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Stratego
ENHANCED HEATING & COOLING PLANS

Enhanced Heating and Cooling Plans to Quantify the Impact of Increased Energy Efficiency in EU Member States

Translating the Heat Roadmap Europe Methodology to Member State Level

Work Package 2

Country Report: Czech Republic

Co-funded by the Intelligent Energy Europe Programme of the European Union

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STRATEGO Website: http://stratego-project.eu
Heat Roadmap Europe Website: http://www.heatroadmap.eu
Online Maps: http://maps.heatroadmap.eu

Executive Summary

The STRATEGO WP2 main report quantifies the impact of implementing various energy efficiency measures in the heating and cooling sectors of five EU Member States: Czech Republic, Croatia, Italy, Romania, and the United Kingdom. The focus in this summary report is on the Czech Republic. The results from this study indicate that a total investment of approximately €50 billion in energy efficiency measures in the Czech Republic, between 2010 and 2050, will save enough fuel to reduce the costs of the energy system. After considering both the initial investment and the resulting savings, the total annual cost of the heating, cooling, and electricity sectors is reduced by ~15% (see Figure 1). These initial investments are primarily required in heat savings for the buildings, district heating in urban areas, and electric heat pumps in rural areas. In essence, energy efficiency measures in the heating sector will enable the Czech Republic to simultaneously reduce its energy demand, carbon dioxide emissions, and the cost of the heating, cooling, and electricity sectors (see Figure 1).

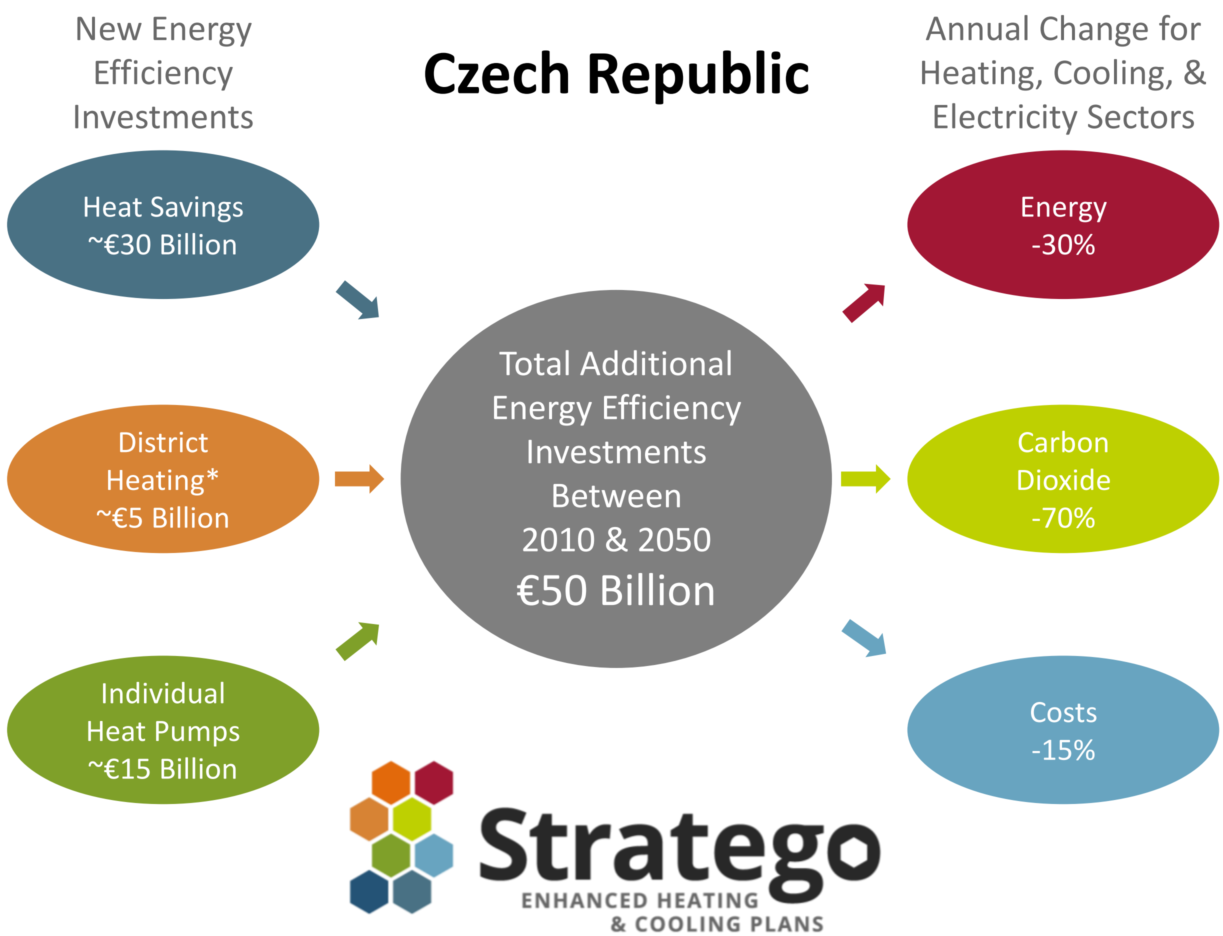

Figure 1: Key investments and main results for the Czech Republic. *This includes district heating supply technologies, pipes, and substations. It excludes the investments required to maintain existing district heating infrastructure.

Aim in STRATEGO WP2

The overall aim of the STRATEGO project is to support local and national authorities in the implementation of more efficient heating and cooling solutions. This support is provided in a variety of ways throughout the different work packages (WPs). WP2, which is the focus in this report, supports the development of advanced National Heating and Cooling Plans (NHCP), which are required under Article 14 of the European Commission's Energy Efficiency Directive. STRATEGO WP2 builds on the two previous Heat Roadmap Europe reports (www.HeatRoadmap.eu), which analysed alternatives for the heating sector at EU scale. In STRATEGO WP2, the Heat Roadmap Europe methodology is enhanced and applied here at a Member State level rather than for all of Europe together.

The overall aim in STRATEGO WP2 is to develop low-carbon heating and cooling strategies, which are called Heat Roadmaps, and subsequently to quantify the impact of implementing them at a national level for five EU Member States, which are the Czech Republic, Croatia, Italy, Romania, and the United Kingdom.

STRATEGO WP2 has fulfilled this aim by combining results from nine Background Reports together in this main report for each of these five countries. The Background Reports provide detailed information about the current and future energy system, including:

- The structure and scale of the existing and future energy system (Background Report 1)
- The hourly pattern of demand and supply across heating, cooling, and electricity (Background Report 2)
- The current heating and cooling demands in the buildings (Background Reports 4 and 5)
- The future development of the heating and cooling demands in the buildings (Background Reports 3 and 4)
- The location of the heating and cooling demand on a 1 km^2 resolution (see Figure 2), which is subsequently used to identify the potential to expand district heating and cooling (Background Reports 6 and 7)
- The potential renewable energy resources available (Background Reports 7, 8, and 9)

All of this information is combined in this main report using an energy model, called EnergyPLAN (www.EnergyPLAN.eu), which simulates the hourly operation of the heating, cooling, electricity, industry, and transport sectors over a single year. Using EnergyPLAN, the current and future energy system for each of the STRATEGO countries is replicated based on the historical year 2010 (Ref 2010), and based on a future 'Business-As-Usual' forecast by the European Commission for the year 2050 (BAU 2050). These two scenarios represent where we are today and where we are likely to end up, if we continue using energy in the same way in the future as we do today. Afterwards, a Heat Roadmap scenario is created for each country for the year 2050 (HR 2050), by adding more energy efficiency measures to the heating sector in the original BAU 2050 scenario. By comparing the HR 2050 scenario with the BAU 2050 scenario, the impact of implementing these new energy efficiency measures in the heat sector is quantified separately for each country in terms of three key metrics: energy (primary energy supply), environment (carbon dioxide emissions), and economy (total annual energy system costs). A summary of the main results from this comparison are presented here for the Czech Republic.

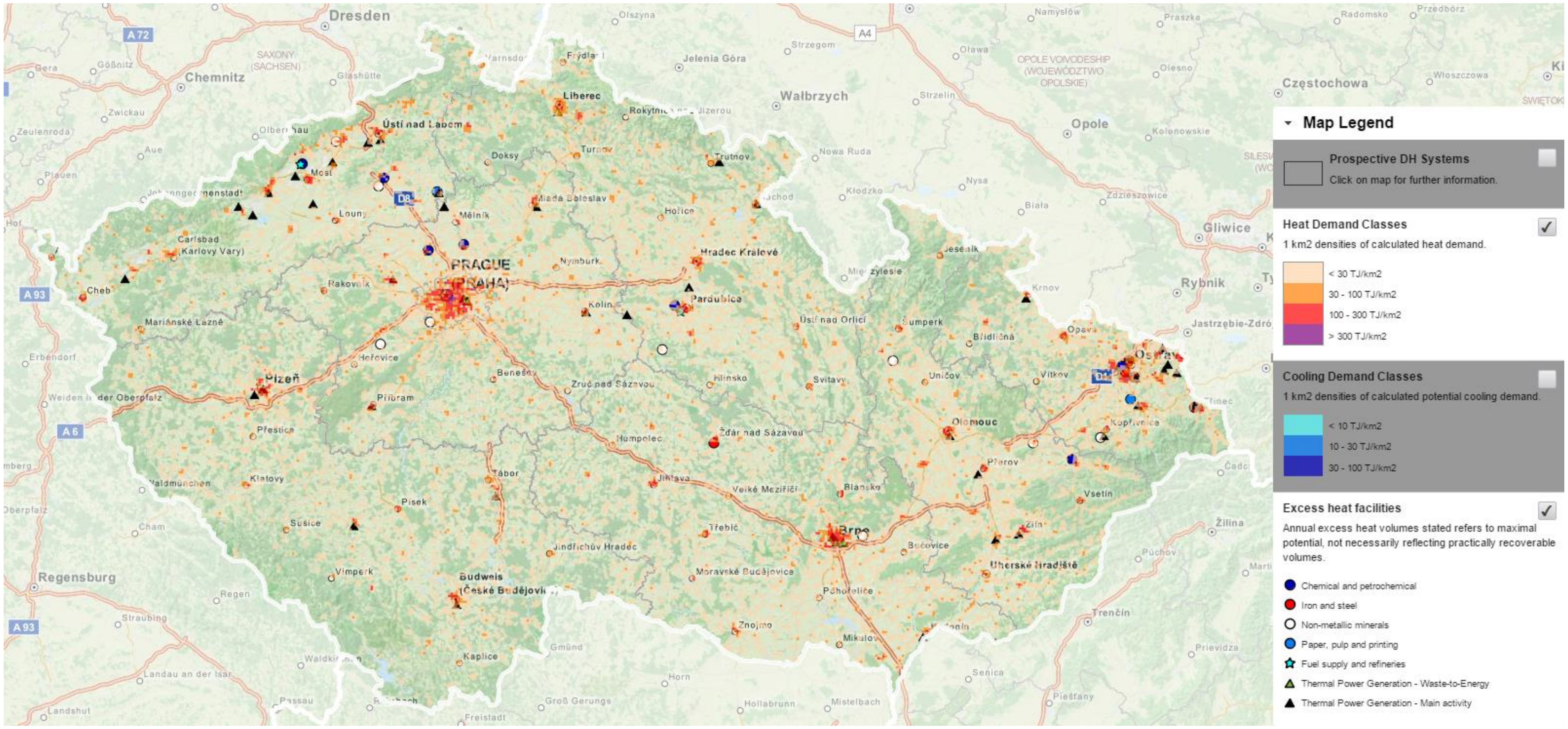

Figure 2: Pan-European Thermal Atlas for the Czech Republic (http://maps.heatroadmap.eu/).

Primary Changes in the Heat Roadmap Scenarios

The primary energy efficiency measures which are added to the heating sector in the Business-Us-Usual (BAU 2050) scenario to develop the Heat Roadmap (HR 2050) for the Czech Republic are:

- More heat savings in the buildings
- Replacing natural gas with district heating in the urban areas
- A comparison between various different individual heating solutions in the rural areas, including electric heat pumps, biomass boilers, electric heating, and oil boilers

The optimal level of heat savings and district heating is identified by increasing each of them in steps of 10% until the cheapest penetration is identified. The primary technology which should be utilised for individual heating has been identified, but the exact mix of individual heating solutions should be investigated further in future work.

The results for, indicate that the heat demand in the buildings should be reduced by approximately 40%, district heating should be expanded from supplying 25% of the heat demand today to approximately 40% in the future, while individual heating in the rural areas should primarily be supplied by electric heat pumps, which are supplemented by smaller shares of individual solar thermal and biomass boilers.

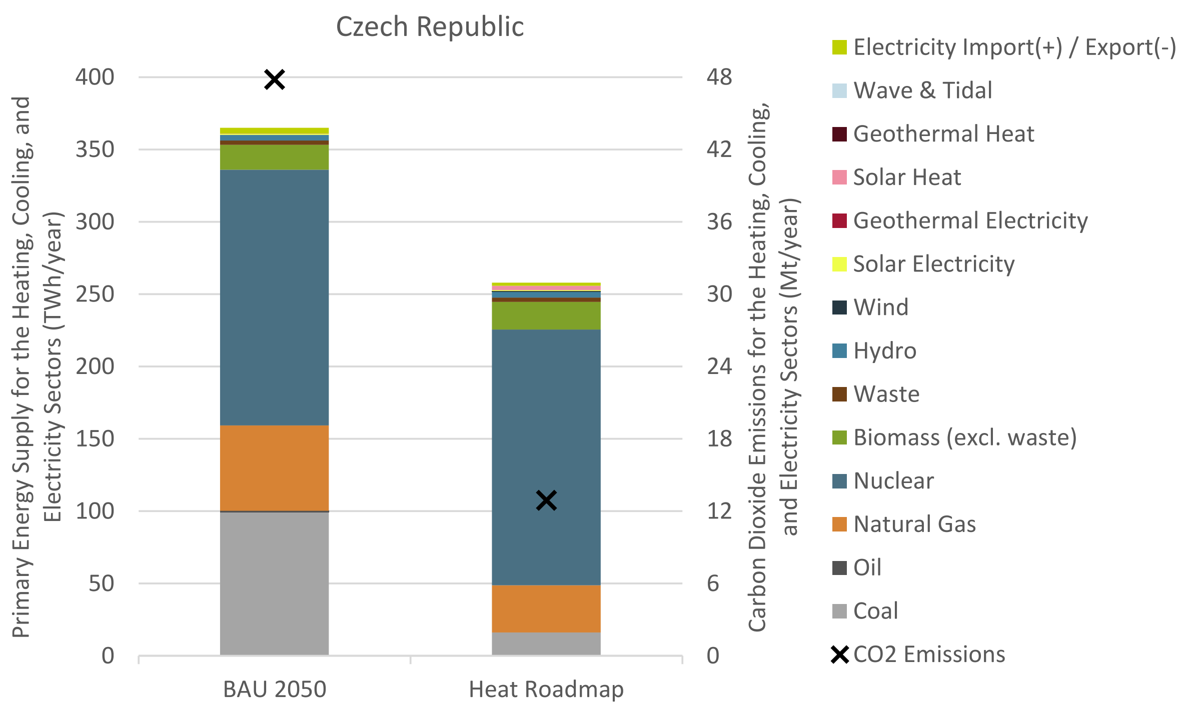

Figure 3: Primary Energy Supply and Carbon Dioxide Emissions in the Business-As-Usual (BAU 2050) and Heat Roadmap scenarios for the Czech Republic.

By implementing these energy efficiency measures, it is possible to reduce the energy demand, carbon dioxide emissions, and cost of the energy system in the Czech Republic. As presented in Figure 3, the energy demand in the heating, cooling, and electricity sectors is reduced by approximately 30% in the Heat Roadmap scenario for the Czech Republic compared to the BAU 2050 scenario. This reduction in energy demand simultaneously reduces the carbon dioxide emissions by approximately 70% and as displayed in Figure 4, the costs are also reduced by approximately 15%. Therefore, the implementation of more energy efficiency measures can reduce energy demand, carbon dioxide emissions, and energy costs at the same time.

In total, the energy demand is reduced by more than 100 TWh/year if the Heat Roadmap scenario is implemented in the Czech Republic*, which is the same as all of the energy required today in Croatia. Similarly, the reductions in carbon dioxide emissions of ~35 Mt/year is more than all of the carbon dioxide emissions emitted from Croatia today (which is ~20 Mt/year). Furthermore, the annual cost of the heating, cooling, and electricity sectors is reduced by almost €3 billion/year.*

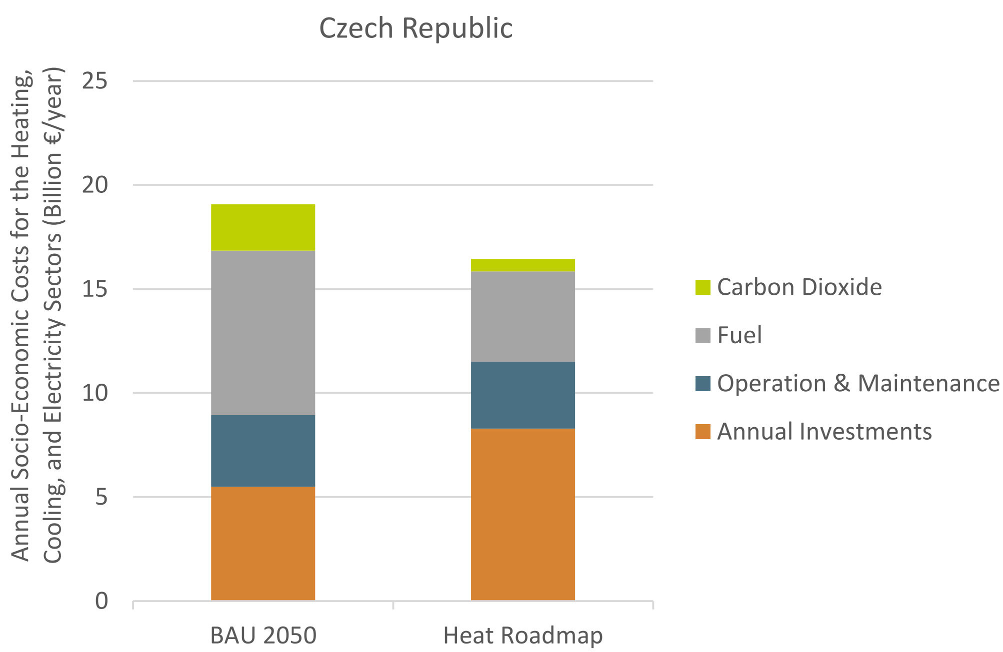

Figure 4: Annual socio-economic costs for the Heating, Cooling, and Electricity sectors in the Business-As-Usual (BAU 2050) and Heat Roadmap scenarios for the Czech Republic.

Even though these energy efficiency measures will require a very large increase in investment, the overall costs are reduced primarily due to a reduction in fuel consumption, which equates to a reduction in fuel costs of ~€5 billion/year in the year 2050. In total, approximately €50 billion of additional investments will be required in the heating and electricity sectors between 2010 and 2050 to implement the Heat Roadmap scenario, which are primarily for existing technologies. Some of these existing technologies will require more investments in the future, while others will require less.

Detailed Changes in the Heat Roadmap Scenarios

A detailed breakdown of investments required between 2010 and 2050 to implement the Heat Roadmap recommendations in the Czech Republic is provided here in Figure 5, which compares the total investments in the Heat Roadmap scenario with the total investments in today's energy system. The majority of investments to implement the Heat Roadmap scenario are required in existing technologies, while the most significant investments required are:

- Heat savings to reduce the heat demand in the buildings: ~€30 billion

- Electric heat pumps for the buildings in the rural areas: ~€15 billion
- District heating technologies for supplying heat and distributing the heat (i.e. the pipes and substations). The supply technologies include solar thermal, geothermal, heat pumps, industrial heat, and combined heat and power (CHP): ~€5 billion

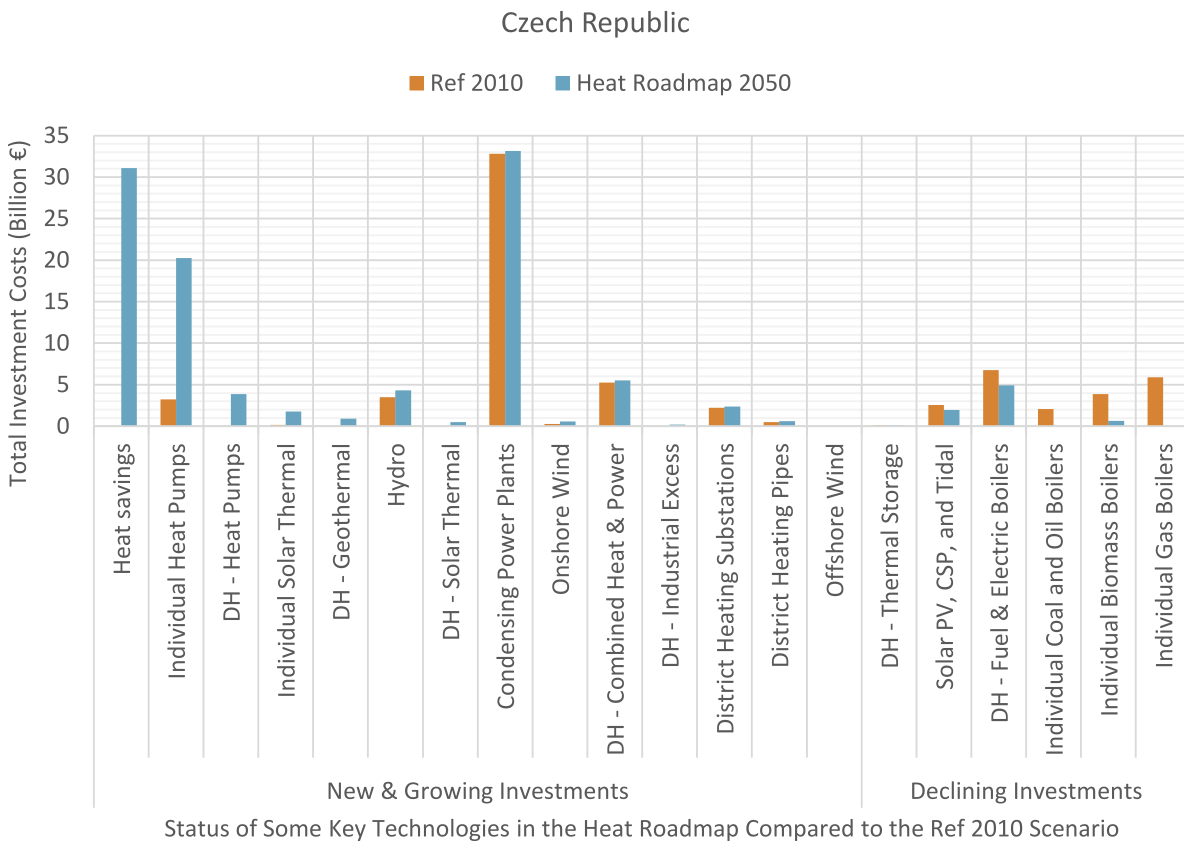

Figure 5: Total investments for some (not all) key technologies in the heating, cooling, and electricity sectors in the Reference (Ref 2010) and Heat Roadmap (HR 2050) scenarios for the Czech Republic.

Together, these technologies represent a total investment of approximately €50 billion in today's heating and electricity sectors between 2010 and 2050 for the Czech Republic, which as mentioned previously will save the same amount of energy as the total consumed today in Croatia. As a result, these investments will create a net reduction in the annual cost of energy for the heating and electricity sectors of ~15%. Therefore, expanding these technologies simultaneously reduces the energy demand, fuel consumption, carbon dioxide emissions, and energy costs (see Figure 3 and Figure 4).

The district heating investments are comparatively small since there is already a relatively large penetration of district heating in the Czech Republic. As the heat demand in the buildings is reduced, the existing heat supply plants on the district heating network can be used to meet the growing demand for district heating, thus reducing the need for new plants to be constructed. Furthermore, these investments do not include the cost of renewing the existing district heating infrastructure that is already in place in the Czech Republic. For example, the existing district heating networks should be upgraded to 4th generation district heating when they are replaced at the end of their life (www.4DH.dk).

Heat Available from Renewable Resources and Excess Heat

The potential availability of renewable resources is also investigated in this study. The analysis includes a detailed quantification of the renewable resources and excess potentials available for the heating sector. From the results it became apparent that there are very large amounts of excess heat already available in the Czech Republic from existing thermal power plants, industrial plants, and waste incinerators, while there is also a huge potential to utilise renewable resources for heating. As displayed in Figure 6, there is almost three times as much renewable and excess heat available in the Czech Republic than is required to meet the high levels of district heating supply proposed in the Heat Roadmap scenario. However, these resources can only be utilised if a district heating network is put in place to connect these resources to the end-user. Without the district heating networks, these resources will continue to be wasted.

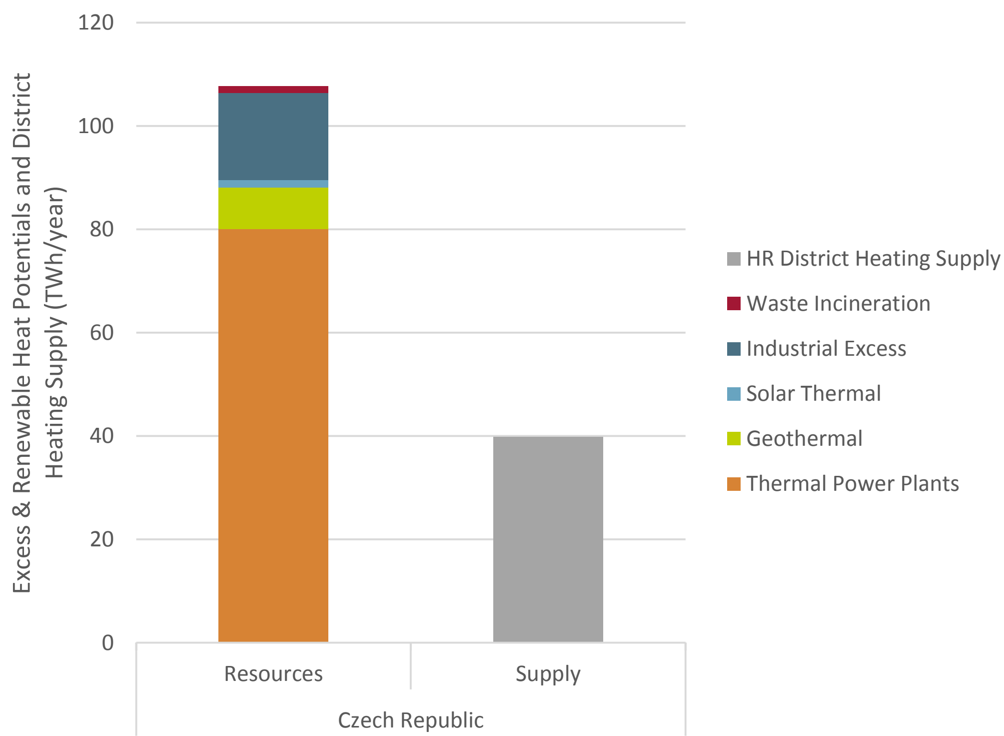

Figure 6: Excess and renewable heat potentials for the Czech Republic, in comparison to the district heating supply proposed in the Heat Roadmap scenario (see Background Reports 7, 8, and 9).

The analysis also included a review of the renewable electricity resources available, such as wind, solar, hydro, wave, and tidal power, as well as the bioenergy resources available, such as forestry and energy crops. After analysing these resources, it became apparent that there is likely to be a shortage of renewable electricity and bioenergy resources if the long-term objective is to decarbonise all sectors of entire energy system in the future, including industry and transport. This reinforces the importance of utilising the renewable and excess heat resources presented in Figure 6 in the heating sector. By using these resources, it is possible to minimise the pressure on renewable electricity and bioenergy resources, which are more important for all parts of the energy system where there are fewer cost-effective alternatives for decarbonisation.

Sensitivity of the Results and Conclusions

The robustness of the results and conclusions for the Heat Roadmap has been analysed for changes to the fuel prices, investment costs, district heating pipe costs, and various assumptions for the amount of sunk costs that may occur as natural gas is replaced with district heating. The sensitivity analyses revealed that potential changes in the fuel prices between 2010 and 2050 will have a very large impact on the overall cost of the energy system. The variations identified due to these changes in the fuel prices are much larger than any variations that have been quantified when implementing the energy efficiency measures in the heating sector. In other words, the cost of the energy system is much more likely to increase due to the future cost of fuel than it is due to the implementation of energy efficiency measures in the heating sector. Even when using today's fuel prices, the energy efficiency measures proposed in this study still do not increase the cost of the energy system, primarily due to the fuel savings that occur when these investments are made. Similarly, although the sunk costs that could occur when district heating replaces natural gas will increase the cost of the Heat Roadmap scenarios, it is unlikely that this increase will be sufficient to make the Heat Roadmap scenario more expensive than the BAU 2050 scenario. After analysing the breakdown of the production cost for district heating networks in this study, it became apparent that the district heating pipes only account for a very small share of the total production cost (only ~5-15%). It is likely that the sunk costs related to the gas and district heating networks have a relatively small impact due to this small share they represent in the total production cost. In summary, although the results in this study are sensitive to future forecasts in fuel prices and potential sunk costs, the conclusion that increased levels of heat savings, district heating, heat pumps, and individual solar thermal benefit the energy system is robust.

Cooling Sector

The initial aim in the STRATEGO WP2 study was to consider both heating and cooling in equal measure. However, after profiling the existing cooling demand in each Member State, it became apparent that the cooling demand is currently much smaller than today's heat demand. As displayed in Figure 7, the cooling demand is currently ~2% of the heat demand in the Czech Republic. The cooling demand is relatively low since less than 10% of the buildings in the Czech Republic actually meet their cooling needs today, with many buildings opting to live with the discomfort of overheating rather than pay for the cost of cooling to a comfortable level. In contrast, it is likely that all of the buildings in the Czech Republic currently provide some level of heating.

This means that the heating and cooling demand are likely to undergo two very different developments in the coming decades. The cooling demand is likely to increase as more buildings start to meet their actual cooling needs, while the heat demand is likely to decrease as more heat saving measures are implemented in the buildings. For example, as already discussed, the heat demand is reduced by approximately 40% in the final Heat Roadmap scenario. As the cooling demand increases and the heat demand decreases, the relative influence of the cooling demand is likely to increase. Once again, if the heat savings recommended in the Heat Roadmap scenario are implemented, and at the same time all of buildings actually meet their cooling needs in the future ('max potential cooling demand' in Figure 6), then the cooling demand will become approximately 30% of the heat demand (see Figure 7). Therefore, when the cooling demand is at similar levels as today, the impact of changing the cooling sector is almost negligible from a national energy system perspective. However, if the demand increases to the maximum demand in the future, then the cooling sector will begin to have an influence on the national system.

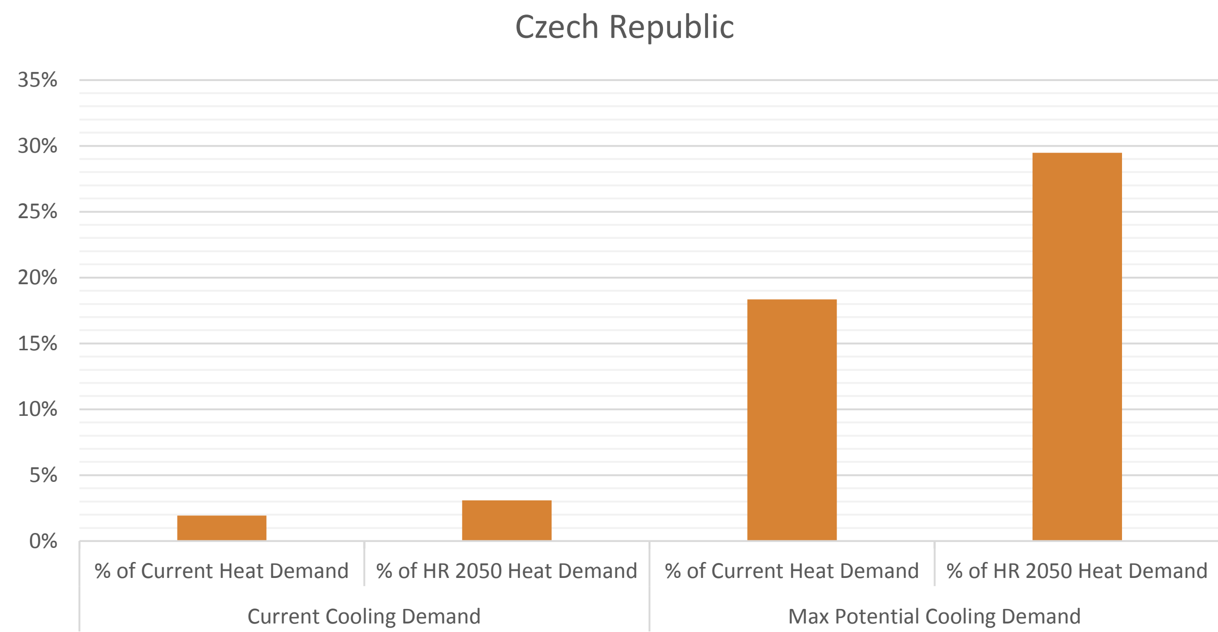

Figure 7: Scale of the Current and Future Potential Cooling Demand for the Czech Republic, compared to the Current heat demand (2010) and the heat demand in the Heat Roadmap scenario (HR 2050).

STRATEGO WP2 Conclusions and Recommendations

The overall conclusion in STRATEGO WP2 is that a combination of energy efficiency measures, in the form of heat savings, district heating in the urban areas, and primarily heat pumps, with smaller shares of biomass boilers and solar thermal in the rural areas, reduces the energy system costs, energy demand, and carbon dioxide emissions in the Czech Republic for the year 2050 compared to a 'Business-As-Usual' projection.

Below is a list of 21 key conclusions and recommendations from this study, divided by specific categories relating to the heating and cooling sector. These are elaborated upon in more detail in the main report.

Heat savings

1. Heat savings reduce the energy demand, carbon emissions, and costs in all countries, but eventually they become more expensive than the cost of sustainable heat supply.
2. The average heat demand in residential and services buildings combined, including space heating and hot water, should be reduced by approximately 40% in total. This equates to a heat density of approximately 110 kWh/m^2.

3. Heat savings should be implemented over a long-term time horizon, in combination with other building renovations.
4. There are synergies between the reduction of the heat demand and improvements in the heat supply such as reducing the thermal capacity required and enabling more heat sources to be utilised on the district heating network.

Heating in Urban Areas

5. District heating is more efficient and cost effective in urban areas than natural gas networks.
6. District heating is technically and economically viable in the North and South of Europe.
7. District heating can utilise very large amounts of excess heat and heat from renewable resources, which are wasted today in the energy system.
8. District heating pipes represent a relatively small fraction of the annualised district heating system cost (~5-15%).
9. The sunk costs that could occur during the implementation of district heating do affect the results for the Heat Roadmap scenarios, but the scale of their impact is not significant enough to change the overall conclusion.

Heating in Rural Areas

10. Individual heat pumps are the most preferable individual heat solution based on a balance across energy demand, emissions, and cost. They should be supplemented by smaller shares of individual solar thermal and biomass boilers.
11. The optimal mix of individual heating technologies should be analysed in more detail.
12. Individual heat pumps may be too expensive in suburban areas, where the heat supply transitions from district heating to an individual heating solution.

Cooling

13. The current cooling demand is relatively low compared to the heat demand, but in the future the cooling demand could be relatively larger.
14. District cooling can reduce the cost and energy demand in the cooling sector, but at present the benefits occur at a local level.
15. The optimal level of district cooling is still unclear.
16. The design of the district cooling network should be analysed in more detail.

Sustainable Resources for the Energy System in the Future

17. There is a large amount of excess heat and heat from renewable resources available, but there is likely to be a shortage of renewable electricity and bioenergy in the future.
18. Further energy efficiency improvements are necessary in electricity, industry, and transport to decarbonise the energy system.

Methodologies and Tools for Analysing the Heating and Cooling Sector

19. Alternative technologies in the heating and cooling sector should be analysed from a complete energy systems perspective.

20. A combination of mapping and modelling is essential to analyse the heating and cooling sectors, but it should also be expanded to other parts of the energy system in the future.
21. A variety of different expertise is required to inform, design, and analyse a holistic heating and cooling strategy.