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**Draft overview on draft scenario definitions, autumn 2014**

This note describes the planned scenarios in a brief overview. The scenario structure revolves around so-called "storylines", which describe various successive policy actions, which lead to an increasingly green and/or cost-effective Danish energy supply.

The storylines are repeated using varying assumptions reflecting the economic circumstances surrounding the Danish energy system and overall economy, e.g.

* the world market prices for fossil fuel, biomass and CO2-qoutas,
* the expected effect of Denmark's closest trade partners' energy policy and its impact on their competitiveness,
* the strength of international competition as captured by the so-called Armington elasticities,
* technological possibilities concerning e.g. electric vehicles, conversion of wind power to liquid fuels, combinations hereof etc.

Further, this note describes the selection of baseline and reference scenarios, which form the background for comparing alternative scenarios with more ambitious Danish energy policies than already agreed..æ

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# The economic world surrounding Danish energy policy

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## Introduction

A key input to any economic model is the surrounding prices for the inputs important to the economic sectors in question. While the economic impacts of energy policy inside the Danish economy and energy system is modelled in reasonable detail, the impact of energy policy in the world outside Denmark (so called Rest-of-World, or RoW), is not modelled at all. This is an important challenge since the impact of RoW energy policy on Denmark is twofold:

* RoW energy policy affects the international market prices of both fossil bio fuels and CO2-qoutas.
* RoW energy policy affects the competitiveness of the Danish economy through their impact on important Danish trading partners.

The goal of the RoW regimes is to demonstrate alternative regimes that would be *possible yet not extreme*. In the context of the current IntERACT it is deemed important to maintain the balance between the illustrating price levels and pathways that would be significantly different from the reference regime and at the same time, providing ‘high’ and ‘low’ estimates that would be *possible* enough to still be informative and useful (as opposed to ‘extreme’ high and low price projections representing the boundaries of hypothetically achievable price developments).

## Three RoW regimes are considered

* A reference level (business as usual / most probable / middle of the road / blue regime) RoW regime, which reflects the most probable development in fuel and CO2-quota prices in combination.
* Black regime reflects a world where little is done to reduce GHG-emission on a global scale, combined with the assumed market factors this results in a high demand for fossil fuel and low demand for biomass, which is reflected in high fossil fuel prices, whereas the price for biomass and CO2-quotas are low. In this regime it is too assume that the GHG abatement cost incurred by Danish trading partners are low, for this reason the Danish economy is assumed to be relative more exposed in terms relative low competitiveness of the Danish Economy.
* Green regime reflects a global commitment to global GHG abatement combined with market factors that keep fossil fuel prices low. This policy is reflected in a high CO2-quota and biomass prices, whereas the fossil fuel prices are low. In terms of competitive the global commitment will most probably result in high abatement cost suffered by Danish trading partners. It is hence assume that the competitiveness of the Danish economy in this case will be relative high.

The RoW regimes are summarised in table 1.

Tabel 1: IntERACT RoW Regimes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Fossil fuel import cost** | **Biomass import cost / biomass availability** | **CO2-qouta price** | **Competitiveness of foreign trading partners** |
| **Black** | High | Low / 750 PJ | Low | High due to low level of abatement costs international |
| **Reference** | New policy | Reference level / 250 PJ | New policy | Reference level |
| **Green** | Low | High / 200 PJ | High | Low, due to high level of abatement costs international |

The competitiveness of foreign trading partners is a particularly difficult topic, which can be handled in several ways.

The simplest solution is to vary the Armington elasticities for international trade, so that the effect on the Danish competitiveness can be dampened or increased according to the assumptions on the impact on foreign energy policy.

Another solution is to find some estimate on foreign energy policy cost and add this to the production costs of foreign goods with which Danish firms compete. This latter option can be implemented in various degrees of precision, as the current model operate with only one sector wide level of foreign production costs changes (i.e. German energy policy affect the cost of German service production in the same proportion as the production of machinery – which is not entirely realistic).

**International prices of fossil fuels**

In order to reduce the complexity of the regimes two key price drivers/determinants are considered:

* Climate policies
* Market factors

**Climate policy**

IEA WEO Current Policies (‘high’ price) and 450 (‘low’ price) fossil fuel regimes are the basis for the alternative development pathways in terms of climate policies alongside the central New Policies scenario. All of the WEO scenario projections operate under the assumption of long-term equilibrium subject to fundamental supply and demand dynamics, i.e. effects of short-term market volatility and fluctuations are not a part of the price pathways of the sensitivity analysis.

The IEA WEO Current Policies scenario only takes into account the policies and measures affecting the energy markets that have been formally enacted (i.e. no further policies or measures with regard to the energy markets are implemented above and beyond those active currently). As such, Current Policies places fewer limitations on the use of fossil fuels as compared to e.g. the central scenario, New Policies scenario) thereby increasing demand and consequently prices.

The 450 Scenario of the IEA WEO implies much lower use and demand (and consequently prices) of fossil fuels due to its assumption of full implementation of the 2010 UN Climate Change Conference commitments (a.k.a. the Cancun Agreements) in the period up to 2020. For the period after 2020, the 450 Scenario assumes that the OECD countries and other major economies are implementing emission reduction measures both within and outside of OECD.

**Market factors**

EIA Annual Energy Outlook serves as the basis for input on the alternative development pathways in terms of market factors for crude oil and coal. It should be noted that the EIA AEO scenarios have been chosen in such a way that they would only entail changes in the market factors whilst climate policy measures would remain unaltered.

A different approach has been applied in the case of natural gas because the natural gas markets are very regional - it would thus be inadequate to use the US-focused EIA AEO scenarios to model the market factors for the European natural gas price projections.

For the ‘low’ price scenario, the Gas Price Convergence Case for Europe from the IEA WEO 2013 is used, whereas oil price-indexing is used for the ‘high’ price scenario.

Several important assumptions are being made:

1. The mechanisms employed and price effects brought about by climate policy scenarios and market factor scenarios have some commonalities, i.e. they are *not* fully complimentary to each other.
2. The quantification of the price effect of each individual factor underlying the climate policies or market developments modelled is beyond the scope of the current analysis. A straight-forward approach of equal 50-50 weighting will be used when combining price projections of different scenario development frameworks (e.g. IEA WEO and EIA AEO) to account both for climate policy effect and market factor impact, respectively. This is also done to make sure that the ‘high’ and ‘low’ scenarios hereby obtained would be representing possible yet not extreme potential price development pathways.

**International prices of biomass**

To account for RoW energy policies, we try to develop three "RoW regimes" which are intend to capture the most important effects of RoW energy policies. The regimes are based on Ea Energianalyse (2013)[[1]](#footnote-1), which provide international prices of biomass under various scenarios. However, adjustments will be made to the low-price scenario, where the assumptions might be considered too extreme.

## Challenges and assumptions associated with RoW regimes

*Scenario choice*

The primary challenge of handling the possible RoW regimes surrounding Danish energy policy is the plethora of possible scenario combinations between various reference and alternative scenarios.

There are two general "way outs" to this problem. One is to limit the number of scenarios as much as possible, especially the number of reference scenarios. Alternatively, the model should be able to handle in theory an arbitrary number of scenarios and references (though in practice the number of references should still be limited to a few). In practice, most of the technical model code does not distinguish between reference and alternative scenarios. For this reason, it is only a matter of simple presentation to make relevant comparisons between selected scenarios and interpret the results as consequences of the chosen policy.

*Data on RoW assumptions*

Another challenge is to acquire reasonable data on the energy policy cost of RoW. One part of this problem is to distinguish between those of Denmark's trading partners who has committed to greener energy policies, another part is to estimate the costs of those energy policies and transform these into changed competitiveness in the terms of the CGE model. It is possible to some extent to use the so-called Armington elasticities for making sensitivity analyses on the magnitude of impact on Danish competitiveness.

However, one aspect missed by this Armington approach is that cases where Danish competitiveness might be increased due to relative large green energy policy costs of our closest trading partners cannot be analysed. For this special case, an analysis where the cost of internationally traded goods is raised can be used. Note though, that the CGE model presently cannot distinguish between different sectors when manipulating with the cost of internationally traded goods and services.

# Base year, reference and alternative scenarios

**Introduction**

We distinguish between three types of scenarios:

1. The base year: an actual Danish macroeconomic data for a past year, i.e. 2010
2. The reference scenarios: a projection of the base year to a specific year (e.g. 2025 or 2035) using external estimates for growth in income, productivity, demand and output, but assuming only adopted policies
3. The alternative scenarios: The reference scenario with the addition of policies not yet adopted, i.e. the reference and alternative scenario is projected to the same year

With this scenario structure, the reference and alternative scenarios can be readily compared and the economic cost of adopting various new policies can be calculated by comparing the relevant alternative scenario with the reference scenario.

The TIMES-DK model simulates 5-year intervals from 2010 to 2050 with full foresight, i.e. investment decisions in e.g. 2045 takes into account which investment decisions that are made in 2050. The CGE model simulates only one year, e.g. 2035.

**Modelling**

The reference scenario in IntERACT is based on various known policies adopted either in the present or in a known near future

What are the adopted policies (implemented in the model)

* Wind 50 % by 2020
* 5,75 % biofuel in transport from 2012
* 10 % biofuel in transportation by 2020
* Other policies?

Other reference scenario assumptions:

* Denmark Convergence program 2014
* Smile model run 2050 on the number and area of dwellings
* Demand driver for Transportation (?)
* Energy prices from World Energy Outlook
* Other?

The alternative scenario assumptions may concern changes in the various policy targets, e.g. stronger requirements for wind power, more biofuel in transport, reduced total emissions or alterations in the tax system. Also changed assumptions on RoW or other technical assumptions on the availability or adoption potential of specific technologies, e.g. electric vehicles. The present version of version of the reference and alternative scenario may be found in the appendix.

## Challenges and assumptions

The main challenge is to identify, select and organise among all the possible alternative scenarios that can be modelled in order to present a coherent and informative decision support framework. For this purpose we use a feature called story lines, see next section.

# Using storylines

**Introduction**

In order to organise the alternative scenarios in a useful way for making energy policy, the results are presented in terms of story lines. A story line is a set of scenarios, each consisting of smaller, incremental changes in the assumptions behind the models. Each change is made using a so-called "handle", where the user can change a specific policy or technology assumption.

Typically, the changes relate to policies, e.g. gradually introducing changed and/or more ambitious energy policies, A story line thus allow the decision maker to follow various developments in policies or circumstances around the policy to identify the impact of specific policy steps and circumstances.

**Modelling**

A story line might be the reference scenario followed by four alternative scenarios, each with an incremental change to energy policy, e.g.

1. Add wind power min target
2. Add biomass max target
3. Drop wind power target and add CO₂ target
4. Drop existing energy tax system and base taxes on energy services

The above storyline thus consists of a reference scenario with changes to a number of "policy handles" (e.g. 3 targets for wind, biomass and CO₂, and a policy handle for energy taxation system).

It is also possible to change the sequence of the policies in order to analyse whether specific policies are particularly costly or effective.

## Challenges and assumptions

One particular challenge of the storyline construction is that great care must be taken when choosing e.g. the different RoW regime. Consider the following three examples of analysing a greener Danish energy policy by comparing a reference with an alternative scenario:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Reference scenario** | |  | **Alternative scenario** | |
|  | DK policy | RoW regime |  | DK policy | RoW regime |
| A: DK solo policy | Black | Black |  | *Green* | Black |
| B: Common action | Black | Black |  | *Green* | *Green* |
| C: DK cheating | Black | Green |  | *Green* | Green |

Note: Differences between reference and alternative are marked with italics.

In example (A) the assumption is that only Denmark will implement a greener energy policy, while the RoW will not. Denmark may thus suffer on its competitiveness, although the cost of internationally traded biomass is lower, thus reducing the cost of some of the Danish energy policy.

In example (B) the assumption is that both Denmark and RoW (that is, those of Denmark's main trading partners which have green energy ambitions) will implement greener energy policy simultaneously. In this case, the Danish competitiveness might suffer less (*ceteris paribus*) than in option (A), but on the downside, the cost of biomass increases, as the world demand for biomass is larger.

In example (C) the assumption is that Denmark can "cheat" on its energy policy, doing nothing while RoW do implement greener energy policies. In this case the greening of Danish energy policy suffers both from going from relatively cheap fossil fuels to expensive biofuels (this is the assumption of Green RoW regime) as well as not enjoying the "benefit" of increased competitor costs[[2]](#footnote-2) of internationally traded goods and services.

The important lesson here is that all three examples are valid scenario choices, but both results and interpretation may be quite different.

A tentative recommendation is to settle for one composition of RoW regime sequence (e.g. black DK/black RoW to green DK/green RoW) and do all analyses according to this. In this case, Danish energy policy choices would be analysed in a context of RoW also fulfilling its green ambitions.

In order to shed light on an alternative assumptions on what would happen if Denmark were the only country which fulfilled its green ambitions, a sensitivity composition of regimes (black DK/black RoW to green DK/black RoW) could be made for a selected number of storylines.

Another challenge is the timing of introduction of policies and / or technologies. Since the model can illustrate any year between 2010 and 2050, there are ample combinations of policies and timing. The user is thus also confronted with a choice on the timing of the introduction. It should be noted that models like TIMES-DK are prone to corner solutions, so some care must be exerted on this topic.

# Other assumptions important to Danish energy policies

## Intoduction

In this section we describe which policy and technology handles that have already been introduced into the IntERACT model and which handles that can potentially be introduced.

This section is still work in progress. The project team would be grateful for contributions to the handles wished for …

## Modelling

The following table illustrated the policy & technology handles that have been / are planned to be implemented in the IntERACT model. The table is work in progress and any inputs are much appreciated.

|  |  |  |
| --- | --- | --- |
|  | **Handles implemented** | **Handles not (yet) implemented** |
| Supply side / utilities | CO₂ target  Wind power target  Biomass maximum import |  |
| Transport | Biofuel blend targets… | Electric vehicle adoption  … |
| Energy efficiency | … | … |
| Macro economics | Armington elasticities  RoW regimes |  |

## Challenges and assumptions

The main challenge here is to arrange scenarios in storylines such that the main policy concerns are illustrated in the best way possible.

1. "Analysis of biomass prices", 18-06-2013 [↑](#footnote-ref-1)
2. Please note that increased costs of internationally traded goods and services may be an advantage to the Danish competitiveness, but at the same time might also be a socio-economic cost, as Danish imports become more expensive. [↑](#footnote-ref-2)