Quantitative co-assessment of the EurEnDel Delphi results

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## Contents

1 Introduction ........................................................................................................................................... 3

2 Quantitative Studies ................................................................................................................................... 3

2.1 European Energy and Transport - Trends to 2030 *(Trends 2030)* ........................................... 3

2.2 “With climate policies” baseline scenario (WCLP)............................................................... 4

3 Results ....................................................................................................................................................... 6

3.1 Delphi Statements ............................................................................................................................... 6

3.1.1 Statement 1: Novel Production Processes ........................................................................ 7

3.1.2 Statement 3: 20% FC cars ................................................................................................... 7

3.1.3 Statement 4: 25% Bio-fuels .............................................................................................. 8

3.1.4 Statement 5: 15% Freight on rail ..................................................................................... 8

3.1.5 Statement 6a/6b: H2 from diverse sources / H2 from RES ......................................... 9

3.1.6 Statement 14: 25% RES ................................................................................................ 9

3.1.7 Statement 15: 5% PV .................................................................................................. 10

3.1.8 Conclusion on Delphi Statements .................................................................................. 10

3.2 Qualification of *EurEnDel* Scenarios regarding CO2 ..................................................... 14

3.2.1 Change of Paradigm scenario .......................................................................................... 14

3.2.2 Fossil Fuel Wars scenario ............................................................................................... 16

3.2.3 Muddling Through Across the Gas Bridge scenario ..................................................... 16

3.2.4 Conclusion on Scenarios .............................................................................................. 16

4 References .................................................................................................................................................. 17
1 Introduction

The scope of this report is to compare quantitative data drawn from the EurEnDel Delphi [Jørgensen et al. 2004] and used for the EurEnDel Scenarios [Velte et al. 2004] with a set of studies based on quantitative modelling. The rationale of this exercise is on one hand to validate the EurEnDel results and on the other hand to contribute to the interpretation of EurEnDel results in comparison to quantitative forecasting.

The analysis embodies firstly the direct comparison between results of the EurEnDel Delphi survey in terms of time of occurrence and quantification of relevance of certain Delphi statements. Secondly the EurEnDel scenarios are classified in terms of their implied CO₂ emissions development.

In chapter 2 below, the quantitative studies are presented that were used for the analysis. Further on in chapter 3, the results of the quantitative co-assessment are presented and interpreted.

More information on EurEnDel can be found at http://www.eurendel.net.

2 Quantitative Studies

Two quantitative studies were used were used for the comparison with EurEnDel Delphi results. These were “European Energy and Transport - Trends to 2030” [Mantzos et al. 2003] and the “With climate policies” scenario [Zeka-Paschou 2003]. Both studies are shortly presented in the following chapters.

2.1 European Energy and Transport - Trends to 2030 (Trends 2030)

As a reference a study was to be taken, which is both comparable in geographic terms and in the time frame and additionally politically and scientifically broadly acknowledged. Therefore, as suggested by the EC scientific officer responsible for EurEnDel, the “European Energy and Transport - Trends to 2030” study [Mantzos et al. 2003] was used as a first reference. Throughout this document this study will in short be referred to as “Trends 2030” study.

The Trends 2030 study uses the POLES¹, PRIMES², and ACE³ models: POLES is a global model and was used model the international framework. PRIMES is a European model and was used for the EU15⁴ countries. As PRIMES was not yet available for the ten accession countries and other neighbouring countries covered in the Trends 2030 study, these countries were modelled in the less sophisticated ACE model.

¹ POLES – Prospective Outlook on Long-term Energy Systems cf. e.g. [Criqui 1999]
² cf. e.g. [Capros 2000] or the documentation CD-ROM of [Mantzos 2003].
³ The Accession Countries Energy (ACE) Model is an energy demand and supply model developed and maintained at the National Technical University of Athens, E3M –Laboratory. A summary description is provided on the documentation CD-ROM of [Mantzos 2003].
⁴ The 15 Member States of the European Union up to April 30th, 2004, i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom
The *Trends 2030* study delivers quantitative results for all single countries that were covered in the analysis, as well as aggregations EU15, EU25 and Europe30. Generally, the EU25 results were used in the analysis within *EurEnDel*, as these were best comparable to the results of the *EurEnDel* Delphi survey.

The key assumptions are the following [Mantzos 2003a], [Mantzos et al. 2003]:

- The *Trends 2030* study is a baseline study that explicitly covers no new policies to reduce greenhouse gas emissions. This is done for analytical reasons in order to assist in identifying any remaining policy gaps in the energy and transport sectors with respect to the EU’s Kyoto commitments.

- Assuming the continuation of current world energy market structures and taking a conventional view on fossil fuel reserves, world energy prices develop moderately as no supply constraints are likely to be experienced over the next 30 years under baseline conditions.

- Baseline assumptions include continued economic modernisation, substantial technological progress, and completion of the internal market. Existing policies on energy efficiency and renewables continue; the fuel efficiency agreement with the car industry is implemented; and decisions on nuclear phase-out in certain Member States are fully incorporated.

- For EU15, the baseline macro-economic scenario assumes continued GDP growth of 2.3% pa on average over the projection period (i.e. 2000 – 2030), similar to that over the past 30 years. The assumed growth rates are modest compared with the ambitions of the Lisbon strategy but also high compared with the current weak state of the EU economy. For the accession states an average GDP growth of 3.5% pa (2000-2030) is assumed, resulting in 2.4% pa (2000-2030) for EU25.

- Furthermore the EU economy is characterised by a further dematerialisation with stronger growth occurring in high value added industrial sectors and services.

### 2.2 “With climate policies” baseline scenario (WCLP)

In order to account for the above-mentioned shortfall in “realism” of *Trends 2030* in terms of future climate policies (i.e. the baseline character), an additional study was used in the *EurEnDel* analysis as a second reference to the Delphi results. For that purpose, the “With Climate Policies” (*WCLP*) scenario [Zeka-Paschou 2003] was chosen, which is used as one of the baseline scenarios in the EU-wide CAFE (Clean Air For Europe) process managed by the European Commission, DG Environment. Again, high relevance in European policies was

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5 The 25 Member States of the EU as of May 1st, 2004, i.e. EU15 plus Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia

6 EU25 plus Bulgaria, Norway, Switzerland, Romania and Turkey

7 A definition is missing, though, which actual policies in the EU and the single Member States and other countries exactly are classified as “new” and “old” policies respectively.

8 For more information on the CAFE process, see [http://europa.eu.int/comm/environment/air/cafe/index.htm](http://europa.eu.int/comm/environment/air/cafe/index.htm)
sought after in the choice of the second reference scenario, as well as high consistency with the first reference scenario (see below).

The *WCLP* scenario, and even more its counterpart in the CAFE process, the “Without Climate Policies” (*WoCLP*) scenario [Zeka-Paschou 2003a] are very closely related to the *Trends 2030* study: *WoCLP* and *Trends 2030* are identical despite the fact that in *WoCLP* the Non-EU15 countries could already be modelled within an extended version of the PRIMES model, while the ACE model was used in *Trends 2030*.

The key assumptions for *WCLP* are the same as for *Trends 2030* (depicted in chapter 2.1 above) with one difference: While *Trends 2030* (as well as *WoCLP*) incorporates no new climate policies, *WCLP* assumes the existence of an EU wide CO₂ emissions trading regime. The “with climate policies” scenario assumes a permit price of 12 € per t of CO₂ in 2010, rising to 16 € per t of CO₂ in 2015 and 20 € per t of CO₂ in 2020. In 2020-2030 the permit price remains constant at 20 € per t of CO₂ [Mantzos 2003a].

On the *WCLP* and *WoCLP* scenarios no written examination text as *Trends 2030* exists. However, the datasets available in [Zeka-Paschou 2003] and [Zeka-Paschou 2003a] are nearly identical in structure to the corresponding datasets of *Trends 2030* [Mantzos et al. 2003]. Thus, an almost parallel analysis of the two scenarios could be performed in order to counter-check *EurEnDel* Delphi results.
3 Results

3.1 Delphi Statements

For eight of the total of twenty Delphi statements of EurEnDel corresponding and comparable data was found in the reference studies. An overview on the statements is given in Table 3-1:

<table>
<thead>
<tr>
<th>Statement No.</th>
<th>Statement Short Name</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Novel production processes</td>
<td>Industrial energy consumption in Europe is reduced by 50% per produced unit through novel production processes</td>
</tr>
<tr>
<td>3</td>
<td>20 % FC cars</td>
<td>Fuel cell driven cars reach a European market share of 20%</td>
</tr>
<tr>
<td>4</td>
<td>25% Bio-fuels</td>
<td>Bio-fuels will have a European market share of &gt;25% in the road transport sector</td>
</tr>
<tr>
<td>5</td>
<td>15% Freight on rail</td>
<td>Improved logistics based on information and communication technologies raise the railway's market share in Europe's freight transport to 15% [1990: 11%, today: 8%].</td>
</tr>
<tr>
<td>6a</td>
<td>H2 from diverse sources</td>
<td>Hydrogen produced from diverse sources and used as an energy carrier constitutes a significant part of the energy system (transport and stationary application)</td>
</tr>
<tr>
<td>6b</td>
<td>H2 from RES</td>
<td>Hydrogen produced solely from renewables and used as an energy carrier constitutes a significant part of the energy system (transport and stationary application)</td>
</tr>
<tr>
<td>14</td>
<td>25% RES</td>
<td>Renewable energy sources cover 25% of Europe’s total energy supply [Today it is 6%]</td>
</tr>
<tr>
<td>15</td>
<td>5% PV</td>
<td>Photovoltaic cells contribute with &gt;5% of European electricity generation [Today it is 0.15%]</td>
</tr>
</tbody>
</table>

Table 3-1: List of Delphi statements subject to comparison with quantitative reference studies

For all covered Delphi statements, the time of occurrence was analysed on one hand. Here, the mean value of 2nd round responses was taken, using only the answers of (self-estimated) expert, knowledgeable and familiar respondents and leaving out the unfamiliar respondents’ answers (compare the EurEnDel Delphi report [Jørgensen et al. 2004]. On the other hand the quantification or level of intensity of the Delphi statements was subject to the comparative analysis. Thus, the combination of “intensity” and time of occurrence from the EurEnDel Delphi was compared to corresponding data from the reference studies. Where possible, a “level of significance” multiplier was estimated in order to quantify the distance between the results of the EurEnDel Delphi and those of the reference studies.

The results of the analysis are presented in the following chapters:
3.1.1 Statement 1: Novel Production Processes

According to the EurEnDel Delphi, industrial energy consumption in Europe is reduced by 50% per produced unit through novel production processes by 2028\(^9\) (lower quartile 2022 – upper quartile 2034)\(^10\).

The reference studies give no explicit information on novel production processes. However, development of energy intensity in industry (measured as energy consumption per value added) is reported as a model output. Here Trends 2030 assumes a 38% reduction by 2030 compared to 2000 while WCLP ends up with almost identical 39%.

Taking into account that the time horizons of the EurEnDel Delphi and the reference studies are comparable, it can be stated that the EurEnDel energy experts are more optimistic than the reference studies. However, with the multiplier between the two levels of intensity being approx. 1.3, the result is in the same order of magnitude.

3.1.2 Statement 3: 20 % FC cars

According to the EurEnDel Delphi, fuel cell driven cars reach a European market share of 20% by 2027 (lower quartile 2020 – upper quartile 2032).

The reference studies give no quantified information on the share of fuel cell driven cars. However, the Trends 2030 study states “fuel cell cars are not expected to gain significant market share until 2030; primarily due to costs but also lack of fuel supply infrastructure” [Mantzos et al. 2003, p.64]. For WCLP no information is available.

It is obvious that the EurEnDel energy experts are much more optimistic than the reference study. Trends 2030 does not quantify what a “significant market share” is. However, if one assumes that a level of significance might be approx. 2%, the “level of intensity” multiplier would be at least >10.

However, while assessing the comparison it should be taken into account that the policy framework conditions implied by the EurEnDel energy experts are likely to be different from the concept of the Trends 2030 baseline study. These differences should not be misinterpreted as a lack of expertise on the EurEnDel energy experts’ side. There are indications showing that economic quantitative models generally tend to underestimate the potentials of emerging technologies. For example, a comparison of projections of the Annual Energy Outlook 2004 by the US Energy Information Administration [EIA 2003] and a Delphi study by the George Washington University (TechCast Delphi; see [Halal and Kallmeyer 2004]) shows significant differences between modelling and Delphi results comparable to the multiplier mentioned above. Additionally it is known from other studies that previous energy models (e.g. from the 1980s) tended to overestimate future energy demands [Laitner 2004].

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\(^9\) Results of the 2nd survey round: Mean value calculated from “time of occurrence” indicated by respondents who classified themselves as either “experts”, “knowledgeable” or “familiar” for the respective topic. (Cf. [Jørgensen et al. 2004])

\(^10\) The given time range refers to the lower and the upper quartile. This means that 50% of the respondents expect an occurrence in the given timeframe, 25% expect an earlier, and 25% expect a later occurrence.
3.1.3 **Statement 4: 25% Bio-fuels**

According to the EurEnDel Delphi, bio-fuels will have a European market share of >25% in the road transport sector by 2027 (lower quartile 2018 – upper quartile 2030).

Both Trends 2030 and WCLP expect bio-fuels to have a market share in transport of slightly above 5% by 2030.

Taking into account that the two time horizons 2027 (EurEnDel Delphi) and 2030 (reference studies) are close together, it can be stated that the EurEnDel energy experts are much more optimistic than the reference studies: The “level of intensity” multiplier would be 5. However, while assessing the comparison it should be taken into account on one hand that for statement 4 “25% Bio-fuels” a relatively high share of 15% of the Delphi respondents answered “Never”. In EurEnDel Delphi respondents’ comments it was highlighted that the potential for domestically produced biomass might be a limiting factor in order to reach such a high share of bio-fuels [Jørgensen et al. 2004]. Furthermore, as already discussed in chapter 3.1.2, there are indications that energy modelling is likely to fail to cover emerging technologies adequately. Additionally, the policy framework conditions implied by the EurEnDel energy experts is likely to be different from the concept of the reference studies.

It is interesting to note, though, that both WCLP and WoCLP come to identical bio-fuel shares, i.e. the CO2 prices assumed in WCLP seem not to influence the development of bio-fuel shares.

3.1.4 **Statement 5: 15% Freight on rail**

According to the EurEnDel Delphi, improved logistics based on information and communication technologies raise the railway's market share in Europe's freight transport to 15% by 2019 (lower quartile 2012 – upper quartile 2023). It should be noted that the percentages of the comparison data given with the Delphi statement (1990: 11%, today: 8%) included short sea shipping. Thus, the EurEnDel Delphi respondents’ response must be interpreted in that way.

Unfortunately, the freight transport data in the reference studies do not include short sea shipping, as the related energy use is allocated to international bunkers according to EUROSTAT rules. Thus the reference studies’ modal shares in freight traffic are not quantitatively comparable to the EurEnDel Delphi data. Despite of intensive research, no other quantitative outlook on absolute short sea shipping development in the EU25 countries was found which might have supported a quantitative comparison of EurEnDel and reference study data. Qualitatively, short sea shipping is generally expected to grow significantly (compare e.g. [European Commission 1999], [European Commission 2003]).

Within the limitations of the reference studies, i.e. taking as 100% only the sum road, rail and inland navigation, the share of freight transport on rail declines in both reference studies from 17% (2000) to 11% (2030).

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11 “Respondents” meaning again self-estimated experts, knowledgeable and familiar of the 2nd round. The “Never” share of experts only is even higher (26%). [Jørgensen et al. 2004]

12 The same concept is applied to international air traffic and deep-sea shipping.
Taking into account that the share of short sea shipping (in a total of road, rail, inland navigation and short sea shipping, i.e. comparable to the reference percentages of the EurEnDel Delphi statement) is likely at least to stay constant or rather to grow, the conclusion can be drawn, that the EurEnDel energy experts expect the share of rail transport to rise significantly and quickly (until 2019!) while in opposite the reference studies expect the share of rail to decrease significantly and continuously until 2030. Thus the EurEnDel Delphi respondents are in clear contradiction to the reference studies. It is impossible, though, to define a “level of intensity” multiplier as for other statements.

3.1.5 Statement 6a/6b: H2 from diverse sources / H2 from RES

According to the EurEnDel Delphi, hydrogen produced from diverse sources and used as an energy carrier constitutes a significant part of the energy system (transport and stationary application) by 2031 (lower quartile 2023 – upper quartile 2040) and hydrogen produced solely from renewables and used as an energy carrier constitutes a significant part of the energy system (transport and stationary application) by 2034 (lower quartile 2026 – upper quartile 2043).

The reference studies do not single out hydrogen explicitly in their tables on energy carriers’ shares in energy demand. However, it is likely that the category “New fuels (hydrogen etc.)” is dominated by hydrogen. In the Trends 2030 study, the share of “New fuels (hydrogen etc.)” is expected to rise to 1.4 Mtoe by 2030, i.e. 0.1% of final energy demand. In WCLP [Zeka-Paschou 2003] no detailed information on the use of hydrogen is given.

Taking into account that the two time horizons 2031/2034 (EurEnDel Delphi) and 2030 (Trends 2030) are close together, it is obvious that the EurEnDel energy experts are much more optimistic than the reference study. The EurEnDel Delphi questionnaire does not quantify what “a significant part of the energy system” is. If one assumes that a level of significance might be approx. 2%, the “level of intensity” multiplier would be at least >20. However, in order to correctly assess the comparison the discussion of chapter 3.1.2 on the coverage of emerging technologies in modelling and Delphis should be kept in mind.

3.1.6 Statement 14: 25% RES

According to the EurEnDel Delphi, renewable energy sources cover 25% of Europe’s total energy supply by 2028 (lower quartile 2020 – upper quartile 2033).

In Trends 2030 a the share of renewables is expected to rise from 5.8% (2000) to 8.6% by 2030, while the renewables’ share in WCLP rises up to 10.5% by 2030.

Taking into account that the two time horizons 2028 (EurEnDel Delphi) and 2030 (reference studies) are close together, it can be stated that the EurEnDel energy experts are much more optimistic than the reference studies: The “level of intensity” multiplier would be approx. 3 (Trends 2030) and 2.5 (WCLP) respectively. Again, in an assessment of the comparison the discussion of chapter 3.1.2 on the coverage of emerging technologies in modelling and Delphis should be regarded.
3.1.7 Statement 15: 5% PV

According to the EurEnDel Delphi, photovoltaic cells contribute with >5% of European electricity generation by 2023 (lower quartile 2023 – upper quartile 2040).

Unfortunately, both Trends 2030 and WCLP don’t give explicit results on the shares of PV in electricity generation, the fuel split-up for electricity generation is “nuclear”, “hydro and wind”, and “thermal (incl. biomass)”. However in the Trends 2030 study text it is stated that “solar photovoltaic energy starts emerging beyond 2020 (accounting for 1.3% of total installed capacity by 2030) [Mantzos et al. 2003, p. 124].

It is obvious that the EurEnDel energy experts are much more optimistic than the reference study. With 1.3% of total installed capacity maybe corresponding to a share in electricity generation of approx. 0.5% (today it is 0.15%) the “level of intensity” multiplier would be at least >10. Taking into account the relatively high difference between the two time horizons 2023 (EurEnDel Delphi) and 2030 (trends 2030) the multiplier would be even higher.

While assessing the comparison it should be taken into account on one hand that for statement 15 “5% PV” a relatively high share of 9% of the Delphi respondents answered “Never”. On the other hand, the limitations of energy modelling in regard of emerging technologies as discussed chapter 3.1.2 should be kept in mind.

3.1.8 Conclusion on Delphi Statements

The results of the comparison between the Delphi survey and the reference studies are summarised in Table 3-2. It can clearly be seen that the results of the EurEnDel Delphi are generally more “optimistic” in terms of technical developments and structural changes compared to the reference studies. The “level of intensity” multiplier which visualises the distance between the Delphi energy experts’ opinion and the model results moves up to >20 for certain statements.

However, these differences should not be misinterpreted as a lack of expertise on the EurEnDel energy experts’ side. There are indications showing that economic quantitative models generally tend to underestimate the potentials of emerging technologies. A comparison of projections of the Annual Energy Outlook 2004 by the US Energy Information Administration [EIA 2003] and a Delphi study by the George Washington University (TechCast Delphi; see [Halal and Kallmeyer 2004]) shows comparable differences to those presented in this report [Laitner 2004]. The fact that previous energy models tended to overestimate future energy demands and underestimated the potentials of new technologies have led to several improvements of quantitative energy models (e.g. the introduction of learning curves). However the EurEnDel results may indicate that additional ways should be sought for to integrate projections on emerging technologies into quantitative models.

Furthermore it should be kept in mind, that the Trends 2030 study is a pure baseline study that fails to assume any new policies to reduce greenhouse gas emissions for analytical reason, and

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13 “Respondents” meaning again self-estimated experts, knowledgeable and familiar of the 2nd round. The “Never” share of experts only is even higher (16%). [Jørgensen et al. 2004]
can generally be qualified as rather conservative. The *WCLP* scenario seems to be a bit more realistic in terms of climate policy, incorporating at least a CO₂ price.

In contrast, the *EurEnDel* energy experts had their own sets of framework conditions in their minds when responding to the Delphi questionnaire. As a matter of fact, these framework conditions are never made explicit. According to the Delphi methodology the assumption is: if an appropriate survey population participates (high degree of expertise and a large-enough sample), then the means over all answers follows what is perceived as the most likely scenario. So one interpretation of the differences between the Delphi results and the references is that the Delphi respondents consider framework conditions as most likely which differ strongly from the framework conditions of the quantitative models used to calculate the reference scenarios.

A hint to what these framework conditions may look like is given by the analysis of what actions the respondents consider as needed in order to promote an early occurrence of the Delphi statements (cf. [Jørgensen et al. 2004]). It is important to bear in mind that the *EurEnDel* Delphi statements were deliberately formulated to be rather ambitious in the employed 30-year time frame (cf. the *EurEnDel* structural analysis report [López and Velte 2003]). Thus the developments and respective time horizons in the Delphi survey should be between what the experts consider to be “most probable” and what they consider to be “technological feasible” if appropriate promotive actions are taken.

As a conclusion, the differences between the *EurEnDel* Delphi results and the reference scenarios should rather be interpreted as making clear what future developments are realistically achievable, if framework conditions and incentives are set correspondingly.
### Demand

| No. | Statement short | Delphi Statement long | Time of Occurrence * | Reference studies: 
| Trends 2030 / WCLP | Comparison Result | Level of intensity multiplier |
|-----|-----------------|-----------------------|-----------------------|---------------------------------|
| 1   | Novel production processes | Industrial energy consumption in Europe is reduced by 50% per produced unit through novel production processes | 2028 (2021 – 2034) | No info on novel production processes; energy intensity reduction 2000 - 2030: 38% (Trends 2030); 39% (WCLP) | Delphi more optimistic than reference studies. | 1.3 |

### Transport

| No. | Statement short | Delphi Statement long | Time of Occurrence * | Reference studies: 
| Trends 2030 / WCLP | Comparison Result | Level of intensity multiplier |
|-----|-----------------|-----------------------|-----------------------|---------------------------------|
| 3   | 20 % FC cars | Fuel cell driven cars reach a European market share of 20% | 2027 (2020 – 2032) | Fuel cell cars are not expected to gain significant market share until 2030 primarily due to costs but also lack of fuel supply infrastructure. (Trends 2030) | Delphi much more optimistic than reference study. | > 10 |
| 4   | 25% Bio-fuels | Bio-fuels will have a European market share of >25% in the road transport sector | 2027 (2018 – 2030) | 5% in 2030 (Trends 2030 and WCLP) | Delphi much more optimistic than reference studies. | 5 |
| 5   | 15% Freight on rail | Improved logistics based on information and communication technologies raise the railway's market share in Europe's freight transport to 15% [1990: 11%, today: 8%]. | 2019 (2012 – 2023) | No info on ICT in railways the share of rail freight transport declines from 17.1% (2000) to 11.2% (2030) (excluding short sea shipping) (Trends 2030 and WCLP) | Delphi much more optimistic than reference studies. | - |

### Storage and Distribution

| No. | Statement short | Delphi Statement long | Time of Occurrence * | Reference studies: 
| Trends 2030 / WCLP | Comparison Result | Level of intensity multiplier |
|-----|-----------------|-----------------------|-----------------------|---------------------------------|
| 6a/ 6b | H2 from diverse sources / H2 from RES | Hydrogen produced from diverse sources (H2 from RES: solely from renewables) and used as an energy carrier constitutes a significant part of the energy system (transport and stationary application) | 2031 (2023 – 2040) / 2034 (2026 – 2042) (H2 from RES) | Share of new energies (hydrogen etc.) in final energy demand will rise to 1.4 Mtoe in 2030 (i.e. 0.1%) (Trends 2030) | Delphi much more optimistic than reference study. | > 20 |

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* (Mean value of the 2nd survey round considering only respondents who classified themselves as either “experts”, “knowledgeable” or “familiar” for the respective topic. The given time range in brackets refers to the lower and the upper quartile. This means that 50% of the respondents expect an occurrence in the given timeframe, 25% expect an earlier, and 25% expect a later occurrence.)
### Table 3-2: Overview on comparison results of Delphi statement responses with reference studies

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<tbody>
<tr>
<td>Supply</td>
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</tr>
<tr>
<td>14</td>
<td>25% RES</td>
<td>Renewable energy sources cover 25% of Europe’s total energy supply [Today it is 6%]</td>
<td>2028 (2020 – 2033)</td>
<td>“Relatively slow penetration of renewables”; the use of renewables will rise by 74% (<em>Trends 2030</em>) between 2000 and 2030 (<em>WCLP</em>: 106%); the share of renewables in gross inland consumption rises from 5.8% in 2000 to 8.6% (<em>Trends 2030</em>) in 2030 (<em>WCLP</em>: 10.5%)</td>
<td>Delphi much more optimistic than reference studies.</td>
<td>3 / 2.5</td>
</tr>
<tr>
<td>15</td>
<td>5% PV</td>
<td>Photovoltaic cells contribute with &gt;5% of European electricity generation [Today it is 0.15%]</td>
<td>2030 (2023 – 2040)</td>
<td>“Solar photovoltaic energy starts emerging beyond 2020 (accounting for 1.3% of total installed capacity by 2030). (<em>Trends 2030</em>) No data on production shares</td>
<td>Delphi much more optimistic than reference study.</td>
<td>&gt; 10</td>
</tr>
</tbody>
</table>

* (Mean value of the 2nd survey round considering only respondents who classified themselves as either “experts”, “knowledgeable” or “familiar” for the respective topic. The given time range in brackets refers to the lower and the upper quartile. This means that 50% of the respondents expect an occurrence in the given timeframe, 25% expect an earlier, and 25% expect a later occurrence.)
3.2 Qualification of EurEnDel Scenarios regarding CO₂

In addition to the direct comparison of Delphi results with quantitative studies (cf. chapter 3.1 above) the EurEnDel scenarios [Velte et al. 2004] were quantitatively assessed concerning their respective position in terms of CO₂ emission scenarios. As a reference, again the Trends 2030 and WCLP studies were used. An overview is given in Table 3-3. In the following chapters the qualifications will be given scenario by scenario.

3.2.1 Change of Paradigm scenario

Overview on the scenario

The Change of Paradigm scenario (cf. [Velte et al. 2004]) is most closely related to a strong policy shift towards sustainable development in the years up to 2030: it is due to a combination of political will, technological progress, structural changes in the economy and urgent environmental pressures that Europe 25 is on the way of achieving great progress in energy efficiency. These combined pressures trigger an aggressive and self-learning move towards much lower levels of energy intensity across all processes and countries. It is mostly a universal attitude, which seeps across all layers of societies and spheres of activity, and produces a “democratic” initiative, summing up efforts by many and in many places.

Quantitative CO₂ emission classification

With the CO₂ reduction to 1990 levels by 2012, the Kyoto protocol is not complied with domestically, but by means of the flexible mechanisms. The CO₂ reduction by 1.5% annually later on is equivalent to a 25% reduction by 2030 compared to 1990. With this setting, the “Change of Paradigm” scenario is far more optimistic in terms of CO₂ reduction than the WCLP scenario [Zeka-Paschou 2003].
### Quantitative Reference Scenarios

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</thead>
<tbody>
<tr>
<td><strong>EU25: EU wide scenario with climate policies (WCLP)</strong></td>
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**EU25: EU wide scenario without climate policies (WoCLP) und EU 25 :Trends 2030 are basically the same.**

### EurEnDel Scenarios

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Table 3-3: Development of CO₂ emissions in the reference studies and the *EurEnDel* scenarios
3.2.2 Fossil Fuel Wars scenario

Overview on the scenario

The Fossil Fuel Wars scenario (cf. [Velte et al. 2004]) stands for a crisis scenario, in which climate change concerns play a minor role when defining priorities for energy policies. Conflicts between the different interest groups prevail on European, as well as on national levels. Economic, social and environmental policy goals are difficult to integrate and there is a general lack of willingness among companies and citizens to bear the increasing costs of environmental protection.

Quantitative CO2 emission classification

Compliance with the Kyoto protocol is no issue under the “Fossil Fuel Wars” scenario. The envisaged growth of CO₂ emissions by 14% compared to 1990 until 2030 is in line with the Trends 2030 study [Mantzos et al. 2003].

3.2.3 Muddling Through Across the Gas Bridge scenario

Overview on the scenario

The Muddling Through Across the Gas Bridge scenario (cf. [Velte et al. 2004]) also implies a major drive towards sustainability, but assumes that long-term climate change impacts cannot be avoided. The transition process is slower and natural gas plays a key role as intermediary solution, not only in power generation, but also in transport.

Quantitative CO2 emission classification

As in the “Change of Paradigm” scenario, the Kyoto protocol is not complied with domestically in the “Muddling Through Across the Gas Bridge” scenario, the CO₂ emissions reaching 1990 levels by 2012. With the subsequent stabilisation of CO₂ emissions at 1990 levels, Europe fails to engage in further domestic emission reduction for long term climate protection. The envisaged development of CO₂ emissions is relatively close to the WCLP scenario [Zeka-Paschou 2003].

3.2.4 Conclusion on Scenarios

The EurEnDel scenarios are consistent with the reference studies in terms of CO₂ emissions development in so far as the reference studies (which have rather baseline character as discussed in chapter 3.1.8 above) accompany the “lower” (in terms of ambition in sustainable development and CO₂ reduction) end of the EurEnDel scenarios. The most ambitious EurEnDel scenario (Change of Paradigm) implies a much higher emission reduction than given in the reference scenarios.
4 References


