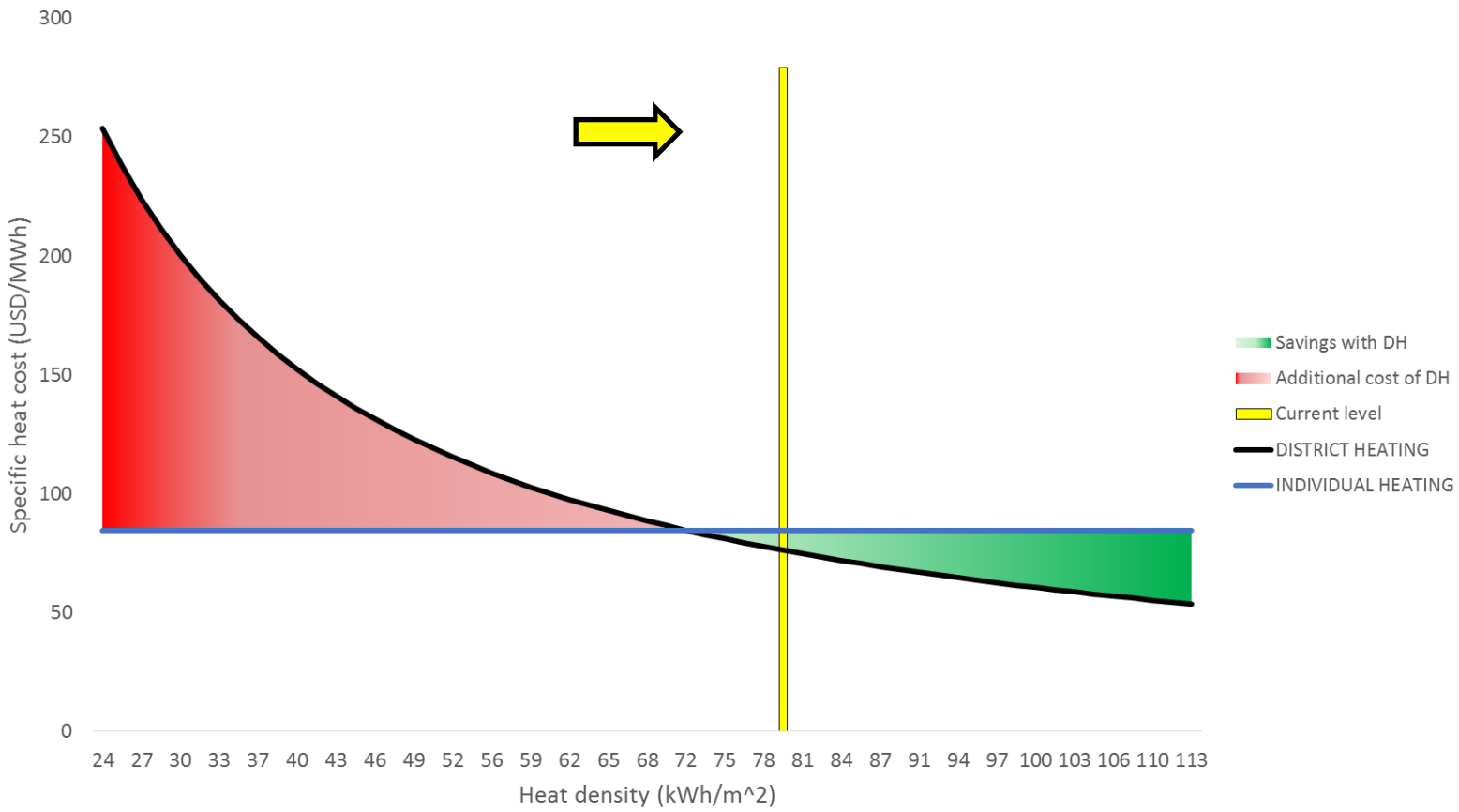
Case B Results – after adjustments



District heating is now feasible!

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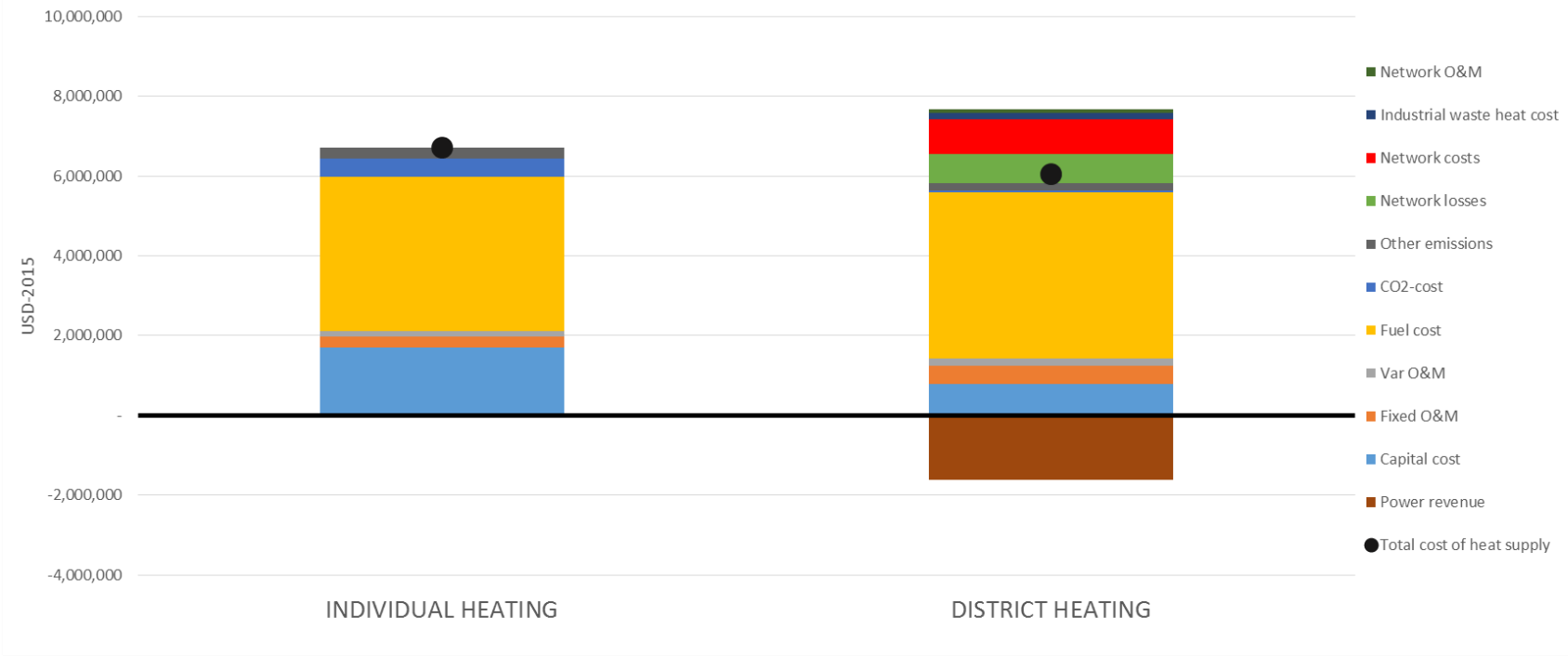
Case B Results



TOTAL COST 6,704,000 $ > **TOTAL COST 6,052,000 $**

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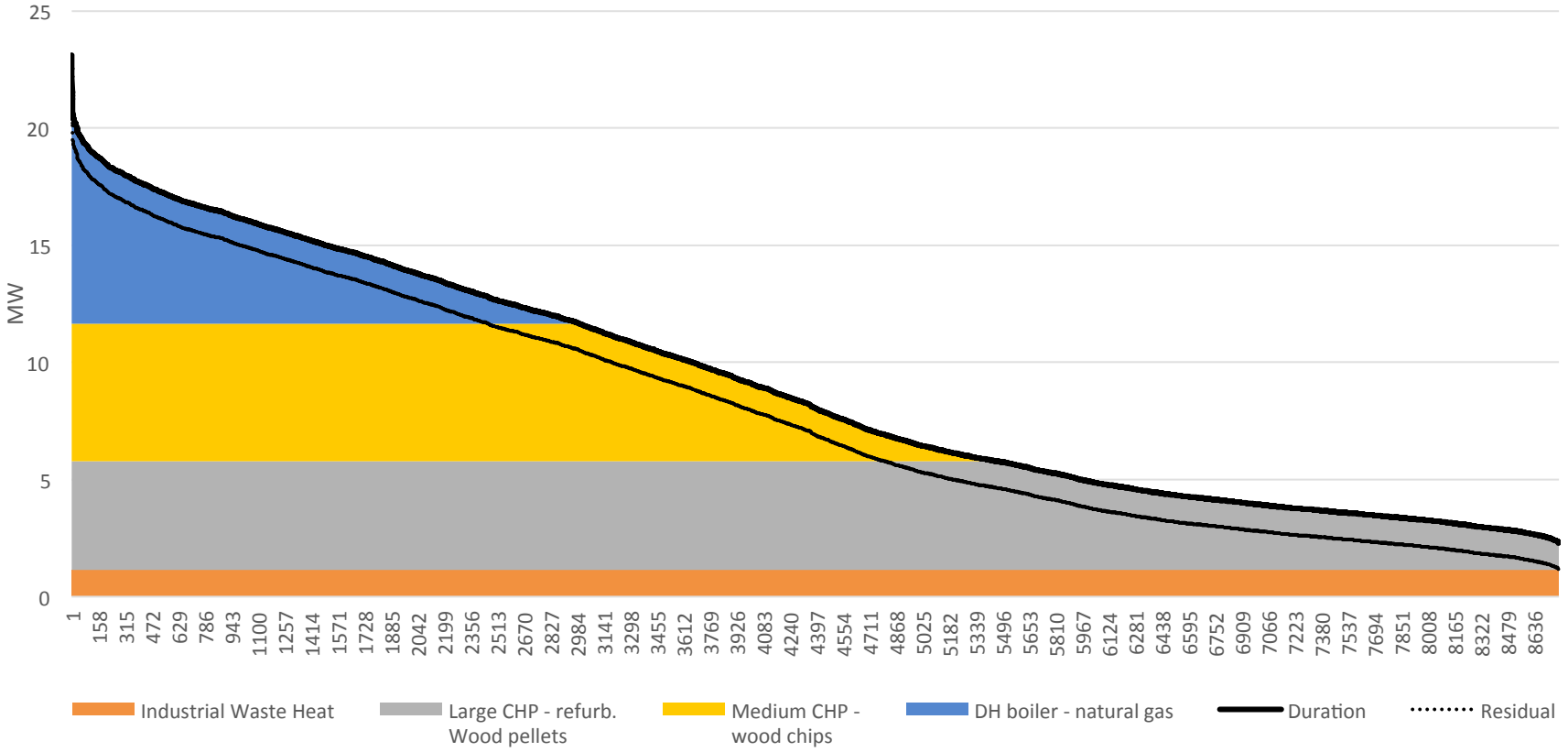
Case B Results



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Conclusions

- ✓ Pre-pre feasibility approach (explorative)
- ✓ Effective tool for urban planners and academical purposes

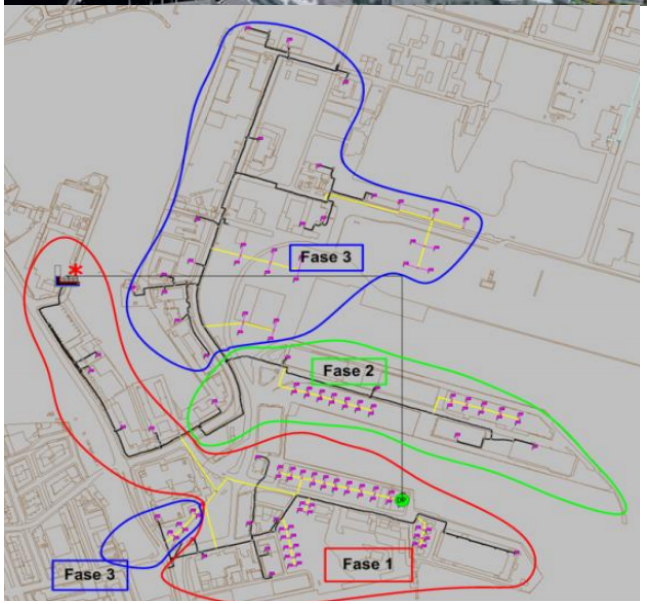
- ✓ Shows under which conditions District Heating is viable if compared to Individual heating
- ✓ Flexibility to change parameters and see how they affect the results

- ✓ Graphic interface under development to make it user-friendly
- ✓ Archetypes will be implemented

- ✓ Same model adapted for District Cooling

Case example from Denmark

- Planning proces for new areas
  - District energy taken into account
  - Socio-economic calculations requirede to approve heating supply
- Nordhavn
  - New city district at former industrial port
  - 40,000 residents and work places for 40,000 people when fully developed (approx. 2050)
- Heat supply
  - Hofor (Distribution company for district heat) has evaluated options
  - Suggests district heating



NPV (mio. DKK)	DH	Ind. air HP	Ind. Ground HP
Base	187	245	285
Higher demand	276	395	467
Lower demand	98	145	177

Source: Projektforslag til København Kommune, FJERNVARMEFORSYNING AF NORDHAVN, HOFOR, oktober 2013

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