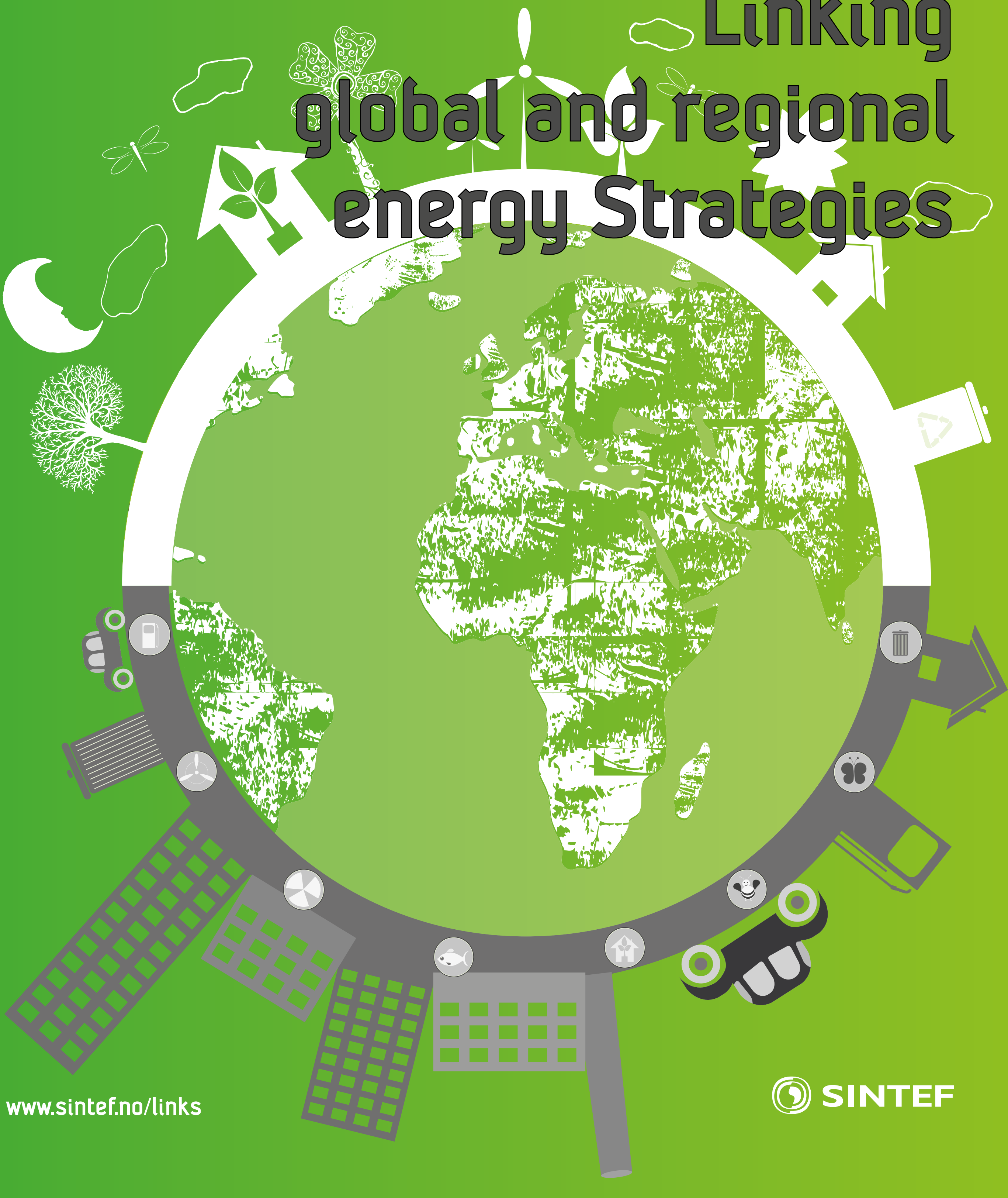
LinkS

Linking global and regional energy Strategies



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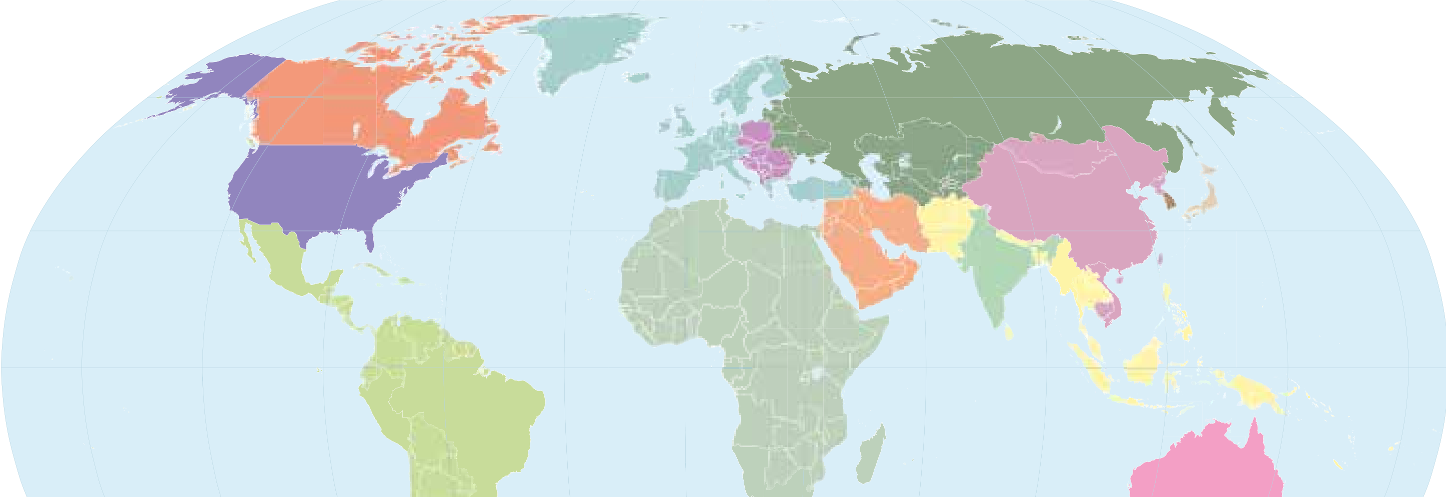


The EU has ambitious strategies for renewable energy and emission mitigation, while other regions have no specific strategies yet. If rapidly growing economies like Brazil, Russia, India and China delay their emission reduction efforts, the OECD countries have to do correspondingly more to keep total greenhouse gas (GHG) emissions within necessary limits by the end of this century.

The global community has to agree on strategies that are efficient and acceptable in several regions.

LinkS was designed to analyze how global long-term strategies can be used as guidelines for the development of energy supply and technology deployment in the regional energy systems of Europe and China.

Linking global and regional energy strategies

Global energy strategies

As an overall approach LinkS used the global long-term model GCAM as the "top model" that gave long-term scenarios for the development of global economy, energy, land use and climate change mitigation in 14 different regions of the world as shown on the map. We developed and explored effective regional strategies to limit human climate impacts for 5 different scenarios.

Four of the scenarios are traditional scenarios for limiting CO_2 equivalents (CO_2-e) in the atmosphere by 2095 with different technology availability: "450 ppm limit", "650 ppm limit", "650 ppm limit without CCS", "650 ppm limit without nuclear or CCS".

Both the 450 ppm CO_2-e and 650 ppm CO_2-e scenarios share the same socioeconomic, technology availability and policy instrument assumptions. We found that both were technically feasible, but both required immediate departures from the reference pathway. The more ambitious climate goal was more expensive.

In the fifth and final scenario we extend the EU 20-20-20 policies in time and space to a scenario termed "Global 20-20-20" where an increasing number of the world's regions gradually adopt the EU policies.

In Global 20-20-20 we assumed an approach which has four policy elements with gradually increasing requirements:

- GHG emissions limit
- Renewable Energy Standard
- Biofuel Standard
- Energy Efficiency Standard

This emissions mitigation strategy differs fundamentally from the 450 and 650 ppm scenarios. The latter employ a carbon price alone, whereas the former employs a combination of policies that include regulatory instruments in addition to a cap-and-trade regime. This new policy package was effective in achieving large reductions in the emission of anthropogenic climate forcing agents.

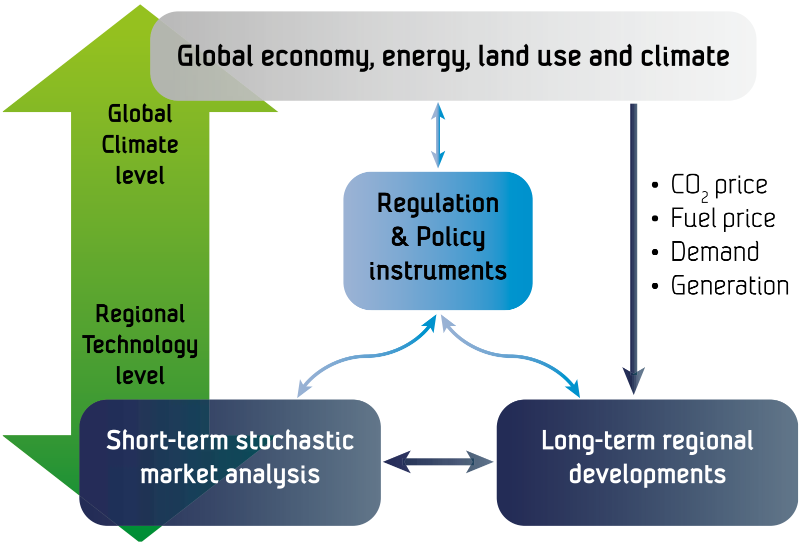
The socio-economic cost was 10 - 15 per cent higher than a pure carbon tax policy, but it lowered the tax emerging from the carbon market. The carbon price lies between carbon taxes in the 450 and 650 ppm limit cases, as might be expected since the Global 20-20-20 policy package produces radiative forcing of 3.2 W/m^2 in 2095, or approximately 505 ppm CO_2-e. In the year 2095, carbon price per tonne of CO_2 for the 650 ppm scenario is approximately $200, the carbon price for the 505 ppm CO_2-e limit is $300, and carbon price for the 450 ppm scenario is almost $800.

Regional energy strategies: Europe and China

In the European regional studies the development of the power system is analysed by the EMPIRE and the EMPS models based on input data from the overall global GCAM model in a time perspective to 2060. Individual countries in Europe have faster developments in the energy sector than estimated by GCAM. This is caused by the ambitious policies for energy efficiency, renewable energy and emissions reductions introduced in the EU the last years.

The Global 20-20-20 scenario is especially interesting with respect to generation and transmission capacities, as it is the policy scenario with the lowest demand in 2050 compared to the two others. However, in terms of generation capacity, investments are just as high as in the 650 ppm scenario, due to the high penetration of wind energy and the need for balancing demand and supply everywhere in the system. The amounts of new transmission capacity are 60 GW, 96 GW and 108 GW for the 650 ppm, the 450 ppm and the Global 20-20-20 scenarios, respectively. To put these numbers into perspective, the initial transfer capacity between European countries is around 67 GW today.

The current electricity demand in China is already higher than estimated in the GCAM scenarios, which are tuned to 2005 as base year. Nuclear and renewable power generation can't fully meet the rapid growth of demand due to the constraints of available resources. Thus, coal-fired power generation will still maintain a rapid growth momentum in China during the period 2010-2020, and will maintain the position as the power generation technology with the largest total installed capacity and highest energy production. However, due to extensive modernization and use of larger-scale units, it is possible to limit the CO_2 emissions from the Chinese power industry.



Research tasks in the LinkS project.

Linking different energy system models

The original ambition in the LinkS project was to soft-link multiple energy system models with different technological, spatial and temporal resolution, and iterate these into a sufficient convergence in selected regions.

By running GCAM as the global "top model" it was possible to use long-term results as input for the regional models, typically CO_2 prices, fuel prices and demand. However, iterating for convergence turned out to be a bigger challenge than anticipated. Even bigger challenges were encountered when we tried to iterate in a triangle between regional electricity and gas models under global GCAM projections. We eventually abandoned the approach of convergence for a triangle of models.

In the case of Europe, we compared two different models for long-term expansion of the electricity system; EMPIRE and EMPS expanded with an investment algorithm. The former model has a more mathematically stringent investment algorithm while the latter has a much better representation of variable renewable generation in Europe.

From the present analysis, it is not possible to conclude that one result is more "correct" that the other since there is no systematic difference between the results from the two models. The results of the EMPIRE model are sensitive to the choice of statistical year for wind and solar resources. The results are sufficiently similar to indicate that either model would be a feasible tool to use for electricity system expansion planning in a 50-year perspective.

Linking policy analysis and energy modelling

We performed the linking of policy and modelling in several stages:

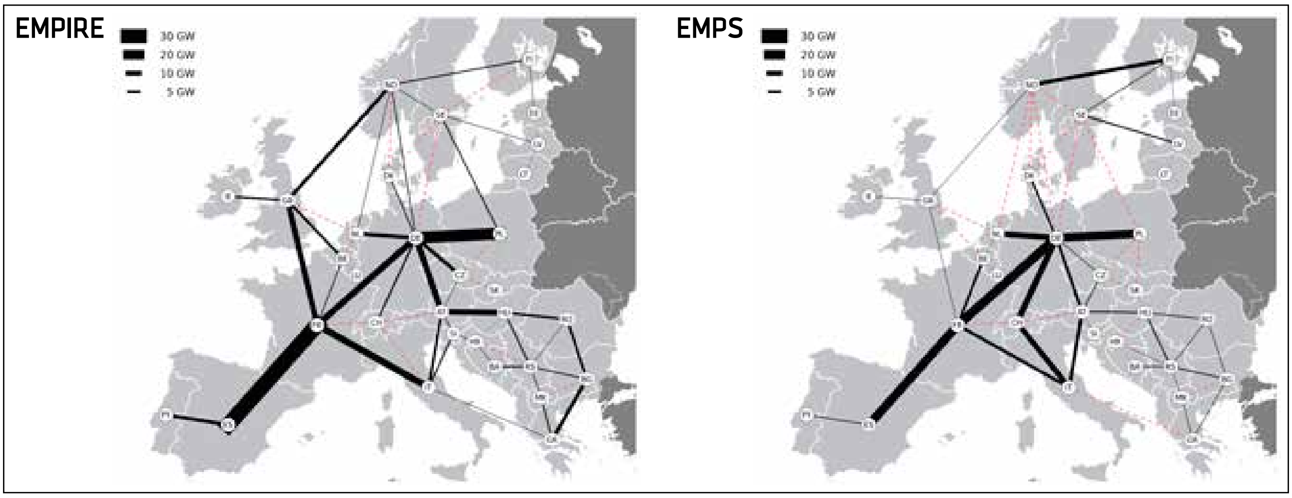
1) Specific policy measures were introduced in GCAM.
2) Results from the GCAM analyses were taken as input to the regional models.
3) Results from the regional models where discussed in a policy context.

In particular, the Global 20-20-20 scenario is an interesting example of an approach that could yield reasonably high emissions reductions. The main conclusion is that bottom-up, regionally independent policy measures could yield significant climate change mitigation results as an alternative to a single global carbon market. Further, we discussed how feasible the specific 20-20-20 measures would be in the regions of USA, EU and China.

Three main steps should be considered when evaluating how a specific region can contribute with climate change mitigation efforts:

1. Identify the anchorage of regional climate policies

- From which policy level do the (climate) policy initiatives in the region stem?
- The policy anchorage might indicate political will and priority.



Cumulative investments by 2050 in exchange corridors between countries in the Gobal 20-20-20 scenario.

The 5 years of LinkS have given the opportunity to link several world-class research teams:

- Joint Global Change Research Institute (JGCRI), Maryland, USA
- Dept of Civil and Environmental Engineering, University of Maryland, USA
- Center for Integrative Environmental Research (CIER), University of Maryland, USA
- Energy, Environment and Economy Institute (3E), Tsinghua University, China
- Dept. of Industrial Economics and Technology Management, NTNU, Norway
- Dept. of Electrical Power Engineering, NTNU, Norway
- Market-Grid Analysis group, SINTEF Energy Research, Norway
- Policy and Governance group, SINTEF Energy Research, Norway

Models:

GCAM – Global Change Assessment Model, a community model of the global economic, energy, agricultural, land use and technology systems owned by Joint Global Change Research Institute/Pacific Northwest National Laboratory.
http://wiki.umd.edu/gcam

EMPS – EFI's Multi-area Power market Simulator, a commercial model for large-scale hydro-thermal power system scheduling owned by SINTEF Energi AS
www.sintef.no/EMPS

EMPIRE – European Model for Power system Investments with Renewable Energy, a new multi-stage investment model for the European power system under development at NTNU.

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2. Linkage and co-benefits of climate policies

- Are climate policy initiatives linked to other relevant policy fields? Are there any potential co-benefits?
- Systematic analysis and overview over a region's climate-specific and climate-relevant policies may produce new suggestions of acceptable climate-***relevant*** policies if climate-***specific*** policies are controversial.

3. Interdependencies

- Identify economic and political interaction and mutual dependencies as a path for common solutions both within and between regions.

The benefits of LinkS in a broader context

One of the most interesting results from the LinkS project is related to the design and implications of the Global 20-20-20 scenario. Although we have assumed that all world regions copy the EU 20-20-20 policies at different points in time in our scenario, each region can in principle design and introduce their own policies independently of each other. Provided these regional policies are sufficiently strong and correctly timed, a set of independent regional policies seems to give almost as large emissions reductions as a global carbon market but at a somewhat higher socio-economic cost. This may therefore be a feasible approach in the absence of a single global agreement and should be considered for future global climate negotiations.

In the case of Europe, SINTEF's EMPS model has been expanded by a new investment module and detailed datasets have been established ut to 2060. In addition, a new model EMPIRE has been developed for long-term development strategies for the power system. There are still possibilities for improving the handling of variable renewable sources in the model, but it will be an important contribution to future European power system studies and further R&D projects for infrastructure development tools.

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