ENGLISH SUMMARY

The present report from the Chairmen of the Danish Council of Environmental Economics consists of three chapters:

- The value of a statistical life
- Air pollution
- Denmark free of fossil fuels by 2050

The aim of the first chapter is to investigate whether the value of a statistical life of DKK 18 million that is currently used in cost benefit analyses of policy measures in Denmark should be revised. The second chapter provides an assessment of whether the current Danish air pollution regulations are appropriate. The chapter recommends new regulation of the use of wood-burning stoves. This would lead to a significant reduction in the health costs associated with air pollution from this source. The final chapter illustrates the economic consequences associated with the Danish goal of being independent of fossil fuels by 2050.

Chapter I: The value of a statistical life

Many decisions related to public policy affect the population's risk of dying in a given period. This is true for policies regarding traffic safety, environmental pollution and healthcare. For instance, reductions in emissions of polluting substances as well as improved road infrastructure can contribute to reducing the population's risk of dying.

A lower mortality rate is beneficial both for the society as a whole and for the individual. However, reducing the population's risk of dying is not without economic costs. Furthermore, the scarce nature of public funds necessitates a prioritization of policies within and across policy sectors.

To help decision-makers in such prioritizations, *the value of*

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a statistical life is a useful tool. The value of a statistical life is an aggregation of the population's willingness to pay for a marginal change in the likelihood of death that adds up to one statistical life. In other words, the value of a statistical life reflects the population's preferences for reducing the risk of dying rather than the value of a single, identified life.

Some may see it as unethical to place a value on changes in safety measures that could prevent (or cause) fatalities. However, if these changes are not valued explicitly, there is a risk that they will instead be valued implicitly and disparately from case to case. An explicit value of a statistical life is therefore preferable, as it enables a transparent and consistent valuation within and across policy sectors.

Like many other countries, Denmark has an explicit value of a statistical life for use in cost benefit analyses of policy measures that affect the population's risk of dying. Currently, the value of a statistical life is DKK 18 million. This value originates from an older EU publication.[1] Compared to the values of a statistical life employed in many other countries, as well as an updated recommendation from the EU Commission, the Danish value seems to be low. The aim of chapter I is to examine whether the value of DKK 18 million should be reconsidered.

The chapter draws on theoretical and empirical literature as well as practices in other countries in determining a suitable value of a statistical life for Denmark. Furthermore, the chapter presents a new analysis of Danes' willingness to pay for reductions in the risk of dying in traffic accidents. The analysis builds on a survey answered by 2,000 respondents aged 18-80 and is representative of the Danish population with regard to age, education, gender and geography. The survey applies the contingent valuation method, which is often used for estimating the value of a statistical life. The respondents were asked to state the amount of money they were willing to pay for a small reduction in their risk of dying in a traffic accident. The calculated value of a statistical life was based on the elicited amounts. The survey was

1) All values in the summary of chapter I are in 2015-prices.

designed in cooperation with Professor Ståle Navrud of the Norwegian University of Life Sciences.

The outcome of the survey suggests that the Danish value of a statistical life lies in the range of DKK 26-36 million, with a best estimate of DKK 31 million. This is nearly twice as high as the value currently used by decision makers in Denmark. Furthermore, respondents' willingness to pay increased with their income and the size of the risk reduction. The latter means that the survey passed a scope test, which is an important criterion for contingent valuation studies according to the literature.

Nevertheless, stated preference methods such as contingent valuation surveys are associated with a fair amount of uncertainty. In particular, many respondents have difficulty understanding and, therefore, valuing small changes in risk. For that reason one should be cautious when interpreting the results from a single survey. The credibility of the current survey can be strengthened by comparing the results with those of other surveys.

In addition to the survey presented in this chapter, two other Danish surveys have estimated the value of a statistical life. These surveys find best estimates of DKK 27 million and DKK 35 million, respectively. Thus, the mean value of the three Danish surveys is DKK 31 million – the same as the best estimate from the survey presented in chapter I.

This new Danish value of a statistical life of DKK 31 million is lower than values typically found in stated preference surveys in other countries when accounting for differences in income. The OECD recently analysed more than 400 estimates of the value of a statistical life from stated preference surveys conducted worldwide. Based on their meta-analysis, they find the value of a statistical life adjusted for a Danish income level to be DKK 36-46 million. This finding suggests that the Danish estimates are quite conservative compared to those found in foreign surveys.

Calculations of the value of life can also be based on a person's expected lifetime income and the value of leisure. The sum of the lifetime income and the value of leisure is considered to be lower than the actual value of life. This is primarily because the full utility derived from consumption, the so-called consumer surplus, is not included in income measures. However, calculating the lifetime income and the value of leisure is still useful, as their sum constitutes a lower bound for the value of a statistical life. For an average Dane, the expected lifetime income, including a conservative value of leisure, is calculated to be DKK 18 million. This is a clear indication that the current value of a statistical life of DKK 18 million is too low.

In conclusion, many factors suggest that the current Danish value of a statistical life is too low. It is therefore recommended that future cost benefit analyses use a value of statistical life of DKK 31 million.

A higher value of a statistical life will influence the outcome of cost benefit analyses of policies that affect the Danish population's risk and safety. Concretely, a higher value of statistical life means that policies that lower the population's risk of dying become more favourable in welfare economic analyses.

The recommended value of a statistical life of DKK 31 million is suited to value changes in the risk and safety of the Danish population in general. However, some policies disproportionately affect the risk of certain age groups. For instance, reductions in air pollution mainly benefit the elderly. Since the elderly have fewer expected remaining life years, it seems appropriate to value policies that affect them using a *value of life years*. This approach can also account for the fact that young people have more expected remaining life years. If the value of a life year is constant across all ages, this implies that the value of life is higher for the younger population.

Consistency between the value of a statistical life and the value of a life year is necessary in order to correctly prioritize policies that affect the population as a whole and those that only, or mainly, affect particular age groups. The current value of a life year in Denmark is approximately DKK

1 million. However, this value is calculated on the basis of a value of a statistical life of DKK 18 million. Therefore, it is recommended that, in the future, the value of a life year is set to DKK 1.3 million, which is consistent with the value of a statistical life of DKK 31 million.

Chapter II: Air pollution

People are exposed to air pollution every day. In the short term this can lead to asthma and bronchitis, and in the long run it can result in coronary heart disease, lung cancer, and ultimately premature death. The health effects entail significant economic costs, which probably constitute the predominant share of the total cost of air pollution. Other costs stem from damage to nature and biodiversity.

Air pollution is transboundary, which means that Danes are affected by emissions from surrounding countries and vice versa. Air pollution emitted in other European countries accounts for the majority of the total Danish health costs related to air pollution. The total costs amount to approximately DKK 39 billion a year, of which Danish sources account for only DKK 7 billion. Conversely Danish emissions lead to health costs of around DKK 31 billion per year in other European countries.

The transboundary nature of air pollution calls for international cooperation if air pollution is to be reduced effectively. Under the auspices of the UN and the EU, country specific emission ceilings have been agreed. These agreements have been crucial in reducing air pollution in Europe. Studies of the costs and benefits of these agreements indicate that the emissions ceilings are relatively close to being cost effective. In overall terms, the international treaties limiting air pollution within the EU have been a success.

Studies suggest, however, that the agreed reductions in air pollution in the EU are slightly smaller than they should be based on an assessment of the benefits compared to the costs of reducing air pollution. This implies that there could be even greater economic gains from reducing air pollution in Europe further. Denmark should, therefore, work for even more ambitious agreements to reduce air pollution within the EU.

As a result of both international and Danish regulation, Denmark's emissions have generally been declining since 1990. The aim of the air pollution regulations in Denmark is, among other things, to help meet the internationally agreed emission ceilings. The regulations are based on different instruments such as bans, limits, taxes and subsidies.

The use of taxes is often a cost-effective instrument when regulating environmental externalities, such as air pollution. According to the Pigouvian principle the level of an environmental tax should correspond to the marginal costs of the inflicted damages. However, the damages that the Danish emissions cause abroad are regulated by international agreements. Given this international framework, taxes should at least be set to reflect the costs of air pollution in Denmark emitted from Danish sources. Higher taxes should be applied if internationally agreed emission ceilings for Denmark cannot be met.

Air pollution consists of a variety of different substances and particles; one being nitrogen oxide (NO_X). From mid-2016 the Danish tax on NO_X will be reduced from DKK 26 per kg emitted to DKK 5 per kg. The current level of the NO_X tax is higher than the Danish health costs from NO_X emissions, therefore lowering the tax is appropriate. The upcoming reduction will, however, be too large and lead to a tax that is slightly lower than the health costs related to emissions of NO_X. Furthermore, the NO_X tax reduction could lead to the internationally agreed 2020 NO_X emission ceiling being exceeded. In conclusion a lowering of the NO_X tax is appropriate, but the agreed reduction seems to be too large.

The current tax on sulphur (SO_X) is generally lower than the health costs in Denmark. The tax should, therefore, be raised from the current DKK 11 per kg emitted to between DKK 15 and 77 per kg, depending on which sector the emissions originate from.

The health costs associated with emissions of both SO_X and NO_X differ between sectors. This is mainly an effect of geographic variation in the emission sources. A uniform tax will, therefore, typically be too high in relation to the derived health costs for some sectors, but too low for other sectors. Taxes on air pollution should ideally vary geographically, but should at very least vary between sectors.

The main Danish sources of air pollution are residential heating, agriculture and road transport. A general analysis of emissions from these three sectors suggests that there is a need for further regulation of the residential heating sector, in which the majority of the health effects come from the use of wood-burning stoves. This sector is characterized by limited regulation of air pollution. On this basis an analysis of the effects of different forms of regulation of air pollution from wood-burning stoves has been conducted. Similar analyses of air pollution from agriculture and road transport have not been carried out.

In the analysis of the regulation of wood-burning stoves, the net socioeconomic benefits of the different types of regulations are calculated and used as the basis for policy recommendations. The analysed types of regulation are:

- Differentiated taxes on the use of stoves, which reflect the derived health costs of using such stoves
- A ban on the use of older stoves
- Subsidies for scrapping older stoves

For this analysis the DCE (Danish Centre for Environment and Energy), Aarhus University, has calculated new geographically detailed accounts of the health effects of emissions from wood-burning stoves. The analysis shows that the costs of using wood-burning stoves are much higher than previously assumed. The higher costs are partly due to the fact that the analysis is based on the higher values of a statistical life and life years, which are derived in Chapter I of this report.

The calculations also show that there are very large differences in the derived health costs depending on where the emissions originate. Not surprisingly, the health costs are significantly higher in areas where the population density is high.

Health costs of using wood-burning stoves also depend on the age of stoves. Older stoves tend to have higher emissions of air pollution than new stoves. Thus, the emissions associated with one hour of “normal” use of an old wood-burning stove in Copenhagen have health-related costs of DKK 41 per hour. For a new wood-burning stove that meets today’s ecolabel requirements (the Nordic swan label), also located in Copenhagen, the health related costs are significantly lower at DKK 7 per hour of use. Similar use of old and new eco-labelled stoves in the most remote parts of Denmark (e.g. Bornholm in the Baltic Sea) are associated with health costs of DKK 5 and DKK 1 per hour of use.

Geographically differentiated taxes on the use of wood-burning stoves, reflecting the health costs under normal use, provides the greatest economic benefit among the analysed forms of regulation.

The differentiated tax would be conceivably implemented by placing a temperature meter in the chimney to record how many hours a stove is used. Such a meter cannot detect the actual emissions but allows the number of hours a stove is used to be tracked. This allows the tax to depend on the level of use, while the tax may also vary according to the location and age of the wood-burning stove.

The socioeconomic net benefits of a differentiated tax are about DKK 3 billion per year in Denmark. The calculations take into account the administrative costs of measuring the use of wood-burning stoves.

The calculated benefits reflect a large reduction in the health related costs. It is estimated that the differentiated tax will reduce the number of deaths caused by air pollution in Denmark by about 300 per year.

Bans on the use of all older wood-burning stoves that do not meet the ecolabel emission requirements also provide great socioeconomic benefits. The benefits are slightly less than for differentiated taxes, but this kind of regulation will probably be easier to administer. In practice, this type of regulation could be implemented as a gradual phasing out of older stoves, which, for example, is being done in Germany.

A scrapping scheme targeting stoves made before 2008 also provides a socioeconomic benefit that is somewhat lower than the other types of regulation. Subsidies for the scrapping of stoves will be more cost effective if they are targeted at scrapping stoves in the cities and population-dense areas in general.

The analyses show that the benefits of regulating wood-burning stoves mainly come from reduced emissions in urban areas. Therefore, introducing a form of environmental zones for stoves, with differentiated taxes or bans on the use of older stoves, should be considered. Although the benefits of regulation in rural areas are less than in urban areas, they are still positive, and regulation should, in principle, cover all of Denmark.

Chapter III: Denmark free of fossil fuels by 2050

In 2015 a global climate agreement to keep the temperature rise well below two degrees above pre-industrial levels was signed at COP21 in Paris. The chairmanship of the Economic Council has previously stated that a target of two degrees can be seen as a suitable compromise between achieving economic prosperity and minimising climate effects, taking into account that there is a risk of serious consequences caused by large temperature increases.

The EU supports the two degrees target and contributes by aiming at a target to reduce total emissions of greenhouse gases in the EU by 80-95 pct. by 2050 compared to emissions in 1990. In Denmark, this target is converted to the objective of Denmark being independent of fossil fuels by 2050.

In Denmark there is no consensus about the size of the economic costs of being independent of fossil fuels. The purpose of this chapter is to illustrate the economic consequences for Denmark associated with achieving this ambition. Whether the Danish aim of independence from fossil fuels is suitable relative to the Danish climate policy framework, set by regulations and targets formulated in the EU, is also discussed.

Estimating the cost of being independent of fossil fuels is subject to great uncertainty. The calculations presented in the chapter are based on scenarios published by the Danish Energy Agency in 2014. Given this setting, the calculations in the chapter show that the energy costs can be expected to increase by DKK 16 billion when switching to fossil free fuel production. This is a somewhat larger increase in energy costs than originally calculated by the Danish Energy Agency.

The increase in energy costs depends on numerous factors such as future developments in fuel prices, technological development and the level of ambition in climate policies in the rest of the world. Consequently, the increase in energy costs could be larger or smaller than indicated. Higher fossil fuel prices would reduce the cost of the conversion, while a slower development in technologies related to renewable energy would increase the costs.

The model calculations presented in the chapter suggest that the level of GDP would be reduced by around 0.3 per cent in the long run. The drop in production reflects lower productivity and a small decline in labour supply. The lower productivity and subsequent lower real wages along with a little less labour supply leads to a decrease in private consumption. This is the main reason for a welfare loss equivalent to 0.5 per cent of GDP. The welfare loss is greater than the decline in GDP, which, among other things, is a result of the fact, that a larger proportion of the production in the fossil-free scenario is used to maintain the capital stock. Overall, the calculations present socio-economic effects that are roughly similar to those found by the Climate Commission in 2010.

At least two factors suggest that the increase in costs might be underestimated. First, the modelling does not include the adjustment costs that are to be expected when companies and households have to change their input of factors of production and their composition of consumption. Second, the calculations assume that the target is achieved using efficient economic instruments. If an unsuitable mix of instruments is used to achieve the target, the socio-economic costs increase. An example of inefficient instruments is support for different types of renewable energy, where the level of support depends on the specific technology.

The Danish target of being independent of fossil fuels by 2050 should be seen in the context of Denmark's commitments to the EU and the EU's climate policy. If the EU is to meet the stated objective of reducing greenhouse gas emissions by 80-95 pct. by 2050, it will require further constraints on the number of quotas within the quota system as well as on the national emission amounts outside the quota system.

If the EU reduces the number of quotas significantly, a shift in the use and production of energy will automatically occur in the EU as well as in Denmark. The total emissions from the quota sector in the EU are controlled by the EU's quota ceiling. Hence, Danish reduction initiatives in the quota sector basically have no effect on the climate. Danish initiatives within the quota sector, such as support for renewable energy can, therefore, only be justified if they are driven by other objectives than a direct effect on the climate.

A frequently used argument for ambitious climate policies in Denmark is that, through setting an ambitious climate policy, Denmark can influence the global level of climate ambitions. An ambitious Danish climate policy could, for example, lead to a faster or larger reduction in quotas in the EU. It is difficult to identify such a demonstration effect, but nor can it be rejected.

An important issue related to possible demonstration effects of Danish climate policy is whether any such effects result from the fact that Denmark does "a lot", such as setting ambitious targets and meeting them, or whether they result from the fact that Denmark demonstrates that achieving ambitious reductions in greenhouse gas emissions can be socioeconomically affordable. If Denmark demonstrates that an ambitious climate policy can be achieved at a low cost, it could have positive spill over effects, while an expensive Danish climate policy could have the opposite effect. Hence demonstration effects can be both positive and negative.

The objective of becoming free of fossil fuels covers the entire Danish economy. A more targeted alternative would be to focus on emissions outside the quota sector. This would reduce costs and have the same effect on the climate (apart from the possibility that Danish climate policy could affect the EU's decisions about quotas amounts). Calculations presented in the chapter show that the increase in energy costs in such a case would be about DKK 7 billion, or less than half the cost of the entire economy becoming free of fossil fuels.

The Danish society would incur additional costs should the EU require significant reductions in emissions outside the quota sector. The best Denmark could do in such a case is to ensure that the reduction targets are achieved at the lowest cost possible.

Efficient reductions outside the quota sector require a uniform price on emissions of various greenhouse gases, regardless of the source. The non-energy related emissions in the agricultural sector should therefore be involved in the regulation too. If the emission reductions must occur at the lowest possible cost, the objective of becoming independent of fossil fuels cannot stand alone, because it does not address the agricultural emissions.

If the EU's emission requirements become less strict for one reason or the other, Denmark would be left with a real choice about the level of its climate policy ambitions. Denmark would have to choose whether or not to go solo if, for

example, the EU chose not to meet the current stated target of reducing greenhouse gas emissions by 80-95 per cent.
It is difficult to estimate the likelihood of the EU not meeting the stated objective. Obviously various interests are at stake in the EU, and clearly it is difficult to agree on significant and binding statements. The current low quota price can be seen as a result of low climate ambitions and that the long-term objectives are not perceived as being fully credible by the market participants. Transparent and credible long-term objectives will help to reduce the costs of achieving the target. The chairmanship of the Economic Council has previously argued that a significant reduction in the number of quotas would contribute to the credibility of the EU's climate goals.

If the EU chose not to live up to its stated objectives, a Danish decision to follow a unilateral, ambitious climate policy could have multiple motives. The most direct reason for an individual Danish climate policy target is that emission reductions outside the quota sector have a direct effect on the climate. In addition to the already mentioned potential demonstration effect, arguments such as energy supply security and possible industrial policy benefits of an ambitious Danish climate policy have been used too. The chairmanship of the Economic Council has previously expressed scepticism about these arguments.

An ambitious Danish climate policy has a number of side effects. Calculations presented in the chapter show that the transition to becoming independent of fossil fuels would, among other things, lead to less air pollution and, therefore, lower health costs. The main part of the reduced health costs would occur abroad, but some would relate to Denmark too. The reduced air pollution would help Denmark to live up to its international obligations in relation to air pollution.

Overall, the calculations presented in the chapter show that the costs of being free of fossil fuels by 2050 probably outweigh the benefits it brings in terms of global climate effects and reduced health costs. As mentioned, the calculations are subject to uncertainty and they depend on assumptions about fuel prices and technological development. If the Danish climate policy focuses on the non-quota sector, the calculations show that the costs can be significantly reduced without reducing the impact on the climate or the health gains.