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SUSTAINABLE ENERGY AS EXPORT COMMODITY

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Introduction

Ever increasing energy demand supported mainly by fossil fuels, and the assumed impact of anthropologic CO2 emission on climate change put the environmental friendly energy production in the global focus. Sustainable energy solutions and increased use of renewable energy sources have become the ultimate goal of the world.

The leaders of Europe have decided to support an offensive CO2 emission target and EU-leaders have agreed on reduction of CO2 emission by 20% by year 2020, compared to 1999 emission level. According to the International Energy Agency (IEA) prognoses, electricity demand within EU will increase by about 30% until 2030. Fulfillment of 20% emission reduction in combination with considerable increase in electricity production is a challenging task that will require European mobilization. Besides increased demand for electricity within EU, there will be a considerable reduction in power generation capacity in Europe during coming decades due to phase out of ageing power plants. Therefore, there will be a strong export market for electricity based on renewable energy sources as commodity.

Among renewable energy sources, e. g. solar, wind, wave, biomass, etc., the most substantial and efficient contribution is provided by hydro power and biomass based thermal power plants. Therefore there will be a need to exploit unused resources of hydro and biomass within Europe to reach the ambitious emission goals stated by the Europe's leaders.

Bosnia and Herzegovina (BiH) is one of the European countries that has unexploited hydro and biomass resources. Building new power plants in BiH and modernizing the existing plants would provide a strong base for export of renewable energy to Europe and thereby facilitate economical development of the country for decades.

Building new hydro power plants as well as utilization of biomass for power production has considerable impact on local environment and the life of the people living in affected areas. To be able to combine economical develop-

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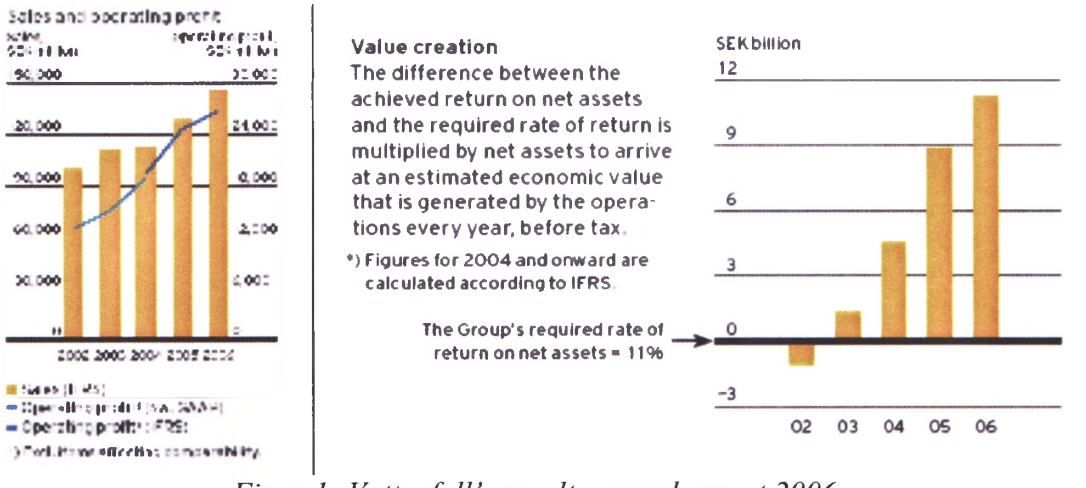
ment and prosperity of the country with high level of public acceptance for the local impact on the environment, one needs to learn from experiences gained so far. The Scandinavian countries, especially Norway and Sweden, have long experience of both building hydro power and utilizing biomass as energy source. This paper provides a historical review of hydro power exploitation in Norway and Sweden, and gives a short review of status of biomass based power generation in Sweden.

Electricity as export commodity

The continuously increasing oil prices, higher extraction cost for unexploited oil reserves, risk for catastrophic climate change caused by anthropogenic CO2 emissions in combination with increasing demand for electricity and energy require new electricity generation capacity based on renewable energy sources and CO2 free technologies.

A high carbon price needs to be introduced, according to international experts, to provide necessary instruments and insurances for energy producers to invest in CO2 capture plants. CO2 capture requires large investments irrespective of the capture technology selected. Besides, the efficiency penalty of about 10%-points imposed by CO2 capture reduces the total amount of power produced by these plants. This will result in higher electricity prices from power plants equipped with CO2 capture. A review of energy companies' revenue during the last five years, e.g. Vattenfall that has a large nuclear power production capacity, shows that there is a huge opportunity for increased revenue for companies who can produce CO2 free electricity in today's market.



Figur 1: Vattenfall's result, annual report 2006.

The need for electricity will increase by about 30% within EU and with about 85% worldwide during the coming decades according to IEA's prognosis See figure 2 (Source VGB 2007).

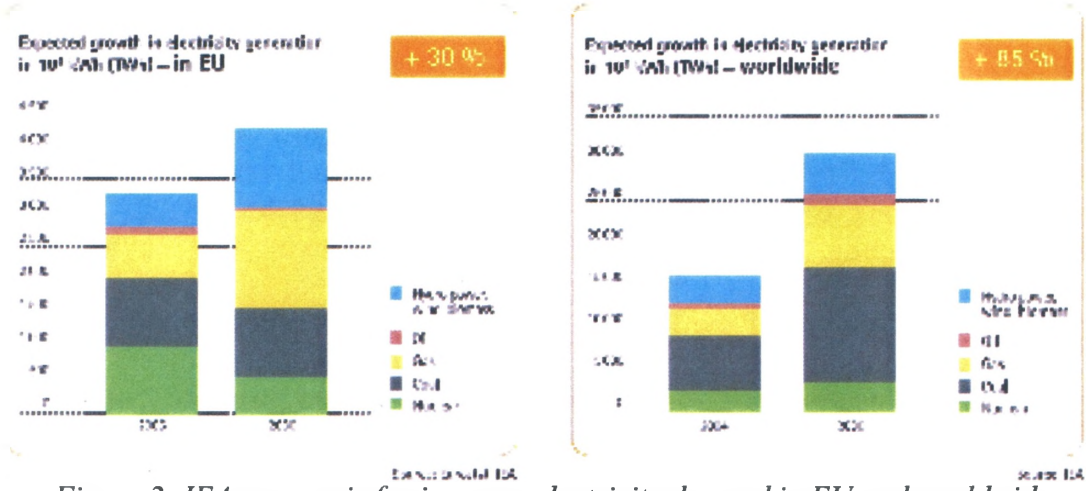


Figure 2: IEA prognosis for increase electricity demand in EU and worldwide

Beside this growth in demand, phasing out aging power plants that need to be replaced with new generation capacity will open a huge export market for countries/companies that can produce and deliver CO2 free electricity. The potential for building up welfare state underpinned with green electricity as export commodity can't be underestimated. (See figure 3, Source: VGB)

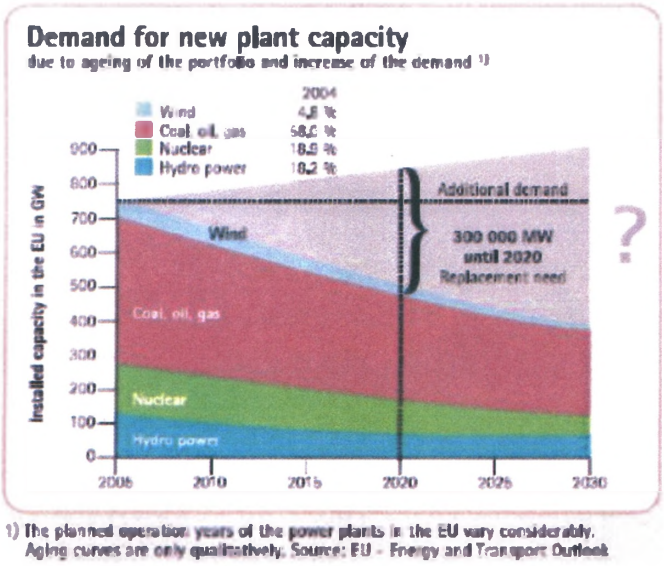


Figure 3: Combination of increased electricity demand and phasing out old plants

The unexploited capacity of hydro power and the grate potential for biomass based electricity production in BiH, combined with a strategic geographical location, in vicinity of large industry nations such as Italy, Germany, Austria, etc., opens an important export market for "green" electricity for BiH.
To be able to utilize these natural resources in a long run, a tremendous upfront investment would be required. Since the country is not in a position to day to make the necessary investments by them selves, there would be a need for collaboration with external investors.
Providing necessary guaranties for social and political stability would be crucial to attract foreign investors. A democratic and transparent process during contracting, planning and construction, as well as provision of necessary information about the benefits for the region and the country would facilitate involvement of the local inhabitants. This approach would result in stability and harmony needed to carry out such a country wide project.
Having the protection of the local environment and the prosperity of all the citizens' of the country as highest priority for the "green electricity" project are most probably the main key factors for a successful implementation.

Bio fuel based electricity production in Sweden

An overview of the energy status

The current energy supply in Sweden is unique in many ways. No coal and very small amount of natural gas is used. The electricity is mainly produced by hydro power (about 50%) and nuclear power (ca. 50%).

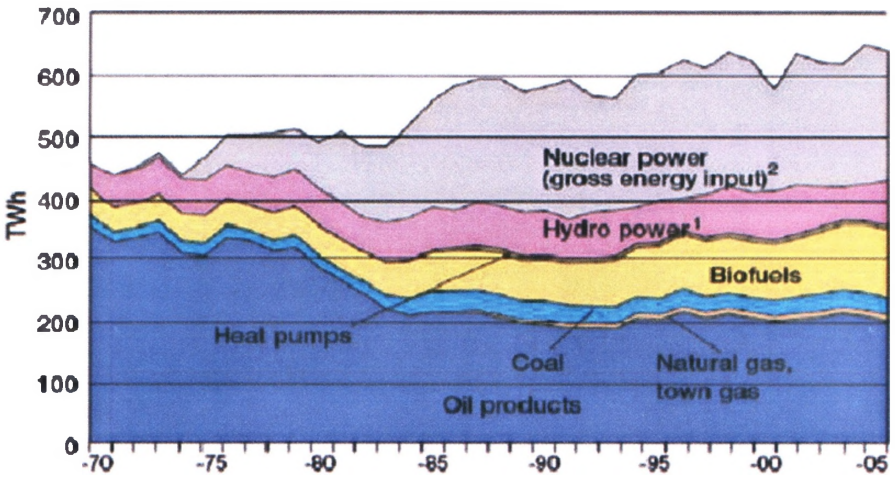


Figure 4: Energy Supply in Sweden 1970-2005

The heat supply in dense populated areas is covered by district heating and private houses use electrical heating, heat pumps and some oil and biomass. Heat and electricity production for the forest industry and pulp and paper industry are produced utilizing bio fueled combined heat and power.

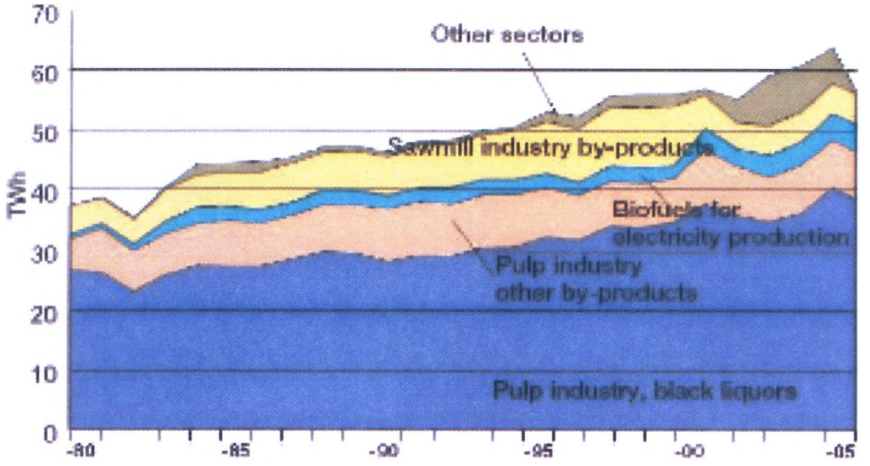


Figure 5: Use of bio-fuels in industry 1980-2005

The energy situation in Sweden before year 2000

During 60th and 70th the nuclear power was built in Sweden. The district heating net was expanded rapidly during 70th and 80th to facilitate replacement of oil by bio fuel.

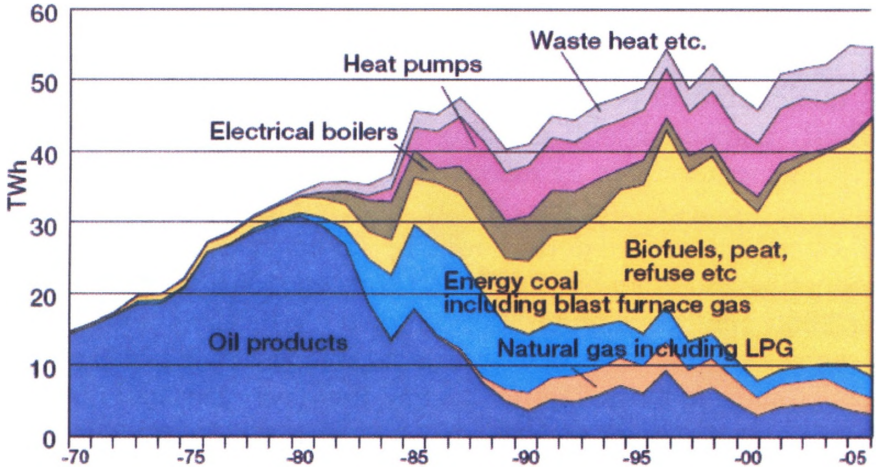


Figure 6: Development of district heating in Sweden

This was followed by construction and use of large scale heat pumps and bio fueled boilers in central heat stations and small scale heat pumps in private

houses aiming at phasing out oil and electrical heating. During 80th and 90th large scale energy efficiency plans were implemented at the end user side. These measures resulted in reduction of fossil fuel use for heat and electricity production in Sweden to just a few percentage of the total energy supply in year 2000. The fossil fuel was then mostly used for transportation.

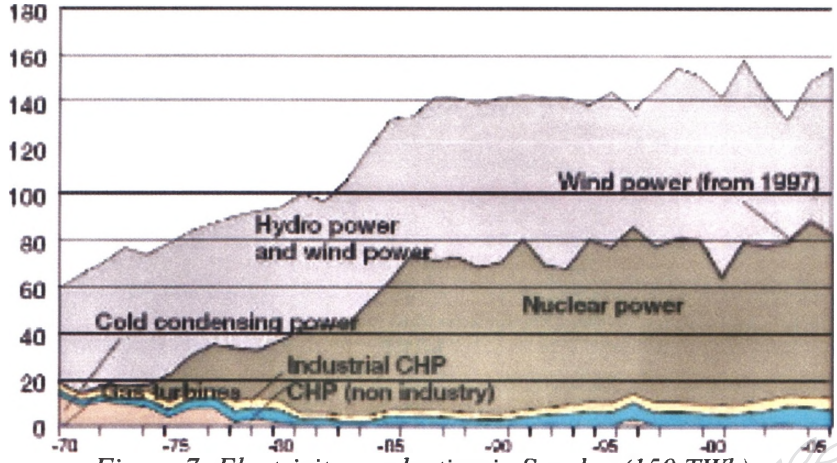


Figure 7: Electricity production in Sweden (150 TWh)

After year 2000- The climate change was the major driving force

In the beginning of year 2000, CO2 emission from heat and electricity production in Sweden was negligible. However, there was a decision in place concerning the nuclear plants' phase out, which stands for about 50% of the Swedish electricity production. The major question was, "how should the phase out of nuclear plants be realized without increase in CO2 emissions?" However, nuclear power phase out is not considered as impending any more.
The electricity demand is still growing in Sweden. Since neither nuclear nor hydro power generation can be extended, because of lack of political support and people's acceptance, and the climate change has become a major concern, increased electricity production should be taken care of by increased wind power production and more bio fuel based combined heat and power (CHP).
After year 2000 until now about 30 bio fueled CHP plants with 20 to 40 MW electrical power output have been build in Sweden. The smallest bio fueled CHP plants connected to the district heating net have electrical output of about 3 MW.
The research and development in Sweden has been directed towards producing as much electricity as possible in CHP plants, utilizing the existing heat demand. There are also plans to replace the natural gas used in gas turbine based CHP plants with biogas. In parallel large investments have been made to

increase the electricity production from wind power, and various types of subsidies have been introduced to support electricity production based on renewable energy sources.
The positive environmental profile of bio fuel as CO2 neutral has being questioned lately as well as use of agricultural land for bio fuel production. The market pries for bio fuel has also increased considerably, due to the demand. Meanwhile the resistance against extension of nuclear and hydro power has weakened.

Two typical examples of bio fueled CHP plants in Sweden Lund

- Fuel: Locally produced biomass (Straw, wood chips, etc.)
- Electrical output: 47 MW
- Heat output: 100 MW
- Investment: 200 Million Euro
- Operational hours: ca 4000 hours/y.

This plant, which is under construction, consists of a circulating fluidized bed (CFB) a grating boiler and a back pressure steam turbine.

Västhamnsverket (Helsingborg)

- Fuel: Biomass and natural gas
- Electrical output: 126,7 MW
- Heat output: 186 MW
- Operational hours: ca. 4000 hours /y

This hybrid plant consists of a bio fueled boiler, a modern gas turbine with heat recovery steam generator (HRSG) and a common steam turbine, where the steam from the boiler and the HRSG is expanded.
There are lot of experience accumulated about building large scale bio fueled power plants connected to the district heating net and industrial CHP both in Sweden and other Scandinavian countries. The technology used is based on boilers and steam turbines, i.e. the Rankine cycle. The boilers are usually constructed as CFB boilers and noticeable progress has been made to increase the turbine inlet temperature up to the level of to 600C, resulting in increased plant electrical efficiency.
Construction and expansion of the district heating net has contributed considerably to increased share of biomass in the energy sector and reduced use of oil.
Large efforts have been made to replace natural gas with biogas in gas turbine based power plants. Thermal gasification, anaerobic biogas production as well as direct biomass firing in gas turbines have been tested and developed. However, non of the methods for replacing natural gas with biomass have

been successful so far besides bio gas from anaerobic gas production in smaller plants.
Electricity production in CHP plants depends on the variation in heat demand and electricity production in wind power plants depends on the weather. However, the large hydro power production in Sweden makes production and control of electricity separated from heat demand and wind/weather possible. Therefore, building CHP and wind power, integrated into the energy production system in Sweden is possible to a large extend.

Historical imprints on the Scandinavian hydropower systems

Controlling water

It is calculated that today 40 000 dams, higher than 15 meters, are raised in rivers all over the world. Approximately five times all the river water in the world (10 000 km^3) are stored in reservoirs. 400 000 km^2 are flooded by dammed water. 80 % of the Northern Hemisphere (USA, Canada, Europe and former Soviet Union) discharge is moderately or heavily regulated. Rivers untouched by man is probably not to be found any more.
The concrete wall is often a modern monument over a state leader or a political system - the Chinese Three Gorges project being one of the latest of its kind. A further example is the well-known Hoover dam in the Colorado River that became a symbol of the American progress. However, big water projects can also turn into symbols of failure. During the growing environmental consciousness in the post-war period, the dam changed from a symbol for progress to a monument of man's control over nature or a symbol of the human degradation of nature.
Control - both technical and formal - of the water system is required for this. Theoretically there is no difference between the build up of a hydropower system or construction of drainage system in a wetland or lowering a lake or maintaining timber floating in a water system or to uphold a net of ditches between fields in an agrarian landscape or perhaps, most apparent, an irrigation system. These are all built up water infrastructures stretching out and binding together the water flow through the landscape to an ever-increasing extent. These infrastructures have an integrated duality. They are both a part of the hydrological cycle at the same time as man controls them. Their complexity consist on one side of a melting together of the non-human and the human in the water infrastructure and on the other side of several demands on the water that have to coexist in the system. As these infrastructures are linked to the water circulation, they depend on and compete with each other. For example there can be different purposes for using water, as between those who want to

dam water - pro-dammers - and those who want to protect their land from flooding - anti-dammers. Mill and sawmill owners, other waterpower users and hydropower developers represent pro-dammers. Their interest is in controlling the flowing water and storing the water to use it when the demand for power increases. A modern anti-dammers interest is the environmentalists who want to stop the harnessing of rivers.
The development of rivers affects the water system ranging over large geographical areas. Changes occur both up and down stream. These encroachments affect the ecological system. Changes in the water system also affect people who live along the watercourses, regardless of the historical context. The structure and scale of the conflict of interests is, however, dependent on the historical situation and the level of technology. By this the hydro-power-based electricity system also plays a part in the general conflict between up- and down-stream interests in the water system, as we have several examples of in the great international river basins of the world.
The modern criticism against hydropower development was from the beginning essentially esthetic. These pioneer critics were an elite of environmentalists, scientists and tourists who wanted to preserve parts of the water circulation in its natural state. After 1970 environmental groups formulated criticism against hydropower development with a distinct ecological platform. One can for example mention that in 1993 the four most important unharnessed rivers in Sweden - the Torne, Kalix, Pite and Vindeln - were declared "National Rivers" by Parliament and were to be free flowing in the future. There are also world wide efforts to reconstruct rivers.
Water related conflicts and systems of norms reflect social relations, rather than, for example, climatic or geographical conditions. These water related conflicts have been governed by normative systems, which developed simultaneously to the build-up of water related infrastructures. They set opportunities and limits for private or public control over the water system.
Water related norms have often occurred in form of special water laws, concerning who owns the water or how one can make alterations in water. The laws have either hindered alteration, frozen water development, or given priority to alterations in watercourses. In Europe most rivers were public. But in Scandinavia, as long as we have had written laws, watercourses have been regarded as private property.

The legacy of the Scandinavian hydro power systems

At the turn of the century Sweden and Norway was heavily dependent on the import of mineral coal. A development of hydropower would give the states a greater independence from this import dependency. Looking from outside one

could at a first glance find these two Scandinavian hydropower-rich countries very alike. However the developments of technical systems are dependent on a social context, its formation is stamped by the historical situation in which the actors find themselves. But the actors can also recreate social conditions in order to better serve their technical ends. The extent to which the actors achieve their goal depends on the society in which the technical system is created. Because of this the stories here told of two neighboring Scandinavian countries are very different.
In the following the Norwegian and Swedish hydropower development is discussed in its earlier days, at the end of the 19th and beginning of the 20th century. The institutions founded during the pioneer years of hydropower development have characterized energy production up till the liberalization of the energy sector in the late 1900s. The comparison starts by discussing some geographical conditions. In the following some institutional terms are discussed, followed by a description of the hydropower policy in Norway and Sweden. Some observation on the organization of the hydropower sectors in Norway and Sweden is also presented.

Geography

Geographical conditions as topographic, and precipitation are of importance for the design of a hydropower based electricity system. Norway could be described as an Eldorado of flowing water. In 1906 a German expert described it like this:
In Norway it is possible to develop hydropower with very small recourses. The country is scarcely inhabited, it is possible to purchase entire catchments, connect them and regulate the water inflow. Norway is shaped for hydropower development. There are large high-lying lakes, which are easy and inexpensive to dam. It is not complicated to gather several catchments districts and with small extra costs form the discharge completely evenly."
Contrary to Sweden the most powerful waterfalls are situated in the south and the harbors of the southern parts of the country are ice-free. The Swedish hydropower treasures was to be found in northern Sweden, were harbors were closed during winter. In comparison Swedish rivers are longer, usually with larger volume of discharge, but with lower height of fall. The technical solution was to gather the height of fall to be able to take out larger effect. An advantage was that the Swedish lakes were placed far upstream in the catchments and could be used as regulation reservoirs for a larger part of the catchments. But the river valleys were more flat than the Norwegian. This meant that a higher water level in reservoirs affected more land - and more people - than in Norway.

Institutional framework and politics

To place the Scandinavian water legislation in a water law context some relevant concepts describing different ways of dividing flowing water have to be introduced: riparianism, and its two differing principles concerning what ways alterations in the watercourses can be carried out: **natural flow rule** and the principle of **reasonable use**. The principle postulates that only the riparian that owns the shore of a lake or a watercourse has the right to use the water contiguous to his shore. All riparians, regardless of the length of, for example, the riverbank, have the same kind of right to the water contiguous to their shore. The riparians do not have to harness their water. The natural flow rule is often replaced with a second variant of riparianism; the principle of reasonable use. This made it possible to alter the flow of water, even if it affected other riparians. The principle was obviously essential for increasing the energy taken from the watercourses. The criteria for reasonable use have changed depending on the historical context. Variables such as benefit for society or the user has often been used as definition of reasonable use. This means that changes in the definition of reasonable use can lead to abrupt changes in watercourses.

As already indicated, the Swedish landscape is characterized by abundant water. Historically one of the main concerns for the Swedish farming population was that the rainwater remained in the fields and drowned the seeds. Therefore, it was important to keep the watercourses open for the direct outlet of water from the cultivated land. The natural flow was important for the anti-dammers. At the end of the nineteenth century, the principle concerning the natural flow rule was established. This was a piece of legislation passed by a parliament in which agrarian interests were heavily represented. A special rights institute - the *kungsådran* ("the kings vein") - defended the principle. In watercourses governed by "the kings vein", a third of the water should always be allowed to flow freely, and it was forbidden to build dams across watercourses. In 1899 Parliament passed an ordinance allowing the building over of "the kings vein" with government permission. Dams were built up in the big rivers. Control of the watercourses had passed over to the dam-owners. But it proved to be impossible to get permission to regulate the rivers. Dissatisfaction of the situation spread among the engineers. They had the knowledge of how to perform efficient harnessing and they assisted to build hydropower plants possessing capacity far over what they could be used for. The director-general of The State Power Board complained that: *"water was allowed to flow identical on Sunday as on weekday"*. It was thus absolutely essential for the hydro-power industry to change the legislation, partly so that they could fully exploit the major investments, and partly for the sake of future

expansion. The motivation was thus not only the need for more power, but also the need to demonstrate the reliability of the new system. The system developers in Sweden had to show that the energy system could grow and satisfy the power demand. The Norwegian water law framework was to be found in the Watercourse law of 1887. It was anchored in riparianism. Riparians were not allowed to harm navigation, log driving or change the water flow - an exponent for the natural flow rule. However, the Watercourse law opened for harnessing waterfalls or regulation of the water flow "in the service of industries". This made the law liberal to expropriation and other types of force when it came to industrial use of waterfalls. The law has been characterized as an expropriation law. As a consequent many riparians accepted selling water falls because of the expropriation threat. The Norwegian canal director wrote about the law: "*To my knowledge, there are no other water law, that to this amount give the control of the development to the private owners own decision without any interference or control by the state*". Parliamentarianism was on the way in Sweden. In 1907 the right to vote for Parliament was extended to all adult men. As a consequence the relative strengths in Parliament shifted. Certainly, the number of speakers for agrarian interests diminished. New political winds, principally represented by the Social Democrats, could increase in strength. The Left forces were not opponents to development of rivers, but they were supporters of stronger state control of hydropower development. In their opinion profits from the expansion of power should benefit all the members of society. It became a political affair and a legal power struggle. The conflict over water regulation at the beginning of the century became the stage where the contemporary oppositions, individual-society, country-city, local-national and agrarian-industrial, were acted out.

The Hydropower developer's aim was to *"work for the rapid and rational utilization of hydro power for the benefit of industry and the country"*. Their first goal was to establish *"a practical water law"*. The hydropower developers directed their campaign for a new water legislation towards depoliticing the limits for enterprise by precluding direct political influence. The decisive instrument was the move to establish special water courts, which would decide about water-related civil engineering projects. The new water courts would not be peopled only by lawyers - technicians would also be decision-makers. With the First World War, a difficult power supply situation arose in Sweden. It became increasingly clear that the country needed to focus on domestic sources of energy. The agrarian interests gave way under this pressure. In 1918, the Water Law was passed, and brought with it the riparianism principle of reasonable use into Swedish law. If the benefit could be shown to be three times greater than the damage, the newly established

water courts allowed water-related civil engineering projects and regulation of the water flow. If these conditions could not be fulfilled, but the enterprise was of considerable benefit to business or community, water-related civil engineering projects could be permitted by the government. Substantial regulation of water had become possible. Now it was the closing off of water, and not keeping it open, that was given priority.

In the middle of early hydropower development Norway became 1905 a fully independent state after the dissolution of the union with Sweden. This became an important driving force behind the build up of a new electricity system. The question of how to manage the hydropower development became dominating in the political discussions of this newborn state.

The background is to be found in the wave of protests against foreign interests in Norwegian industry. One of the problems was the very weak Norwegian credit institution. Foreign citizens controlled 39 % of the capital stock in Norwegian industry. Shortly after 1905 one estimates that foreigners had purchased Norwegian waterfalls representing 500 000 horse powers. This was the double of the effect used by Norwegian industry at that moment. The motives were investments for new industry, but also a speculation for selling the water falls at a better price. There was a widespread comprehension that speculators, especially foreign, cheated Norwegian peasants because they did not know the dormant values of their waterfalls. The 1909 concession laws ruled that it was only the state, municipalities and Norwegians who where allowed to buy waterfalls without a concession. The law also stipulated about fees on production and electricity production for state and municipalities. Furthermore there were social demands on the construction of the powers stations and dams, for example that the working force should be Norwegian citizens. Another principle introduced was The Reversionary Right. This meant that after 80 years the waterfall would be given to the Norwegian state without any compensation. (The reversionary right is at the moment object for discussions with the EU).

1917 the Norwegian Parliament passed the final concession laws. And they were even more radical. From now on only Norwegian companies could be given concessions. The political struggles over the concession laws were the first in the rebirth, free Norway. But how do we interpret them?

Usually they are understood as a reaction of foreigners purchasing Norwegian waterfalls. They have been explained as tools for a national protectionism after the dissolution of the Swedish-Norwegian union in 1905, and thereby as legal defense against foreign influence. But are there more answers to find? They could also be analyzed as a protest to a quick industrialization process and the need for the state to regulate the utilization of natural resources. Norwegian historians have also showed that the investments did not decrease and foreign

interests were given room. Half of the concessions (1906-1910) were given to foreign companies. One can claim this should not be analyzed as a policy of the powerless. The social demands in the concessions on Norwegian labor and sub suppliers, production fees and the reversionary right were signs of an offensive industrial policy. (These concession laws have been formative for the institutional framework of Norwegian oil development).

The Swedish and the Norwegian hydropower systems

The Norwegian hydropower system has been characterized as a decentralized and at the same time a divided system. The Norwegian municipalities and counties produced electricity for domestic needs, as for example lighting and heating. The power demanding industry often owns their own power sources, where they produce their own electricity. The Norwegian state has played an active role in designing this system. Municipalities and counties could buy waterfalls without concessions and from 1911 municipalities had the right to expropriate waterfalls. The state also purchased waterfalls and later sold them to municipalities. Since 1920 nearly every Norwegian power station is built by a county or a municipality. The Swedish power production was very centralized. The state owned Vattenfall produced nearly half of all electricity in Sweden. The combination of a big state power producer and a couple of private power producers has been named "the Swedish system". The state power board was given great freedom of action and its management was put together of industry. Around 1920 both Norway and Sweden had confirmed an institutional framework that would be in function for nearly the rest of the 1900s. There were however great differences: Norway had reversionary right, time limited concessions, social demands on construction works, restrictions for foreign interests, political influence over the conditions when building power stations and rights for municipalities to expropriations of water falls. On the other hand Sweden: there were no fees, no time limits, the allowance was given when one could prove that the value of the power station was three times the damage, and the decisions was to be taken in non-political water courts.

To conclude it is important to point at the difference of level of democratization in Norway and Sweden. In Sweden right to vote for everyone was not yet carried through. In Norway there were full right to vote for men since 1899. A more developed democracy and an active independence policy in different fields can explain the radical hydropower policy in Norway.

Epilogue

During the last years comprehensive changes have occurred in the Norwegian and Swedish hydropower system. Due to liberalization of the electricity market the organizational system have changed. The electricity marked is now characterized by commercialism and internationalization. For example the Swedish state producer Vattenfall has become one of the giants in north European electricity production and by this expanded out of its former national frame. The growth is no longer characterized by harnessing of waterfalls, but by buying greater parts of an expanding European electricity marked. By controlling Swedish hydro- and nuclear power, Lettish hydropower, Lithuanian nuclear power and German and Polish coal generated power production, one has accomplished a heterogeneity that, in perspective of an electricity system logic, can be very rational. Scandinavian electricity marked is by the structural and political changes today commercialized in an open electricity marked. One could call this an institutional revolution of the Scandinavian power systems.