Background Paper

GRÜNE LIGA Netzwerk Ökologischer Bewegungen

Vattenfall's planned CCS demonstration plant is not a sustainable energy solution

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0 Summary

With a CCS demonstration plant at the brown-coal-based Jänschwalde power plant in Brandenburg the energy concern Vattenfall intends to commence in 2015 the large-scale capture of CO_2 and its storage beneath a built-up area. EU funding of 180 million euros is earmarked for this project. Following changes to the technical concept, we have evaluated the documents that Vattenfall submitted to the Brandenburg *Landtag* (parliament) and licensing authorities and come to the following conclusions:

- Vattenfall plans the construction of a new brown-coal-fired power plant at the Jänschwalde site, instead of the previously intended conversion of existing installations to CCS.

- The CO_2 reduction objectives for 2020 of the State of Brandenburg, which could hardly be described as ambitious, can now not be met, as intended, through CCS technology. Vattenfall's proposal to offset this through the co-incineration of biomass and an increase in the efficiency of existing installations is inconsistent and not sustainable.

- A massive, climate-damaging extension of the operating life of the existing power plant units at the Jänschwalde site is planned by Vattenfall and threatens to make attainment of CO_2 reduction objectives for 2030 impossible. For then, the resettlement of villages for new open-cast mining sites would serve, contrary to all political assurances, the further operation of power plants that have an adverse effect on the climate.

- The maintained 35.3% efficiency of the new power plant remains below that of the existing power plant. Vattenfall attempts to conceal the huge loss in efficiency through the absence of data. Around one-third more brown coal could be required for generation of the same amount of electricity with CCS than without CCS.

- Vattenfall's data proves that CCS technology consumes one additional cubic metre of water for every captured tonne of carbon dioxide. The enlargement of the Jänschwalde power plant increases water consumption even more, and this despite the fact that water in the catchment area of the River Spree is a valuable and scarce resource.

- It is intended that the question of the safety of carbon dioxide capture and permanent storage be excluded from approval procedures for the new power plant.

- With the planned mere 95% purity of the CO_2 to be stored, Vattenfall will lag from the very beginning behind possible technical possibilities, and this solely on economic grounds

The above aspects are explained in more detail below.

1 Approval procedure

A procedure for approval of substantial modifications at the Jänschwalde power plant is commenced pursuant to Article 16 of the Federal Immission Control Act. Responsibility lies with the State Office for the Environment, Health and Consumer Protection (LUGV). The transport and permanent storage of CO_2 should be approved separately in accordance with a so-called "Carbon Dioxide Storage Act" (or "CCS Act"), which has not yet been enacted, and will probably fall under the responsibility of the *Landesamtes für Bergbau, Geologie und Rohstoffe* (*LBGR*).

In December 2009, Vattenfall submitted initial documents on construction of the new power plant to the state authorities. An initial discussion on the framework of environmental examination (scoping meeting) took place on 25 February 2010. On 1 June 2010, however, Vattenfall had announced changes in the technical concept. Specific information was only made available in documents – so-called scoping documents – from 17 September 2010, which were submitted for the purpose of preparation of a further scoping meeting at the State Office for the Environment, Health and Consumer protection (LUGV).[1] In addition, Vattenfall informed the Economics Committee of the Brandenburg *Landtag* on 25 August 2010 about the new plant concept, as well as about how, from Vattenfall's point of view, the CO_2 reduction objectives of the State of Brandenburg should be achieved.[2]

2 Brief description of the project

Unit F, with a capacity of 500 megawatts (MW), is one of six units at the Jänschwalde power plant (3,000 MW). It comprises the steam generators (boilers) F1 and F2, which together drive a turbine set and a generator. Vattenfall wants to convert Unit F in such a way that after combustion CO_2 can be washed out of the waste gas stream ("post-combustion process"). Next to it, a new Unit G should be built, which combusts brown coal with pure oxygen instead of air, in order to obtain highly concentrated CO_2 (oxyfuel process). Here, pre-drying of brown coal should be carried out, which taken by itself would increase efficiency. The captured CO_2 from both units should be compressed and prepared for transport into areas designated for CO_2 injection. In the original concept, post-combustion should be installed for one-quarter of flue gas from Unit F, and boiler F2 replaced by a new oxyfuel boiler F3. Here is a comparison in diagrammatic form:

		Units A-E **Conventional operation**	**Unit F** **Conventional operation**	**Unit F- CCS** **Refit post-combustion**	**CCS** **New oxyfuel boiler**
Existing installations	electrical output (gross)	2500 MW	500 MW	0	0
	CO_2 emissions per year	20 mill. t	4 mill. t	0	0
	net electrical efficiency	~ 35.6 %	~ 35.6 %	0	0
Old Concept Dec. 2009	electrical output (gross)	2500 MW	125 MW	125 MW	290 MW
	CO_2 emissions per year	20 Mio. t	1 mill. t	1 mill. t	1-2 mill. t
	net electrical efficiency	~ 35.6 %	28.9 % (with ~ 70 % capture)		
New concept Sept. 2010	electrical output (gross)	2500 MW	450 MW	50 MW	250 MW
	CO_2 emissions per year	20 Mio. t	3.6 mill. t	0.4 mill.. t	1.3 mill. t
	net electrical efficiency	~ 35.6 %	(reportedly) 36.4 % (with ~ 10 % capture[3])		~ 35.3 % (with ~ 90%)

[1] Vattenfall: Untersuchung der voraussichtlichen umweltrelevanten Auswirkungen und Vorschlag zum Untersuchungsrahmen zur Vorbereitung der Umweltverträglichkeitsuntersuchung für die Errichtung und den Betrieb des CCS-Demonstrationsprojekts Jänschwalde am Standort Kraftwerk Jänschwalde vom 17.09.2010, im Folgenden: Scopingunterlage

[2] Das Demonstrationsprojekt im Land Brandenburg – Klimaschutz durch Innovation. Präsentation von Hubertus Altmann, Vattenfall Europe Mining & Generation vor dem Wirtschaftsausschuß des Landtages Brandenburg am 25.08.2010, im Folgenden: Präsentation im Wirtschaftsausschuß

[3] 20 % of the waste gas stream of one of the steam generators is equivalent to 10 % of the unit.

Theoretically, with very high capacity utilization, up to 4.5 million tonnes of CO_2 could be emitted per unit. In the table, however, a currently realistic order of magnitude is shown, which, moreover, in all three variants is easily comparable. Efficiency in the case of CCS is only meaningful in combination with the achieved rate of capture.

3 New construction instead of conversion: no climate protection until 2020

The table clearly shows that coal consumption and CO_2 emissions increase compared to the former technical concept. With the same number of full-load hours less CO_2 will be stored underground (1.7 up to 3 mill. t), but at the same time more CO_2 will be emitted into the atmosphere (23-24 mill. t instead of 21 mill. t). The main reason for this is that the conventional climate-damaging boiler F2 will now not be decommissioned but rather continue in operation.

This is in contravention of the Energy Strategy 2020 of the State of Brandenburg. This strategy, which was adopted by the Brandenburg Government in 2008, lays down, despite a commitment to brown coal as an energy source, the target of "reducing CO_2 emissions in the State up to the year 2020 by 40 per cent compared to the level for the year 1990. By the year 2030 they should be reduced by a further 35 per cent compared to 1990."[4] This implies:

CO_2 emissions 1990	91.0 mill. t
CO_2 emissions 2006	59.5 mill. t
Target 2020	54.6 mill. t
Target 2030	22.8 mill. t[5]

In the power plant area, the reduction target for 2020 should be achieved through the CCS demonstration plant: "Through the construction and operation of the first CCS demonstration plant in the State of Brandenburg at the energy centre in Jänschwalde CO_2 emissions from the generation of electricity from brown coal can be reduced from the year 2015 by approximately 2 million tonnes per year."[6] The State Government made explicitly clear in its answer to a parliamentary question that "further operation of the so-called boiler "F2" at the Jänschwalde power plant additional to the planned CCS demonstration plant would contravene the CO_2 reduction targets in the Energy Strategy 2020."[7] And that is exactly what Vattenfall now intends to do!

Before the Economics Committee of the Brandenburg Landtag Vattenfall maintained that, despite enlargement of the power plant, "demand for fuel will not increase. The concept has no effect on brown-coal mining sites that have already been approved, or are the subject of approval proceedings".[8]

It should be noted that:

- In the approval proceedings Vattenfall makes completely different statements: "The delivery of raw brown coal takes place by rail. The additional demand for coal for Unit G, amounting to about 4,700 t/d, requires about 6 additional trains per day."[9] The increasing consumption of cooling water (see below) also points to greater fuel input. That is why Vattenfall wants to avoid a binding commitment on lower emissions from the existing units.
- It is technically possible to decommission a steam generator without affecting the demonstration project. Backing away from the promised decommission has nothing to do with the CCS concept, but is rather the attempt on Vattenfall's part to increase existing power plant output and maximize profits.

[4] Bericht der Landesregierung „Energiestrategie 2020 des Landes Brandenburg“, Landtagsdrucksache 4/6292, ausgegeben am 21.05.2008, im Folgenden: „Energiestrategie 2020“, p.32
[5] Energiestrategie 2020, p.38
[6] Energiestrategie 2020, p.40
[7] Antwort der brandenburgischen Landesregierung auf die Kleine Anfrage Nr. 239 der Abgeordneten Carolin Steinmetzer-Mann (DIE LINKE) Landtagsdrucksache 5/614, ausgeben am 19.04.2010
[8] Vattenfall-Präsentation im Wirtschaftsausschuß, p.14
[9] Scoping documents p.11

- It is not intended that the new Unit G be permanently operated with CO_2 capture. In two of every three defined operating modes the climate gas is further emitted into the atmosphere.[10] Whether operation with carbon capture will really become part of normal operations, or whether a new conventional power plant will emerge, is nowhere regulated in a legally binding manner. Vattenfall keeps all loopholes open, in order to be able at any time to return to climate-killing operations.

4 Emission reductions in another way – Vattenfall's deceptive package

In view of the fact that the new power plant on the basis of CCS can contribute nothing towards achievement of Brandenburg's CO_2 reduction objectives, Vattenfall now claims that it wants to achieve this objective in other ways. According to its presentation to the Economics Committee of the *Landtag* on 25 August 2010, a reduction of 2 million tonnes of CO_2 by the year 2020 should be achieved in the following ways:[11]

- A saving of 200,000 tonnes per year through the post-combustion plant at Unit F.
- A saving of 500,000 tonnes per year through the "co-incineration of biogenic solid fuels in power plants". In reply to a question, it was stated that wood chips would be involved, which Vattenfall would purchase worldwide.
- A saving of 900,000 tonnes per year through "an increase in the efficiency and portfolio optimization" of existing power plants.
- A saving of 400,000 tonnes per year through "optimized operation of the Jänschwalde power plant".

Here, it must be said:

- The co-incineration of biomass at the sites of brown-coal-fired power plants in the Lausitz Region is not a sustainable option for climate protection. With worldwide purchase, sustainability standards will probably not be complied with, or alternatively, other biomass users will be forced to adopt non-sustainable operations. In the case of incineration in existing Vattenfall power plants, with their efficiency of between 30 and 40 per cent, the loss of two-thirds of the energy of valuable biomass threatens. Energetic biomass use is best located in the proximity of heat users! This is not possible with the brown-coal-fired power plants in the Lausitz, whose in part extremely low proportion of decoupled heat can also be secured by reducing brown coal input without co-incineration of biomass. The Vattenfall concept would result in biomass being imported into the Lausitz from abroad, the electricity from its co-incineration then being largely exported from Brandenburg, and the resulting heat finally being completely emitted into the atmosphere.
- Should technical increases in efficiency actually be achievable by the year 2020, this potential should have been taken into consideration in the 2008 Energy Strategy and CO_2 reduction objectives of the State of Brandenburg. In this respect, Vattenfall has up to now deliberately mislead state policy-makers concerning technical possibilities.
- Moreover, increases in efficiency as such do not guarantee a reduction in brown coal input and CO_2 production, since they could also be used for additional production of electricity from the same quantity of brown coal. This is generally the case when measures are undertaken at turbines in order to achieve more effective utilization of a constant quantity of steam.
- Should consumption and emissions in fact not increase compared to previous operations, this will be due to lower capacity utilization as a result of the feeding-in of wind power and emissions trading, which have their effect independent of the demonstration plant. These effects will presumably occur before the CCS demonstration plant comes into operation.

[10] Betriebszustände 1 bis 3 siehe Scopingunterlage, Anlage 2 (Anlagen- und Verfahrensbeschreibung), p.13

[11] Vattenfall-Präsentation im Wirtschaftsausschuß, p.15

- Further capital expenditure in existing units is obviously intended to justify at a later date a massive extension of the operating life of Germany's most climate-damaging power plant units.

5 Extension of operating life – no climate protection by 2030?

Demonstration plant Unit G is presented by Vattenfall as a necessary step towards development of commercial oxyfuel units, which should emerge after 2020. But when this testing and demonstration function is fulfilled, it is intended to keep the installation, with its electrical efficiency of about 35%, in operation for a further 15 years.
"At least 20 years" operating life (that is, from 2015 until at least 2035) are also claimed for Unit F,[12] although 90% of its operation would be conventional and harmful to the climate.
As far as concerns the other five existing units A – E, it has been stated that "in about 20 years, from the present perspective, the useful life of the approved Jänschwalde power plant will end".[13] This means that Vattenfall plans further operation of the climate-damaging units until the year 2030.

Here, it has to be said:

- Due to the fact that power plant efficiency will no longer correspond with the latest developments in technology, long-term plant operation, which would no longer be necessary for the purpose of demonstration and development, represents a massive waste of the raw material brown coal. This is consistent neither with the objective of environmentally compatible energy supply nor with the efficient use of resources.
- Further operation of existing units until 2030 also wholly calls into question the climate objectives for 2030 of the State of Brandenburg. Instead, as previously often maintained, of replacing these units with climate-friendly units around 2020, inefficient 500 MW units would continue in operation until 2030 or later.
- Then, contrary to all political assurances, new brown-coal mining sites would serve the further operation of power plants that are extremely damaging to the climate. This involves in Brandenburg the compulsory resettlement of around 2.150 people (900 for the Jänschwalde-North mining site and about 1.250 for the second phase of the Welzow-South mining site). In the Nochten mining site in the State of Saxony, which is connected by a Vattenfall-owned railway link to the Brandenburg power plants, the resettlement of a further 1.500 people threatens. Vattenfall plans to commence brown coal mining between 2020 and 2025 at all three of the above-mentioned sites.

6 Efficiency: every fourth mining site just for carbon capture?

In the scoping documents, Vattenfall mentions a net efficiency rate of 36.4% for Unit F, and 35.3% for the new oxyfuel Unit G.

Here, it has to be said:
- With the claim made before the Economics Committee of 36% efficiency for the CCS plant as a whole, Vattenfall would have policy-makers believe in a better status of oxyfuel technology than is in fact achieved. With 35.3%, Unit G lies not higher but actually lower than the efficiency of the existing power plant.
- The difference between gross nominal capacity (250 MW el) and net nominal capacity (167 MW el) is immense, and represents on-site consumption by Unit G of 33% of the generated electricity. This is made up of "conventional" on-site demand and the additional demand resulting from CCS. Vattenfall neither states the level of this additional consumption through CCS nor provides data that would enable a well-founded calculation. The fact is that the oral statement made before the Economics Committee, to the effect that the unit "would be 43% without CCS" (net efficiency at the level of the

[12] Scopingunterlage S.5
[13] Scopingunterlage S.20

power plant currently being built in Boxberg) is technically incomprehensible. It would then be unclear, for what purpose the oxyfuel unit is equipped with pre-drying of brown coal, which should noticeably increase efficiency, but is not yet deployed in Boxberg Unit R. In reality, the loss in efficiency resulting from CCS could be markedly higher than the 8 percentage points claimed in oral statements. Assuming a relatively plausible on-site power demand of 5% of gross output,[14] the loss in efficiency through CCS would amount to 14.8 per cent, and one-quarter (about 28%) of the brown coal would only be combusted to be able to capture CO_2. With this state of technical developments, every fourth brown-coal mining site would be developed solely for the on-site power requirements of CCS. In other words: For the same quantity of electricity one-third more brown coal (about 34%) will be required than without CCS. The energy requirement for CO_2 transport and injection into the storage site is here not even considered.

- The net efficiency of 35.3% raises doubts as to whether in later commercial plants the 40% or even the 42% claimed by Vattenfall can be achieved. The pre-drying of brown coal is already being employed, and further increases in efficiency are only conceivable through a marked increase in steam temperatures and pressures. Already with the construction of the new power plant Unit R in Boxberg, with just a slight increase in steam parameters with conventional technology, problems have been reported with the boiler pressure test.[15]
- Whether the claimed efficiency in the demonstration plant will actually be achieved, should, in the case of construction, be the subject of independent examination.
- The figure of 36.4 % efficiency for Unit F is above all previously published figures for the existing power plant, which lie between 35.0 and 36.0 %.[16] At the same time, it will be still further reduced through on-site consumption at the post-combustion plant. The massive refitting measures that would be required to reach 36.4% efficiency are, however, mentioned nowhere in the description of the plant or procedures.
- The efficiency of a plant that has been completely converted to post-combustion is not discernible. For in Unit F around 90% of the resulting waste gas will be further emitted untreated into the atmosphere through the cooling tower. Were separation to be applied to the entire waste gas stream, the energy input would noticeably reduce efficiency.
- The energy input for transport and injection into the storage site is reflected in none of the stated figures. Transport and injection are, however, also elementary features of CCS technology.
- It has basically to be borne in mind that the discussed figures for electrical net efficiency always define ideal operation of the plant in question. Particularly under part-load conditions, as will probably prevail for power plants in the coming decades, the efficiency actually achieved in practice could lie several percentage points lower. Vattenfall has presently published a part-load curve neither for the current status of existing plants nor for the planned new plant.

The apparent improvement in efficiency from 28 to about 36 per cent through the new concept[17] is based for the most part merely on statistical effects:

- The oxyfuel boiler will be provided with its own generator. For this reason, efficiency must no longer be averaged for post-combustion and conventional operation (cf. Table).
- Retrofitting with post-combustion (highest energy consumption) was massively reduced from 25% to 10% of the unit's waste gas stream; conventional, climate-damaging operation in Unit F dominates by far.
- In addition, technical complications in integration of the oxyfuel installation are no longer an issue; only here will actually improved technical properties be achieved. The above-mentioned purely statistical effects will, however, have a significant influence on efficiency.

[14] In the Boxberg Unit R 34.8 MW from 670 MW is equivalent to about 5.2 % on-site consumption. Cf. Breuer, Heinrich: Contribution to the "Brown Coal Conference" on 13 May 2005 in Dresden, foil 14.
[15] Vattenfall-Mitarbeiterzeitschrift terravatt, Februar 2010, p.9
[16] Vattenfall-Informationsblatt „Aus Braunkohle wird Energie“. Sourced on 11.10.2010 at http://www.vattenfall.de/standortkarte/kraftwerke/pdf/fb_tgb_conojaewa_kw_jaewa.pdf
[17] Vattenfall-Präsentation im Wirtschaftsausschuß, p.12

Vattenfall presents its case to decision-makers with false figures, talking them into believing in great technological progress. In its presentation to the Economics Committee of the *Landtag* efficiency and specific residual emissions in the old concept are assigned only to the oxyfuel plant, although they represent average values of different technologies.[18]

7 Increasing water consumption: Vattenfall is pumping the Lausitz dry

The extension of the power plant with a CCS plant gives rise to an additional consumption of raw water in the Jänschwalde power plant of 6.9 million cubic metres per year. "The quantity of service water therefore increases from 63 mill. m³/a to a maximum of 70 mill."[19] The largest proportion of the additional water (about 4 mill. m³/a[20]) is discharged via the cooling towers into the atmosphere and therefore lost to groundwater and surface waters in the Lausitz. This quantity is equivalent to the average water consumption of around 86,000 persons in Germany.[21] In view of the declining low water level in the River Spree, the very opposite would be required, namely a reduction in cooling-tower losses in power plants in the Lausitz.

CCS also consumes more water per installed capacity: While 3000 MW have up to now required 63 mill. m³ of water and the installation of 250 MW CCS requires a further 6.9 mill. m³, consumption increases from 21,000 cubic metres per year and megawatt with CCS to 27,600 m³/a*MW. There is an additional consumption of 1.65 mill. m³ of water for the capture of 1.73 tonnes of CO_2. CCS technology thus additionally costs around one cubic metre of water for every captured tonne of carbon dioxide! From the water management point of view this is irresponsible with regard to the demonstration installation, but all the more irresponsible with respect to the complete reconstruction of the Jänschwalde power plant on the basis of CCS, which is advocated by Vattenfall.

8 According to Vattenfall, safety of transport and permanent storage should be excluded!

223 tonnes of CO_2[22] should be pumped per hour from the CCS plant via pipelines to the planned underground storage site; a total of 1.7 million tonnes per year is assumed.[23] Vattenfall plans to completely disregard this, however, in its environmental impact assessment, and simply create a fait accompli with the power plant construction site. We are of the opinion, however, that a plant for production of liquefied carbon dioxide can only be approved when environmentally sound storage of CO_2 is proven and public interest in the long-term security of the storage site is satisfied. It is not intended to evaluate present CO_2 injection tests at Ketzin before 2020, yet Vattenfall plans to start transporting gas from Jänschwalde through the pipeline already in 2015. Moreover, problems in CO_2 liquefaction will not be examined in detail, although a concentrated discharge of the gas at the northerly end of the power plant site would directly affect a busy public road.

9 Contamination of the CO_2 stream

Whereas with the post-combustion retrofit 99.5% purity of captured CO_2 is intended[24], Vattenfall plans to configure the oxyfuel unit with 95% purity[25]. Since by far the greater proportion of CO_2 would accumulate in the oxyfuel unit, injection of CO_2 with 95% purity would occur. It is therefore Vattenfall policy to lag behind the CO_2 purity that is technically possible solely on economic grounds.

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[18] Vattenfall-Präsentation im Wirtschaftsausschuß, S.12
[19] Scopingunterlage, S.70
[20] Scopingunterlage, S.70
[21] 127 litres per day and person have been assumed
[22] Scopingunterlage, Anlage 2 (Anlagen- und Verfahrensbeschreibung), S.17
[23] Vattenfall-Präsentation im Wirtschaftsausschuß, S.12
[24] Scopingunterlage, Anlage 2 (Anlagen- und Verfahrensbeschreibung), S.11
[25] Scopingunterlage, Anlage 2 (Anlagen- und Verfahrensbeschreibung), S.17

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