VLEEM II - Minutes of the Mid-term Assessment Meeting ECN, Amsterdam, 25 & 26 September 2003

Thursday 25th of September

Bertrand Chateau (Enerdata), Nathalie Quercia (Enerdata), Jean Marie Bouchereau (Adème), Thomas Hamacher (IPP-MPG), Markus Biberacher (IPP-MPG), Dag Martinsen (FZ Jülich), Regina Eich (FZ Jülich), Birgit Pittermann (Verbundplan), Martin Patel (Univ. Utrecht), Dirk Jan Treffers (Univ. Utrecht), Timo Marquez (Univ. Utrecht), Koen Smekens (ECN) and Paul Lako (ECN)

WELCOME

Koen Smekens welcomes everybody at the ECN office in the Shell headquarters in Amsterdam.

REVIEW OF THE MEETING AGENDA, OBJECTIVES

Bertrand Chateau reminds that this is the mid-term assessment meeting of VLEEM 2. The last meeting in the series will be a conference together with partners in the so-called Sapientia project.

The first objective of the meeting is to agree on how to account for sustainability in VLEEM 2 case studies in regard to the definition of EU energy RT&D programs.
The second objective is to launch the second phase of VLEEM 2, i.e. the development of the case studies and the identification of the roadmaps that are consistent with the sustainability criteria.

Thomas Hamacher has comments on ENERDATA's synthesis on sustainability. Bertrand proposes to discuss this topic in the afternoon. Koen Smekens draws the attention to the agenda: it leaves room for additional discussion from 14.45 to 15.45 hr.

PART 1- REVIEW OF VLEEM 2 DEVELOPMENT

WP1: Enhancement and extension of the conceptual and analytical framework of the demand sub-model (B. Château)

WP1 task 1 entails 'Enhancement of the sustainability criteria for energy RTD strategies and elaboration of a memorandum on sustainability'.
A seminar on 'Human development and sustainability of energy systems' was held on April 30th 2003 in Paris.
This seminar is the main input to the synthesis on sustainability that will be finally included in the mid-term report of VLEEM 2: "Accounting for sustainability in VLEEM". A draft of this synthesis circulated in August 2003. T Hamacher made comments about this draft; Enerdata waits for comments of the other partners before mid October.

WP1 task 2 addresses 'Enhancement of the assessment of the very long-term economic growth in relation to demographic transitions and technical progress in the world'.
This task addresses *inter alea* a review of theoretical approaches relevant for the assessment of economic development in VLEEM 2. It also contains the development of a very simplified macroeconomic general equilibrium module within VLEEM-BASES:

- Equilibrium GDP/consumption/investment according to the age structure of the population.
- Equilibrium salaries/consumption/transfers/savings according to the age structure of the population.

Next steps are:

- Calibration and validation of the module for all world regions. (mid October)

- Linkage between investment and savings on the one side and unemployment on the other side. (end October)
- Finally, a chapter will be drafted for the mid-term assessment report. (end October)

WP1 task 3 includes an 'Assessment of the economic and energy exchanges and trade among regions'.
Within this task the global allocation of energy intensive industries and international trade of related products are assessed by Martin Patel and Dirk Jan Treffers (Univ. Utrecht). Another important subject is the global competition for goods and services and related trade:

- Accounting through ratio actual volume/potential volume of labour, in relation to assumptions on protectionism and balance of payments.
- No modelling of imports/exports.

Next steps are:

- Calibration and validation of global competition for all world regions.
- Integration of the international trade of energy intensive products, calibration and validation. (End of October if the Ultecht University is ok)

WP1 task 4 entails an 'Enhancement of the assessment of the very long-term transport systems and related needs for energy services, both from the households and production sides', which includes the theoretical and modelling development of future transport systems:

- Time for mobility generated by self-accomplishment services outside the home in addition to "zahavi's time".
- Global cost function including the value of time (Beckers equation) to be integrated in VLEEM-BASES; generalisation to all functions remains under question.

The original hypothesis that everybody spends about one hour a day travelling has been modified: a differentiation is made between 'current daily travel time' and 'occasional self-accomplishment time'. Thomas Hamacher asks whether the different approaches are consistent. B. Chateau answers yes.

Next steps are:

- Integration in VLEEM demand sub-model. (mid October)
- Calibration and validation. (end October)
- Chapter in mid-term assessment report. (end October)

WP1 task 6 addresses 'Socio-economic data collection related to life-styles and behaviours in selected developing countries':

- Collection of current statistics relevant to VLEEM demand model from international and national sources currently accessible; incorporation in the model data files (completed).
- Preparation of a simplified questionnaire for collecting additional necessary data from main developing countries representative of VLEEM regions (completed).

Next steps are:

- Identification of counterparts in selected LDC's, jointly with the VLEEM consortium.
- Additional data collection from counterparts.
- Chapter on 'Data situation and expectations for VLEEM demand sub-model' in mid-term assessment report.

WP1 task 7 addresses 'Integration of all above parts in the overall VLEEM framework', which entails socio-economic modelling:

- Macro-economics of all regions (nearly completed).
- Gender separation in population (completed for one region).

Next steps are:

- Transport in relation to self-accomplishment (ongoing).
- Water delivery and other production.

WP2: Development of the DACES module for long-term conventional energy demand-side and supply-side technologies and coupling with the VLEEM framework (M Patel, DJ Treffers)

Martin Patel starts with a presentation on WP2 with the following contents:
A. Steel
B. Methodological: fertilisers
C. Results: buildings
D. Results: transportation
E. Elasticities

A. Steel

Methodology:
DJ Treffers explained that they produce forecasts for consumption on the base of relations between cons per cap and wealth (based on forecasts for GDP and Pop). The forecasts for consumption permit to obtain:
-on the one hand, elasticities to wealth of Vleem activity indicators submodel
-on the other hand, estimates for energy use in 2050 for heat, electricity and fuels based on forecasts for production and analysis of energy efficiency potentials, and related elasticities to information of useful energy per unit of energy service.

Timo Marquez analysed the consumption of steel in different countries and world regions as a function of GDP (both per capita). Martin shows figures for the world and for Latin America. They conclude that they can't use the same relation for all the countries (For some materials it is possible to make a general curve and for other it is not); so they want to do different routes for the main regions.

They are able to forecast primary energy requirement until 2050 with a robust way. For the years after they proposed to make two scenarios and take into account a mean gap between the two scenarios.

Thomas Hamacher asks whether it would be possible to provide a picture of an energy intensive factory (steel plant) of the future, as what has been done for houses. Martin Patel thinks that it is difficult to generalise for steel plants or other energy intensive industries. The energy efficiency improvement of those industries has largely been by means of marginal improvements and substitution of fuels.

Thomas Hamacher thinks that it would be meaningful to have some idea about how the development of fuel cells could influence the steel industry. Koen Smekens notes that –irrespective of specific process innovations – the main output from the steel industry will remain steel. The technology of steel production will change in the future. However, there could also be changes in the demand for steel, e.g. by substitution of steel by aluminium. These changes and interactions could determine the demand for primary energy for the energy intensive industry.

Martin Patel will give information on the technical development of the steel industry and hydrogen as an energy carrier.

Martin Patel also shows the function of aluminium consumption and GDP (both per capita) for countries and world regions. This relation seems to be less straightforward than for steel.

Martin Patel shows a figure of the production of primary and secondary steel in North America for the period 1979-2100. Bertrand Chateau asks how recycling has been addressed. Martin Patel replies that is has been assumed that the same dynamics in recycling (proportion between primary and secondary steel) would apply in the future as has been observed in the past. According to Martin Patel an educated guess will be necessary with regard to the extent to which recycling will change the proportion between primary and secondary steel. Scrap could be an important material for developing countries with relatively small steel works based on scrap.

According to Martin Patel, the global steel production would increase by a factor of about five between 2000 and 2100 in a Business As Usual scenario. Industrialised countries would show a very low growth of steel consumption. However, developing countries would end up with a level of steel consumption in 2100 that is comparable with the level of the industrialised world.

The technological development is estimated as follows:

- An estimate is made of the best available technology. Then it is assumed that under some conditions the difference between this level of energy use and the thermodynamic minimum would be reduced by one-third and possibly by another one-third in the period 2000-2100.
- This approach will be applied to both primary and secondary steel production.

Martin Patel notes that depletion of iron ore does not seem to be a problem, even in case of a substantial increase of steel consumption. A quite different development of global steel production would only apply in case of different lifestyles. According to Thomas Hamacher there is still ample room for technological development in steel production. Koen Smekens asks whether there are any indications of a different primary energy mix in terms of GJ/tonne for steel in the future. Martin Patel will try to address this question.

Dirk Jan Treffers has made an estimate of the amount of transport energy required per tonne of steel in a BAU scenario. From a life-cycle point of view, the fraction of transportation energy would remain rather stable, viz. 10-15% of the total primary energy per tonne of steel.

B. Fertilizers

Dirk Jan Treffers shows figures of the relation between the amount of fertiliser used and GDP per capita and between the global fertiliser production and the energy and feedstock consumption (natural gas) from 2000 to 2100. There is no significant relation between fertiliser use per ha of arable land and GDP per capita. Koen Smekens advises to substitute the fraction of the GDP related to agriculture for the GDP. It is possible that this gives a meaningful relationship. Apart from ammonia-based fertiliser, also potassium and phosphate based fertilisers are used.

C. Space Heating For Buildings

Dirk Jan Treffers shows a trend view of the final energy demand for space heating for buildings.

Bertrand Chateau thinks that this could be an underestimation. This is because the fraction of income devoted to space heating and other energy services within homes remains fairly stable on the very long term. The size of the buildings (per capita) may change. According to Thomas Hamacher the technology for passive houses is available. However, implementation of passive house technology could be a problem. Martin Patel thinks that the amount of m^2 per capita may increase. We should not be too optimistic for the trend case.

Dirk Jan also shows a figure of the tonnes of materials used for buildings in the EU-25 countries for the period 2000-2100. In this figure a distinction is made between different materials, like cement, brick, timber, roof tiles, glass, etc.

Bertrand Chateau notes that the figures on materials for buildings should be consistent with the demand model. Dirk Jan Treffers and Martin Patel have found some differences in the historical use of different materials (and extrapolations based on these data) and an approach based on the amount of materials that would be needed for a building (and extrapolations based on these data).

D. Transportation

Dirk Jan Treffers shows a graph of the relation between total traffic per capita and GDP per capita. Bertrand Chateau has some comments on this graph. A problem might be that increasing traffic in personal vehicles may be inconsistent with the assumption that daily travelling time does remain stable at one hour per person per day. Paul Lako asks whether it is possible to analyse existing long-term energy scenarios in this regard: is there an overestimation of the person-km's based on personal vehicles, assuming that the rule of one hour per person per day is valid?

E. Elasticities

Dirk Jan Treffers shows data with regard to elasticities for production and information. There is still some problem in case of production of materials for buildings.

WP3: Enhancement and extension of the conceptual and analytical framework of the technology sub-model; K. Smekens, G Kolb, T. Hamacher, P Lako, W..Pospischil

Paul Lako gives an overview of the activities up to now. In the framework of VLEEM 2, ECN Policy Studies and Verbundplan made an assessment of hydropower. It presents *inter alea* the development of hydropower in different countries and world regions, makes a distinction between large-scale and small-scale hydropower and gives some insight in the question of sustainability.

Another activity planned is a report on biomass and waste technologies and potential. This will be a common report from ECN Policy Studies (Paul Lako and Koen Smekens) and Verbundplan (Birgit Pittermann and Wolfgang Pospischil). Verbundplan has already done quite some work on biomass and waste. It is planned to produce a draft report on biomass and waste by the end of 2003. ECN Policy Studies will draft a chapter on the potential of biomass in world regions. It will be passed to the VLEEM 2 partners for comments, most probably by the end of October 2003.

Dag Martinsen mentions that the monograph on nuclear fission has been updated by STE/Juelich.

WP4 : VLEEM mathematical and software development; M. Biberacher, B. Chateau

Markus Biberacher gives a presentation on Software Development: ArcView is a GIS based graphical software package, 'surrounded' by GAMS, TASES, databases, a climate model, and BASES (demand model). It includes solar and wind data, based on a GIS structure. For EU-25, hourly solar energy data are used and for other regions daily data. Thomas Hamacher notes that solar data might be obtained from climate change models. However, this is not envisioned in VLEEM 2.

The model may be defined for different regions, e.g. the world, a world region, a country, the city of Augsburg, etc.

Thomas Hamacher continues with 'Back-casting', which is influenced by certain 'events', like:
- Political, economic and social settings (strong support for climate change, limited world trade, no enthusiasm to support large- scale nuclear).
- Major events (depletion of resources, evidence of climate change becomes obvious or even dramatic).
- Major investments in energy conversion and infrastructure, major organisational arrangements (construction of first fusion power plant, globally acting companies).

The VLEEM Software Philosophy is based on:
- GIS-based data base and user interface.
- Time and space resolution model (TASES)
- Balance model (with GAMS)..
- Demand model (BASES).

The balance model includes:
- Indigenous production, import and export.
- Transformation.
- Total final consumption.
- Final transformation.
- Needs.

Furthermore 4 calibration decades (1960, 1970, 1980, 1990), 11 'back-casting' decades (2000…).

The balance model is a kind of 'physical optimisation model', which is actually intended to be used more as a simulation model with inclusion of constraints. It delivers balance tables for all milestone years. The objective function is the sum of all primary energies and installed capacities, which are weighted according to the 'user'. Among the constraints considered are emissions of greenhouse gases and

depletion of (fossil) fuels. 'Back-casting' with a simple balance model provides data to evaluate major 'events'.

Bertrand Chateau asks how the balance model is linked with TASES. According to Thomas, TASES is very important for the 'high renewables' case. In the 'high fossil' case, the infrastructure is also important and therefore the need for a model like TASES (with regional detail) is important. For the nuclear case, regional details are not so important.

Clarification is still needed how the connection is made between the balance model and the demand model.

PART 2 – SUSTAINABILITY IN VLEEM CASE STUDIES : SOCIO-ECONOMIC ISSUES AND SCENARIOS

Sustainability issues in VLEEM: Social and economic aspects (B. Chateau)

Bertrand Chateau gives a presentation of how demography and migration impact energy systems in the very long term in VLEEM 2. Fertility rates are basically driven by how women try to get grip on their life. A decreasing number of children would be the result of a higher development stage. There is also a cultural component in the demography development.

Questions raised are:

- Does the continuation of population growth jeopardise the social viability in the very long term? Globally or regionally or both? Is the Malthusian UN assumption on stabilisation of the world population by 2050 necessary?
- At which speed and down to which point may a country's population decrease without breaking socio-economic equilibria?
- To what extent may population migrations among world regions contribute to regional socio-economic equilibria or destroy them?

Needs for energy services are mostly determined by cultural habits and the use of time, in addition to affluence:

- Energy services related to the 'food' function increase as time-budget decreases.
- Energy services related to the 'shelter' function: a matter of architecture and materials.
- Energy services related to mobility: mostly a matter of access to cars, speed and time-budget.
- Energy services related to 'self-accomplishment': mostly a matter of time-budget and cultural budget.

Cultural traditions determine wealth:

- Cultural conditions may slow down or accelerate progress in basic education of future workers, and therefore the future productivity of labour.
- Cultural traditions determine the role of women in the society, and therefore their basic education level, their participation to paid work and their fertility.

Thomas has a few questions about relations assumed by Bertrand Chateau. Martin Patel thinks that the failure of the WTO negotiations at Cancun demonstrates the power of the western world vis-à-vis the developing countries. Developing countries cannot keep up with industrialised countries in an easy way, even towards 2100. Bertrand Chateau also raises the question whether wealth is the only parameter of interest. Martin Patel indeed regards well-being as important.

Bertrand Chateau draws the attention to the United States, a region that is supported by the rest of the world in terms of budget deficit and trade deficit. The world that we will describe could be very different if this situation continue or not. The 'American way of life' could diffuse more or less to the rest of the world. There could be a scenario with a widespread 'American way of life'. According to Bertrand, the demographic development will strongly influence the economic development. However, flexibility may be possible through the labour time. If the number of years of paid labour would become larger than the current level, the impact of the demographic transition could be smoother.

Bertrand Chateau asks the participants of the VLEEM 2 project to comment on the synthesis report. Does the way in which the future world is described correspond to their view? Maybe, we have to skip criteria like bio-diversity, although this criterion could be important for biomass. These and other aspects will have to be discussed.

Thomas Hamacher makes a few notes on the draft sustainability paper. He thinks that it could be worthwhile to present more quotations. He would favour also to introduce several examples of sustainability definitions and theories (e.g. the way the World Bank defines sustainability). According to Martin Patel, there is a need for weighting of different sustainability criteria. Some criteria may be dealt with qualitatively and others quantitatively.

Bertrand thinks that a distinction should be made between the development of consistent scenarios which can be more or less sustainable, and weighting mechanisms for the sustainability criteria. There should be some general guidelines how to construct 'sustainable' scenarios.

Introduction to socio –economic scenarios for case studies (K. Smekens)

Koen Smekens elaborates on the three types of scenarios proposed in ENERDATA's synthesis on sustainability.
With regard to GDP:

- The HiPop (high population) type scenario would show a regionalised homogenous development and growth,
- The MidPop type scenario would show a converging economic growth. However, this does not necessarily presume the level of GDP of the US to be reached everywhere.
- The LowPop type scenario would show first a converging global economy, and after 2050 a diverging growth for developed and developing regions.

With regard to Migration Pattern:

- The HiPop type scenario would show a high migration within and towards the developed world.
- The MidPop type scenario would show first a high migration pattern, but later on a slowdown due to the economic development.
- The LowPop type scenario would show a high migration within and towards the industrialised regions, afterwards a homogenous level globally, turning back to a flow towards the industrialised world.

With regard to land use change and agriculture:

- The HiPop type scenario would show a domination of food production, support for developed world products remains distorting; pressure on land however initiates conservation and degradation mitigation actions.
- The MidPop type scenario would show a lower land pressure and high environmental concerns result in a well-managed use.
- The LowPop type scenario would show a land pressure that is offset by increasing management effectiveness and results in a stable and diverse land use.

With regard to resource availability:

- The HiPop type scenarios would show a maximal exploration of conventional and unconventional resources; fossil energy remains the most important, but may depleted by the end of the century.
- The MidPop type scenario would show a world in which fossil resources are exploited with high efficiency, together with an increased use of renewables.
- The LowPop type scenario would show a world in which fossil fuels are used maximally, and reserves remain sufficient over the century.

With regard to resource distribution:

- The HiPop type scenarios would show a world in which security of supply drives the energy policy of the industrialised regions, dominating the energy market; renewables are mainly used for local markets.
- The MidPop type scenarios would show a world in which energy becomes a global commodity on a demand driven global market; the energy portfolio becomes wider and more diverse.
- The LowPop type scenario would show a world in which high growth drives global energy markets, resulting in high price levels, followed by a relaxation of the market in the second half of the century.

There is a discussion on the position the main oil producing and exporting countries of the Middle East countries, whether they will fully play the global market game or they will try to conserve oil by raising the price long before the depletion of their oil resources. There is also discussion whether the developed countries will develop nuclear energy as a means to become less dependent on oil.

With regard to technological change:
- The HiPop type scenario would show rapid and varied developments, large-scale breakthroughs are limited; a conservative approach is assumed in the developing regions.
- The MidPop type scenario would show that major transitions are possible towards clean energy systems (H2, fusion, etc), with widely spread diffusion of those technologies.
- The LowPop type scenario would show an advance based on current developments (IGCC), although new options (H_2) emerge as well; diffusion slows down in the second half of the century.

With regard to climate change:
- The HiPop type scenario would show weak global targets, policy aimed at adaptation.
- The MidPop type scenario would show a world in which global targets result in climate change mitigation.
- The LowPop type scenario would show regionalised and balanced efforts that are stronger than in the HiPop type scenario.

With regard to nuclear power:
- The HiPop type scenario would show regionally diversified and increased attention for safety, but little growth potential.
- The MidPop type scenario would show the appearance of advanced fission as well as fusion.
- The LowPop type scenario would show a relatively high importance of fission power.

Bertrand Chateau wonders whether the assumptions with regard to nuclear energy are consistent for each of the scenarios.

Martin Patel has the feeling that there is some difference in approach compared to the 'A1, A2, B1, B2 approach' in the IIASA-WEC scenarios. It seems that the A1 scenario has been skipped. He also wonders whether all of the three scenarios are sufficiently different (particularly the third scenarios). Thomas Hamacher regards the first and second scenario as not sustainable.

Bertrand Chateau says that we have to describe guidelines how to incorporate sustainability in energy policies within all scenarios. That is why he did not try to give an overview of all sustainability definitions and theories. According to Bertrand we should not go too far into details of the sustainability of scenarios in the story line. We are not able to say ex-ante which scenario is sustainable and which is not. He suggests that the VLEEM 2 partners give comments on the presentation of Koen Smekens. He also recommends to modify the qualitative assumptions into more quantitative assumptions. The mid-term report will include the story lines of the scenarios.

Thomas Hamacher thinks that the question of nuclear energy or the question of climate change may be too much prescriptive, taking into account the purpose of back-casting. He wonders whether climate change constraints have been effectively incorporated in the three scenarios, consistently with the back-casting concept. Koen Smekens believes that the criteria that he introduces are compatible with the back-casting approach. He also thinks that climate change is addressed in the scenarios, although in a different way and to a different extent.

Martin Patel thinks that it would be possible to start with three different scenarios in terms of population, and impose on them different GDP growth levels (High, Medium and Low growth).

Bertrand Chateau thinks that the general outline for each scenario may limit the degree to which sustainability is reached in the world as a whole. However, if the outcome for the world as a whole is not totally satisfactory, it may be more or less satisfactory for some parts of the world.

Socio-Economic Variants With Vleem-Bases

Nathalie Quercia gives a presentation of the impact of the fertility level on the population forecasts. Three scenarios were presented corresponding to the three scenarios presented by K Smekens.
World results:

- HiPop (assumption of 2,5 Children/woman)=> 11 Billion people
- MidPop (same fertility assumption as ONU's medium variant for 2025 and 2050 and same tendancies until 2100 for rich countries and stabilisation for other countries)=> 8 Billion people (about same results as ONU)
- LowPop (assumption of 1,2 Children/woman)=> 6 Billion people

Conclusion of an important population aging in the three scenarios.

Bertrand Chateau gives a picture of the impact of population ageing on macro-economic equilibria in France. He gives an example of the demographic and economic assumptions underlying the picture.

The outcomes for France are almost independent of the solution of the pension problem. With current consumption and transfer patterns, there is a constraint with regard to investments if it is assumed that the balance of payments should not become negative. The purpose of the modelling is to look at the structure of the GDP taking into account the evolution of the structure of population presumed in France. The outcomes are related to the presumed consumption of the different age categories. Thomas Hamacher is interested to know the underlying assumptions. Bertrand Chateau says that he would be able to give the formulas that are included in the model.

Friday 26th of September

Bertrand Chateau (Enerdata), Nathalie Quercia (Enerdata), Jean Marie Bouchereau (Adème), Thomas Hamacher (IPP-MPG), Markus Biberacher (IPP-MPG), Dag Martinsen (FZ Jülich), Regina Eich (FZ Jülich), Wolfgang Pospischil (Verbundplan), Birgit Pittermann (Verbundplan), Martin Patel (Univ. Utrecht), Dirk Jan Treffers (Univ. Utrecht), Koen Smekens and Paul Lako (ECN)

Bertrand Chateau continues the mid-term assessment meeting. He reiterates the question how to incorporate sustainability criteria in the scenarios. Thomas Hamacher reiterates that the back-casting approach is at risk with the proposed scenarios. He quotes a paragraph from the synthesis report 'Accounting for sustainability in VLEEM' (Enerdata):

> 'The use of back-casting is strongly connected with the concept of sustainable development or more generally with a concept of a desirable future. The whole task is to find trajectories able to convert the existing system into a desired future system, without violating human rights, the principles of democracy and pluralism' (p. 3 of the 1st draft report, Enerdata, August 2003).

There is some discussion on the way back-casting has been used until now. There will be presentations from Thomas Hamacher, Dag Martinsen and themes like fossil fuel availability.

PART 3 – ADOPTION OF ENVIRONMENTAL SUSTAINABILITY CRITERIA AND VLEEM 2 CASE STUDIES

SUSTAINABILITY ISSUES IN VLEEM: ENVIRONMENTAL CRITERIA

History of greenhouse gas effect and ideas with regard to sustainability

Thomas Hamacher presents the case of a climate change policy base on a 'short history' of the greenhouse gas effect. The history starts with the 19th century scientist Arrhenius. 1896 Arrhenius postulates the enhancement of the greenhouse effect due to anthropogenic CO_2 emissions. The theory of the greenhouse effect caused by fossil fuel combustion was furthered by Plass (additional CO_2 in the atmosphere leads to enhanced absorption of long-wave radiation), Suess (carbon from fossil fuels stays in the atmosphere, keyword: ^{14}C) and Revelle (up-take of carbon by sea-water) around 1955. A few years later measurements of the atmospheric CO_2-content started to become available (Mauna Loa, Hawaii).

Geo-engineering Approach.
Geo-engineering means that major parameters of the system earth are actively modified, e.g. the overall albedo or the uptake of carbon by the oceans. This could be by means of adding some substance to kerosine used by airplanes or addition of substances to the oceans to increase the uptake of carbon. Also increasing the albedo of the surface by changing the colour of highways is deemed 'beneficial'. Such ideas (mainly from science fiction books) might become very relevant.

Tolerable Windows Approach
Another approach is the *Tolerable Windows Approach* (TWA). However, we do not know the hard limits of the environment.

The debate on climate change can be phrased in two ways:
- The danger of climate change forces us to change the energy system completely.
- Progress in energy technologies make it possible to supply even arising demand of energy, with less and less carbon emissions.

The potential to reach 'zero' emission. A technological cluster can only be considered sustainable, if – in the most extended application of the cluster – a state could be reached with 'zero' CO_2-emission from the energy sector. There is a discussion on 'zero' CO_2 emission. Thomas Hamacher thinks of a remaining CO_2-emission of 1 GtC in 2100. From 2100 on you would have a sustainable energy system.

The emission level in 2100 should not surpass a certain threshold level, of e.g. 1 GtC/a in 2100. According to Koen Smekens this would cause a heavy reliance on CO_2 emission reduction in the last decades of the century. Martin Patel thinks that we should try to prevent that the hard part of the trajectory is concentrated in the last decades of the 21st century. Koen Smekens thinks that the time lags in the first half of the 21st century are real.

Bertrand Chateau thinks one could try to reduce CO_2 emissions in an equal pace throughout the 21st century. Martin Patel thinks that there may be different speeds of CO_2 reduction per decade, caused by lack of technologies in the first compared to later decades. Bertrand Chateau wonders whether the framework proposed by Thomas Hamacher would raise objections from the EC.

According to Bertrand Chateau, the problem is how to allocate a 'zero' emission level in 2100 to different regions of the world. He would prefer different CO_2 reduction targets for industrialised and developing countries. Koen Smekens thinks that we should be neither over-pessimistic nor over-optimistic. He mentions a methodology - 'contraction and convergence' - that has been developed in the UK and has been used to allocate CO_2 reduction targets to industrialised countries and developing countries.

According to Thomas Hamacher, the potential of technologies and clusters to achieve 'zero' emission has to be analysed.

The flexibility of the technological mix will be used to judge the sustainability of the development:
1. Has the mix the potential to reduce emissions?
2. Are back-stop options available in case some of the technologies fail to fulfil their potentials?

Koen Smekens suggests to define a few scenarios with endpoint in 2100 that will most likely fulfil the sustainability criteria that we acknowledge. The outcome in terms of CO_2 emissions of different regions of the world in 2100 may be compared with the so-called SRES scenarios of the IPCC. We do not have to repeat the SRES work.

Martin Patel needs clear-cut targets for CO_2 emissions reduction in the long term (2100) for the demand side assumptions. If we do not have those targets, we are at risk to underestimate the changes on the demand side and leave most of the CO_2 reduction to supply-side technologies.

According to Bertrand Chateau, there are some political goals of a factor four CO_2 reduction or 80% CO_2 reduction in 2050, at least in some industrialised countries. Such targets may be translated into a target of 15% CO_2 reduction per decade. Koen Smekers suggests that different countries or world regions might have a more moderate CO_2 reduction target (less than 15% per decade). This would of course apply to developing countries.

Thomas Hamacher remains in favour of a more radical approach ('zero' emission in 2100). However, if the EC would reject such an approach and this approach would be more difficult to implement than another one, he could also imagine some approach of CO_2 reduction per decade. In the latter case, you would have to give convincing arguments for such an approach.

Bertrand Chateau suggests to assume some fixed percentage of CO_2 reduction each decade, starting from now for industrialised countries and later on for developing countries. Wolfgang Pospischil suggests to add flexible mechanisms (e.g. CDM) to the portfolio. If the report is meant to be useful for the EC, then you could think of adding flexible mechanisms.

Koen Smekens thinks that he could send an improved version of the document on scenarios and sustainability with the desired CO_2 reduction levels for industrialised and developing countries, including suggestions from Martin Patel and others (developing countries, flexible mechanisms). This second version of the document on scenarios and sustainability could be circulated among the partners of VLEEM 2 in the course of October.

Thomas Hamacher thinks that this approach is attractive to some extent. He has a report from a board advising German government, with indicators and road maps for sustainability.

Nuclear energy and sustainability in VLEEM 2

Dag Martinsen summarises the study from Gerhard Kolb and him on nuclear energy and sustainability. The study addresses inherent safety. Some future reactor types could be considered as inherently safe.

Another criterion is prevention of proliferation of nuclear weapons. This criterion is important, as it could impact the viability of a scenario of widespread use of civil nuclear energy. The study also focuses on technologies that may reduce the amount of high-level waste, viz. breeders or ADS (Accelerator Driven Systems). In the meantime we will have to look for permanent storage of a part of the high-level waste that is not 'recycled' (because it cannot or because the 'recycling technologies' such as ADS are not yet available).

Dag Martinsen explains that a zero stockpile of high-level waste (Plutonium) can be reached by the Juelich-model for the end of the century. In the midterm it may allow to build a few types of nuclear power plants with a different level of generation or reduction of HLW. The model facilitates discussion on the degree to which nuclear energy might be sustainable or not.

Bertrand Chateau wonders whether the criteria for sustainability with regard to nuclear energy are consistent. He would favour not only a criterion for the endpoint, but also for the midpoint.

Thomas Hamacher thinks that we cannot make strong statements for the midpoint. However, according to Bertrand Chateau the EC requests to give a statement about the midpoint. Thomas Hamacher and a few others present think that the storage of Plutonium for a few generations is not the real problem.

According to Dag Martinsen a maximum could be put on the stock of Plutonium at different mid-points. In that case the nuclear capacity would be limited as well. Bertrand Chateau mentions the nuclear case from VLEEM 1. However, he wonders whether all the sustainability criteria are fulfilled in the next few decades. According to Thomas Hamacher this is not the case. There will be high-level waste for decades, at the midpoint and most probably still in 2100. However, the same applies to the emission of CO_2 in the 21st century.

There are differences between CO_2 emissions and Plutonium. CO_2 emissions are a global problem, the plutonium stock is a problem of nations and regions within countries. Thomas Hamacher argues that doubling the amount of Plutonium in stock until say 2050 does not mean doubling of the risk.

Koen Smekens suggests non-nuclear scenario variants for each of the three main scenarios. This idea is welcomed. Paul Lako suggests to make a clear distinction between fission and fusion power. We had such a lengthy discussion on inherent safety, high-level waste, plutonium, etc. However, those issues are hardly relevant for fusion power. Therefore, he is in favour of adding fusion energy to the renewable energy sources. In this way, a scenario variant with a 'nuclear moratorium' does not necessarily impact the possible development of fusion energy.

Dag Martinsen concludes that for the EC there should be some criterion for the stockpile of plutonium also for the midterm. He will report the discussion to Gerhard Kolb and they will try to deal with the problem of the stockpile of high-level waste (casu quo Plutonium) for the midpoint as well.

Other sustainability criteria in VLEEM 2

According to Bertrand Chateau it is not sensible to presume that society will wish to keep fossil resources for later centuries in all the scenarios. However, there might be 'cultural' reasons in some scenarios and some regions of the world to curtail the depletion of fossil fuels. The problem is how to put restrictions on the amount of fossil fuels used in the 21st century, when resources of fossil fuels (particularly of coal) are ample. Some limitations with regard to some fossil fuels in some regions and scenarios might be applied.

Bertrand Chateau wonders whether there should be a minimum level of indigenous production of energy or a limit on the import dependence. Is there a possibility that the world oil market would not develop in a quiet and stable way (as happened in 1973). There is only the target that 12% of the primary energy supply in the EU15 should be based on renewables in 2010.

Bertrand Chateau asks whether there is a need for some criterion with regard to extreme flows of some energy carriers. He refers to the argument of security of supply. Thomas Hamacher thinks that in several scenarios (be it nuclear based or renewables based) there might be huge flows of energy. For fossil based scenarios there could also be very large flows. Martin Patel suggests to look at the results of scenarios, and then discuss whether the outcomes are reasonable or not.

The attendants to the meeting accept that we cannot impose a quantitative criterion for security of supply. However, after having made the calculations, the preliminary results will be discussed with the partners of

VLEEM 2 and (possibly) with a representative from the EC. Also, the paper on sustainability (1st draft Synthesis from Enerdata) will be passed to the EC, and the absence of a quantitative criterion on security of supply will be made explicit.

According to Thomas Hamacher, there are some criteria for land use, e.g.:
- Agriculture is more important than biomass production. Byproducts from agriculture are free.
- 10 to 20% (say 15%) of the total land available should be natural forests for bio-diversity etc
- A maximum biomass area as a percentage of the total arable land area or some other surface criterion.

The use of desert areas is not detrimental. Are there any further criteria for land-use? Other criteria like restricting the amount of km^2 covered by solar photovoltaic or biomass to the amount of km^2 covered by roads in industrialised countries do not seem to be sensible.

Martin Patel proposes to take the arable land, then deduct the land used for agriculture, furthermore deduct some land needed for forestry and natural forests (bio-diversity), ending up at the amount of land available for biomass.

IIASA (Mr. Fischer?) has a model on land use, according to Thomas Hamacher. We could use data from IIASA. ECN Policy Studies (Paul Lako and Koen Smekens) will take the lead with regard to land use and availability of land area for biomass. ECN Policy Studies will take due account of studies by IIASA (via e.g. Wolfgang Pospischil). By the end of October a chapter on the potential of biomass in different world regions will become available for inclusion in the 'monograph' on biomass and waste technologies and potential from Verbundplan and ECN Policy Studies. Comments and enhancements from the VLEEM 2 partners will be collected.

VLEEM 2 CASE STUDIES

Technology paradigm: networks versus primary carriers
Thomas Hamacher presentated some remarks about the fusion technology

Cases to be analysed in VLEEM 2 (T. Hamacher)

Thomas Hamacher gives a presentation on cases & clusters that may be analysed in VLEEM.

1.

	Global Link (Multinationals)	Regional
Renewable	Use global resources (tricky new infrastructure)	Use regional resources (strong pressure on demand reduction)
Fission/fusion		Complete supply possible
Fossil sequestration	Use of global resources	Storage of CO_2

2.

	House of the future (Space heating, hot water, cooling, appliances)	Traffic	Energy intensive plant
Hydrogen world	Fuel cells	Car + fuel cell	Fuel cell?
Electrical world	Heat pumps	High speed trains	Process heat?

Martin Patel wonders whether the electrical world would imply a world in which electrical energy would be based to the maximum extent on carbon-free energy carriers (like uranium). The case 'electrical world' would possibly imply a nuclear case. We should know more precisely what the case 'electrical world' really means. Thomas suggests that ('CO2-free') electricity would cover about 40% of the primary energy demand of the world in the case of 'electrical world'.

3.

	House of the future	Traffic	Energy intensive plant
Renewable	PV, solar thermal, geothermal	Bio-fuels	
Fission/fusion			
Fossil		Traffic stays based on fossil fuels	CO_2 sequestration in case of centralised energy production

Martin Patel thinks that they will be able to give data that are to be used by Thomas and Markus in their models if the specifications for the data are sufficiently straightforward.

Demand for space heating in VLEEM 2 scenarios

Dirk Jan Treffers shortly presents a methodology for dialogue on energy used a few years ago. The dialogue was focused on a couple of scenarios for the Netherlands that were based on two world energy scenarios from WEC-IIASA. There was feed back from a group of participants to the dialogue. Copies of the two visions on the Dutch energy supply for use by the National Dialogue were passed to the participants of the mid-term assessment meeting.

Martin Patel thinks that in case of space heating there may be two types of houses, viz. a standard house and a 'house of the future' (as established by Verbundplan in VLEEM 1).

Bertrand Chateau wonders how the elasticities are applied to the different case studies. Thomas clarifies that you not only need figures on the needs of energy services, but also the definition of the degree of insulation of a house (the standard house and the house of the future) and a definition of the conversion system (be it an efficient boiler, a fuel cell system or a heat pump).

Koen also proposes to have different options for houses, like single family houses and multifamily houses. Within these categories you could choose between standard types and passive types of houses. Then you can choose your combinations for each scenario. In a scenario with emphasis on renewables it is presumable that there will be only 'houses of the future' from a certain point in time. For other scenario other assumptions may be made.

B.Chateau reminds that VLEEM addresses the combination of energy supply and energy demand for different parts of the population, from young people to old people, from singles to families. The structure of the population will determine the structure of housing. The elasticities for the needs of energy services for comfort account for this and have to be compatible with a specific scenario. The share of dwelling types in terms of standard house or 'house of the future' should be straightforward.

According to Thomas Hamacher the energy demand of a multifamily house may be two times higher than the energy demand of a detached single family house. Martin Patel thinks that we have to presume some area of m^2 of floor per inhabitant, irrespective of the percentage of multifamily houses in the total stock.

Bertrand Chateau is not convinced that a multifamily house always require two times the amount of energy as a detached single family house. He thinks that we can only say something about affluence. He thinks that you cannot impose a view of today on the distant future.

Martin Patel thinks that you have to define the housing stock in order to prevent a too large margin in the future energy demand. According to Bertrand Chateau we have information on the different classes of families and households. Martin Patel thinks that we have to define the degree to which there will be densely built houses (multifamily) or more detached houses, whether there will be mostly conventional (standard) dwellings or on the opposite mostly 'houses of the future'.

Bertrand Chateau accepts that building density may be important for our scenarios. However, we should be careful not to project too much the vision on houses and living of today on the future. Koen Smekens thinks that you should have some ideas on the way people are living, e.g. in several types of houses, in the future. Bertrand says that we have knowledge of the different types of families and households of the future.

For supply technologies we will have clusters of technologies. For the demand side, we just cannor define precisely the types and numbers of electrical appliances. Bertrand Chateau just wants to warn for a too deterministic approach with regard to the percentage of some type of dwelling or equipment. He proposes to make a matrix to translate the output from the one type of model into input in terms of dwellings in the other model. It is necessary to have one matrix per region.

WORK PROGRAMME AND AGENDA FOR THE NEXT YEAR (WP5)

Modelling interactions (end of the year)
IPP have to make all the case of the matrix for transport and housing for each region
Utrecht University is entrusted with doing the matrix for industry processes
Enerdata have to continue the C++ programmation

Detailed scenario description: Koen Smekens is going to make a world table including comments done during the meeting before the end of October. Partners have to react after K Smekens will send the matrix

Detailled description of the case study (technical assumption): Consists in the description of tases and interaction with load curves.

4 regions have to be considered in priority: Europe, North Am, South Asia and China.
Enerdata plans to have the demand matrix for this 4 regions at the end of November.

Data processing: should be completed for the end of June.

Reporting:
The mid term assessment report have to be done for the end of October. An outline will be made by Bertrand Chateau and will be circulated to be completed. The aim of the mid term assessment report is to give an overview of what we achieved and what will must still be done.

Martin Patel insists on the fact that DJ Treffers will leave the Utrecht University at the end of December; so the biggest of the Utrecht University's work must be done before this date.

Preparation of the joint conference with Sapientia
It is necessary to develop the analysis since June, because the Sapientia conference will be in October or November and our report has to be completed at least on a draft version for this conference.

To remember, the aim of Sapienta is to build a decision model for policy makers in analysing the impact of policy decision making and the impact of technologies.

Next meetings:
8-9 January 2004 in Grenoble
22-23 April
End of June in Austria

A meeting must be organised between Julish and IPP about the technology

Dissemination of Vleem results: BC will present the results in the WEC (Sydney) Sept 2004.