9. $UPCO_2$: A PROGRAM TO REDUCE THE GHG EMISSIONS IN THE UNIVERSITY

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UPCO2. Program to reduce GHG emissions in the Technical University of Catalonia (UPC).
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Key words: *GHG emissions, energy efficiency in buildings.*

In the middle of 19^{th} century, an outstanding Argentinean wondered how it was possible for the British men to pay the highest price for taking away the Argentinean wool and at the same time to import the cheapest coats in Argentina. Where was the trick? Now we know it: the British productivity that made this miracle possible was based on a system that released carbon from the lithosphere into the atmosphere. The secret was to externalize some costs for which all of us have to pay now.

The Kyoto Protocol has transformed the greenhouse gas (GHG) emissions in an aim of the economic activity. First of all because the emissions are limited. Then property titles are handed out by giving emission rights to the countries. And finally a market to exchange these emission rights would be created.

The development of any activity requires utilities which are provided by the consumption of different products. And these products are made by processes generating GHG emissions, normally due to the use of energy from fossil fuels. This means that any activity has associated GHG emissions and therefore it will be affected by the Protocol.

The manufacturer of the products and the supplier of the services will need to improve their production processes in terms of GHG emissions, reducing them per every unit of product or service provided. The Kyoto Protocol will force these agents to find new processes considering the new costs of emissions.

Taking this context into account the whole Technical University of Catalonia (UPC) as an institution considers that it should adapt to the Kyoto Protocol new frame. As a result, the $UPCO_2$ program has been created to reduce the GHG emissions associated to the UPC. It has the following objectives:

- to evaluate the emissions associated to the UPC activity
- to design the most efficient strategies to reduce them (kg saved CO_2 / invest €)
- to implement and to evaluate the strategies
- to introduce the emission reduction as a new value into the UPC
- to spread the results and the experience to the society

Basically, the sources of GHG emissions in the UPC are:

- the obligated mobility of its near 40.000 members (students, professors, administrative and service staff)
- the consumption of the necessary resources to carry out the activities of education and research, especially, the necessary energy for the buildings (near a hundred in 400.000 m^2)
- the emissions due to material manufacture of the new constructions and equipment in the UPC

There are several reasons for UPCO_2's first activities to specially focus on the emissions due to building:

- in the UPC Sustainable Plan 2015 arranging the environmental actions in the University, there is a preferential line about building and climate change, - in the field of the emissions arisen by building, the UPC has an own know-how with large possibilities of development, there is the opportunity to get aids to invest in energy efficiency in buildings

UPCO_2 activities related to construction consist of analyzing which are the factors that affect the GHG emissions, which is their importance, which strategies would be possible to apply to reduce them and to reduce their cost. The factors that affect the emissions are:

- energy demand of the building. It includes energy demand for air conditioning, artificial lighting and services.
- emissions efficiency of energy installations: efficiency of the systems and emissions depending on the kind of energy.
- use and management. Differences between occupancy rate designed and real. Management of energy resources by users and staff.

Specific assessment tools have to be developed in each area, and also the relations between them. Tools for the said demand and energy factors are already quite developed, while those for use and management still need to be found. There is no point in considering GHG prediction and evaluation separately, since management determines them. The final result should articulate new global points of view, letting us to understand a building as an efficient product according to GHG emissions needed to obtain building's main utility: habitability.

Gaining experience in definition and use of prediction and measure systems for GHG in buildings and its standardization inside the Kyoto Protocol frame are some of the expected benefits from UPCO_2 actuations in buildings. They could be used as clean development mechanisms (CDM) or any other saving measures considered inside the Protocol.

Design of buildings should be understood from the new GHG emissions efficiency points of view. This knowledge could be therefore applied to other areas outside UPC.

10. DISPATCH MODELING OF A REGIONAL POWER SYSTEM - INTEGRATING INTERMITTENT POWER GENERATION

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Key words: *wind power, power system modeling*

1. Summary

The past decade has seen a significant growth in wind power in Europe, and wind power is by many considered to be a key technology in a sustainable power generation system. However, in order to make possible a large scale integration of wind power, while safeguarding a high security of supply, economically acceptable ways to handle the variations in wind power production need to be identified. This paper presents a model, which has been developed to study the effect of large-scale integration of variable wind power in a power generation system which includes base load plants.

The model optimizes the power production of each power plant in the system so that the electricity demand is met at the lowest systems cost. As more wind power is introduced to a power generation system, periods during which other power plants are uneconomical to run become more frequent. Whether it is economically advantageous to shut down these plants in such a situation, or to keep them running, depends on the length of these periods. The model is designed to evaluate which alternative that is favorable from a systems perspective. Under the assumptions given, the model results suggest that power plants with low start-up costs or high load turn down ratio will maintain their production as the wind power production increases, while units with low load turn down ratio and high start -up costs have to decrease production.

2. Background

Since wind power production is subject to uncontrollable variations, wind power plants must be combined with other plant types to achieve an economically and socially acceptable power generation system. The result of the introduction of wind power in a typical power generation system can be seen as a bridging system, i.e. a system which typically is dominated by thermal units. When constructing the model an effort has thus been made to include the ability/inability of thermal power plants to respond to the wind power variations. The questions in focus have been; How should thermal units be run to balance the wind power variations in the most cost effective way and how will this way of running thermal units influence power system properties such as emissions and marginal costs? The work is a first step in finding a methodology to study integration of variable RES based power generation in the AGS project “Pathways to Sustainable European Energy Systems”.

3. Model

A mixed integer programming approach has been used to model the alternative ways that the power plants can choose to handle variations in wind power production and power demand. The model assigns each thermal power plant with a minimum power production level and a start-up cost. In order to identify occasions of a startup an integer variable is introduced, which indicates whether the plant is running/ready to run or not. As long as the power plant is running/ready to run, the minimum power production level assures that the production does not take values lower than the physical limitations of the plant (i.e. corresponding to the load turn down performance of the plant). The possible increase in power production of a running unit is available to the system as reserve capacity.

The reserve capacity answers to production variations within 15 minutes. The more wind power that is

introduced to a power system the more reserve capacity has to be set aside. In this model the relation between reserve capacity and wind power developed in previous studies have been used, and each time step it is required that a sufficient amount of capacity is set aside to form a reserve. A 15 minute time resolution can thus be avoided. The time resolution of the model is instead set to one hour in order to be able to consider the start-ups of the power plants. Western Denmark has been used as a case study for the work, i.e. the model simulations have been carried out for the power system of this region and with data from 2005.

4. Results

Initially wind power was assumed to be prioritized, as wind power producers in Western Denmark are guaranteed to sell the power they produce. Simulations suggest that in a situation where wind power is sold on the market the wind power plants would still be profitable to run at all times that power production is possible. This is explained by the low running costs of wind power plants compared to fuel consuming plants. In both the prioritized case and the market case it is thus up to the fuel consuming units to compensate for variations, both in wind power production and power demand.

Three scenarios have been applied to the region; one scenario without wind power, one with the present wind power capacity and one with a 50% increase in wind power capacity. Simulations suggest that the number of start-ups of the thermal units will increase with installed wind power capacity. Simulations also indicate that the utilization of units with low start-up costs or low minimum production levels is marginally affected by the wind power production, whereas the utilization of units with high start up costs and high minimum production levels will decrease as the wind power production increases.

In the study, units with high start-up costs and high minimum production levels (low load turn down performance) are large coal fired plants designed for base load production. These units have low running costs, whereas gas fired units have lower start-up costs but higher running costs. In the simulations, as described previously, the units with low start-up costs, and high running costs, were used to the same extent in a system with wind power as in a system without wind power. The marginal cost of electricity therefore did not decrease as the wind power capacity increased, despite the low running costs of wind power.

The model can also be used to visualize to what extent the wind power replaces domestic power production and to which extent it is exported. In the case of Western Denmark the simulations suggest that a 50% increase in wind power capacity would increase the amount of replaced domestic power production per unit of installed wind power (under the assumption that the transmission capacity remains unchanged). This would result in a larger decrease of carbon dioxide emissions per unit of installed wind power than today, despite the increased number of plant start-ups. Western Denmark can thus install wind power to get closer to its Kyoto undertakings also in the future.

5. Conclusions

A dispatch model of a regional power generation system has been developed and applied to Western Denmark. The model results suggest that wind power variations introduce aspects that influence the competitiveness of the thermal units in the power system relative one another. The influence of large scale wind power grid penetration can only be reviled if the power production of the system is optimized on an hour-to-hour basis, taking flexibility aspects, such as start-up costs and minimum power production levels, into consideration. It is therefore suggested that models of this type is utilized when investigating bridging systems including large-scale wind power.