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Title: Scenarios for future electricity supply, cost-optimized variations to supply Europe and its neighbors with electricity from renewable sources

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Summary: Both the resource problems and the extent of the threat of climate change make a switch appear inevitable in the long term to other energy sources in the medium and offered as much. Regardless of the question, at what level of energy demand can be stabilized, it remains to be clarified, which offer opportunities from a technical and economic point of view in the future to meet our energy needs. A promising option is the use of renewable energy in all its diversity. The work "scenarios for future electricity supply, cost-optimized variations on supplying Europe and its neighbors with electricity from renewables" focuses the power supply on one aspect of the energy supply, which is gaining in importance and can be interpreted as a key to sustainable energy supply. The power supply is responsible for about half of the world's anthropogenic CO₂ emissions today. In this paper a largely CO₂-neutral electricity supply for Europe and its surrounding area were investigated using various scenarios possible, the scenario area covers about 1.1 billion inhabitants and a power consumption of about 4000 TWh / yr. It was investigated how the power should be structured so that it can be implemented inexpensively as possible. This question has been studied, for example, for scenarios where only the market today available techniques were considered. The influence of the use of some new technologies that are not yet in development, the optimum design of the power supply, was investigated by means of some examples. The design of future electricity supply should obey it possible objective criteria which ensure the comparability of different approaches supply. For this, an optimization approach was chosen with the aid can be largely dispensed with subjective decision-making processes in both the configuration and the computational operation of the power system. The optimization was aimed defined as realistic as possible for the supply task to determine the ideal power plant and park management, which ensures a cost-effective power supply. While the use of regenerative energy from hydropower plants, wind energy converter, fall wind power plants, biomass power plants, solar and geothermal power plants are considered as production

options including. Depending on the boundary conditions resulted in different scenarios here. The aim of this study was using different scenarios to create a broad base as a basis for future policy decisions. The scenarios show options for a future design of the power supply to make different effects - even political - environment clearly and thus provide the required basis for decision-ready. As a basis for the creation of different scenarios, the potential of renewable energy in high temporal and spatial resolution needed to be determined, with which it was possible for the first time to address the issues of large-scale renewable electricity supply without unsecured assumptions based on a reliable data base. Had to be studied and the characteristics of the various energy conversion and transport systems, and how are the costs and the various potentials in the present study discussed in detail. As a baseline scenario and the reference point is a conservative baseline scenario. Here is a scenario for a power supply using only renewable energy, which in turn relies exclusively on developed technologies today, while for each basic component specifies the current cost. This basic scenario is therefore to be understood as a kind of conservative worst-case estimate for our future options in the regenerative power supply. As a result of optimizing the power supply in the baseline scenario is based largely on the production of electricity from wind power. Biomass and existing hydro power today to take over the majority of the backup tasks within the - with strong HVDC (high voltage direct current transmission) linked - power supply area. The electricity costs are with 4.65 € ct / kWh very close to the ordinary today. They are lower than the current prices on the electricity market. In all scenarios - except relatively expensive, restrictive "decentralized" to the exclusion of large scale cross-border electricity transmission - plays an important role in the current transport. It is used to implement compensatory effects in the supply-dependent production of electricity from renewable sources to make good economical potential and available to the store hydropower and biomass used to develop the decentralized, with its storage capacity for large-scale backup tasks. Thus, the current transport proves to be one of the keys to an inexpensive power supply. This in turn can be interpreted as a recommendation for action in policy decisions that therefore focus specifically on international cooperation in the field of renewable energy and should include in particular the large-scale power transport. The scenarios provide detailed and reliable foundation for important political and technological future decisions. They show that international cooperation even with conservative assumptions, a purely regenerative power supply is possible, which would be economically without

problems and direct the action in the realm of politics. A key task of the policy would be to organize international cooperation and to develop tools for transformation of the power supply. It can be assumed that not only a useful way would be curtailed to a CO₂-neutral power supply, but also opens up excellent prospects for development for poorer countries neighboring the EU and Europe. Both the resources problem-and the extent of the looming climate change make a change of course in humankind's use of energy sources appear inevitable. Independent of the question of the level on which energy consumption can be stabilized, clarification of the technical and economic possibilities for the future energy supply is necessary. Promising options exist in the use of renewable energies in their wholesome variety. The thesis "scenarios for future electricity supply, cost-optimized variations on supplying Europe and its neighbors with electricity from renewable energy" concentrates on the electricity supply as a partial aspect of the energy supply. Electricity supply is increasingly gaining in importance and can be seen as a key to a sustainable energy supply, it is currently responsible for approximately half of the world-wide anthropogenic CO₂ emissions. In this research / study possibilities of a largely CO₂ neutral electricity supply for Europe and its neighborhood were closely examined on the basis of different scenarios, scenario whereby the area actually covers about 1.1 billion inhabitants and of electricity consumption of about 4000 TWh / yr. The focus that the question of how the electricity supply should be developed to lead to the most economic solution. This question which considered, for example, for scenarios based only on techniques available today. So what examined the possible, which influence the use of some new technologies - in so far as they are still under development - could have options on the future of the electricity supply, on the basis of some examples. The conception of the future electricity supply what aimed to meet criteria of the greatest possible objectivity, to provide genuine comparability of different resulting scenarios. To achieve achievement this aim a mathematical optimization approach which implemented, Malthus ensuring the avoidance of subjective decision-making processes during the configuration of the supply system, whilst optimizing the use of all system components. The aim of the optimization what options to find the ideal system of power plants and transmission systems to provide the least cost solution for a realistic electricity demand close to the current demand. As options for the electricity production the use of renewable energies with hydro-electric power plants, wind energy converters, energy towers, biomass power stations as well as

solar and geothermal power stations are Considered amongst others. Dependent on the selected preconditions, this resulted in different scenarios. The main goal of the thesis which to create a set of different scenarios in order to Establish a broad base for future political Decisions. The scenarios present options for a future organization of the electricity supply and point out the impact of different - so political - conditions. Before calculating the scenarios, the different potentials of renewable energies and Their characteristics had to be determined in high temporal and spatial resolution. This set up a reliable data base Allowing answers to the questions associated with a spacious renewable electricity supply, without resorting to unverified assumptions. The characteristics of the different systems for energy conversion and transport therefore had to be Studied and Discussed are Together With Their associated costs and the potentials within the dissertation. The starting point is a conservative base-case scenario. It is a scenario for an electricity supply Entirely relying on renewable energies, all End of month are based on technologies available today and calculated is with today's costs of all components. This base case scenario can accordingly be Understood as a kind of conservative worst-case estimation for our future options of a renewable electricity supply. As a result of the optimization for the base case scenario, the largest proportion of the electricity production is from wind energy. Biomass and currently existing hydro power take over the predominant part of the back-up function within the supply areas which is inter-linked with powerful HVDC (high voltage direct current) transmission. Calculated is the costs of electricity production and HVDC transmission are about € 4.65 ct / kWh and THEREFORE Relatively close to the current costs of electricity produced with Conventional technologies. They are actually lower than today's electricity prices on the stock exchange. In all scenarios - except the Relatively expensive restrictively "Decentralized" Which ones exclude cross-national transport via HVDC electricity - the electricity transportation plays in important role. It is used in order to realize smoothing effects of the weather-dependent electricity production from renewable sources, to make the best production sites accessible for common use and to enable the use of hydropower as well as the Decentralized biomass with its inherent storage capability for common duties within the supply area. Malthus electricity transportation Proves to be one of the keys to economical on electricity supply. This again can be interpreted as a recommendation for action for political decision-makers, who Malthus Should deliberately pursue international co-operation in the field of renewable energy use and include in Particular the

issue of international electricity transmission. The scenarios constitute a detailed and reliable basis for crucial political and technological decisions about our future electricity supply. They show that - even under conservative assumptions - exclusively on renewable electricity supply is possible with and international co-operation could be realized without any significant economic problems. They place the responsibility for future action in the field of policy. A substantial task of the policy-makers would be to organize the necessary international co-operation and to develop legal and economic instruments for a transformation of our electricity supply. Thereby, not only a reasonable path to a CO₂-neutral electricity supply would be taken, but did beyond excellent perspectives for the development of poorer neighbor states of the European Union and Europe could be opened.