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BEFORE THE STATE OF WASHINGTON

ENERGY FACILITY SITE EVALUATION COUNCIL

In the Matter of Application No. 2006-01	)	
ENERGY NORTHWEST	)	DECLARATION OF GEORGE PERIDAS, Ph. D. IN SUPPORT OF NORTHWEST ENERGY COALITION'S OPENING BRIEF ON ENERGY NORTHWEST'S GREENHOUSE GAS REDUCTION PLAN
PACIFIC MOUNTAIN ENERGY CENTER POWER PROJECT	)	

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I, George Peridas, under penalty of perjury under the laws of the State of Washington, declare that the following is true and correct to the best of my knowledge:

1. I hold a Masters and a PhD degree in mechanical engineering from the University of Oxford, and a Masters in Environmental Technology from Imperial College, London. I am currently employed as the Science Fellow for the Natural Resources Defense Council ("NRDC"), where I head NRDC's efforts relating to Carbon Capture and Sequestration ("CCS") technology, policy, and regulation. I have been studying CCS for a number of years now, and was part of a team that investigated the economics of CCS for the Department of Trade and Industry of the UK government.

2. On June 20, 2007, at Energy Northwest's invitation, I gave a presentation to the Board of Energy Northwest on the feasibility of performing sequestration at the Pacific Mountain Energy Center ("PMEC"). My presentation outlined the state of knowledge regarding CCS and summarized geological sequestration options in the Pacific Northwest. My submission to the Board, entitled "A Presentation to the Energy Northwest Executive Board, Pacific Mountain Energy Center Workshop," is attached to this declaration as Attachment B.

3. As I explained in my presentation to the Energy Northwest Board, research on CCS has been ongoing for many years now, with major international conferences taking place since the early 1990s. Since then, knowledge on the subject has greatly expanded, to the extent that the Intergovernmental Panel on Climate Change ("IPCC") issued a special report on CCS in 2005. An extensive Massachusetts Institute of Technology ("MIT") study on the Future of Coal in 2007 also examined CCS in depth. There is a substantial body of evidence, knowledge, and peer-reviewed literature on CCS.

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4. In many ways, CCS is not new. There are three elements to successful geologic sequestration of carbon dioxide: capture, transportation, and sequestration. All three of these elements have been demonstrated and operated in commercial, large scale installations. In the paragraphs below, and in Attachment B, I summarize the knowledge we have obtained from application of these three elements, and outline the steps and the types of studies that Energy Northwest must undertake to apply this knowledge base to the PMEC.

5. The first element of CCS is the initial capture of the carbon dioxide emissions. "Pre-combustion capture" is applied to conversion processes that gasify coal, petroleum coke, or other feedstocks (such as biomass) rather than combusting them in air. In the oxygen-blown gasification process, the feedstock is heated under pressure with a mixture of pure oxygen, producing an energy-rich gas stream consisting mostly of hydrogen and carbon monoxide. Coal gasification is widely used in industrial processes around the world, such as in ammonia and fertilizer production. Hundreds of such industrial gasifiers are in operation today. In power generation applications as practiced today this "syngas" stream is cleaned of some impurities and then burned in a combustion turbine to make electricity in a process known as Integrated Gasification Combined Cycle ("IGCC"). Commercially demonstrated systems for pre-combustion capture from the coal gasification process involve treating the syngas to form a mixture of hydrogen and CO2, and then separating the CO2 primarily through the use of solvents. These same techniques are used in industrial plants to separate CO2 from natural gas and to make chemicals such as ammonia out of gasified coal. However, because CO2 can be released to the air in unlimited amounts under today's laws, except in niche applications, even plants that separate CO2 do not capture it; rather, they release it to the atmosphere. Notable exceptions include the Dakota Gasification Company plant in Beulah, North Dakota, which

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captures and pipelines more than one million tons of CO2 per year from its lignite gasification plant to an oil field in Saskatchewan (the Weyburn project described below), and ExxonMobil's Shute Creek natural gas processing plant in Wyoming, which strips CO2 from sour gas and pipelines several million tons per year to oil fields in Colorado and Wyoming. The principal obstacle for broad application of pre-combustion capture to new power plants (and the main reason behind limited deployment of IGCC with carbon capture) is not technical, it is economic: under today's laws it is cheaper to release CO2 to the air than capture it. The cost of CO2 capture is by far the most expensive element in the CCS chain of operations, estimated to be in the region of 75% of total costs, depending on the geological setting and the distance of transport.

6. The second element of CCS is the transportation of captured carbon dioxide to the injection site, if needed. CO2 pipelines today operate as a mature market technology and are the most common method for transporting CO2. The first long-distance CO2 pipeline came into operation in the early 1970s. Presently over 2,500 kilometers of pipelines transport more than 40 million tons CO2 per year from natural and anthropogenic sources in the United States, mainly to sites in Texas, where the CO2 is used for Enhanced Oil Recovery ("EOR"). The regulatory framework for these pipelines is well established.

7. The third element of CCS is the sequestration of the carbon dioxide in geological formations. Injection of carbon dioxide has been successfully demonstrated on a large scale. Indeed, approximately 35 million tons CO2 annually are injected in mature oil reservoirs for the purposes of EOR, a practice that has been around for several decades. The CO2 aids in retrieving oil that is otherwise stranded in reservoirs, which would be near the end of their economic life without such advanced techniques. EOR is not tantamount to CCS. In the

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former, the objective of the process is to maximize oil yields using the least amount of CO2, which has to be bought in as a resource, often at some expense. The objective of sequestration on the other hand is to maximize the amount of CO2 stored in the geological formation, and to ensure permanence of storage. However, as I explain below, the extensive body of technical expertise gained from EOR practices is directly related to CCS.

8. There is considerable scientific knowledge regarding the mechanisms for trapping carbon dioxide in sedimentary geological formations. For example, residual trapping limits carbon dioxide mobility through capillary forces. Solubility trapping occurs when injected carbon dioxide dissolves in fluids within the geological formation. Stratigraphic trapping occurs when overlying impermeable rock formations prevent upward movement of carbon dioxide from underlying reservoir reservoirs. Mineralization trapping occurs when injected carbon dioxide forms carbonate minerals and essential becomes part of the solid rock into which it was injected. Attachment. B at 3. Both the Intergovernmental Panel on Climate Change ("IPCC") and the interdisciplinary team from the Massachusetts Institute of Technology ("MIT") concluded that such sequestration methods in appropriately selected and operated geologic reservoirs are likely to trap over 99% of injected carbon dioxide over 1,000 years. Id.

9. There are several commercial and research projects that inject carbon dioxide in sedimentary geological formations for permanent sequestration. For example, the Sleipner project in Norway has been operating since 1996 and injects about 1 MtCO2 annually into a deep saline formation in the North Sea. BP's In Salah project, operating in Algeria since 2004, injects a similar amount of CO_2 stripped from natural gas back into the water leg of the natural gas field. The Weyburn project receives CO2 captured and transported from North Dakota to Saskatchewan and has been operating since 2000 and injects 1-2 $MtCO_2$ annually. Weyburn is

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particularly interesting in the context of capturing and sequestering CO_2 from an IGCC power plant such as PMEC, because the capture technique would be the same as in the Great Plains Synfuels production facility in North Dakota that supplies CO2 to Weyburn. All three of these projects include monitoring programs. The results of that monitoring indicate that the CO2 is remaining sequestered in the formations and that there is no reason to expect any CO2 leakage from these projects. These projects just mentioned give me a great deal of confidence that CO2 can remain permanently sequestered in geological reservoirs.

10. All that said, not all types of sequestration are at the same stage of maturity. Sequestration in porous sedimentary rocks is an area where we can have high confidence owing to years of study, and many millions of tonnes of CO2 injected. Other types, such as sequestration in coal seems are still being investigated. The trapping mechanisms and kinetics of storing CO2 in coal seams are not yet fully understood, and there are concerns regarding the ability of coals to receive large volumes of CO2 due to swelling, alongside other issues. There are even more substantial concerns surrounding sequestration in basalts, which still remains experimental with a substantial amount of work remaining to be done before we are in a position consider it a viable option for commercial scale sequestration. My submission to the Board of Energy Northwest contains a fuller explanation. Research in both these types of sequestration is both valuable and desirable – but it is misleading and unacceptable for Energy Northwest to cite current shortcomings in some types of sequestration to cast doubts on the viability of sequestration as a whole.

11. In order to sequester CO2 emissions at PMEC, the task for Energy Northwest is not to develop the technology from scratch or even to radically alter it. As the experience with EOR and large-scale sequestration projects demonstrates, each of the three elements for

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successful sequestration has been developed and used in a variety of other contexts over the years. Energy Northwest's task is to combine the three elements and apply the existing knowledge and techniques to PMEC. Energy Northwest can use conventional injection techniques used in EOR and additionally ensure permanent storage through: (1) a more extensive geological site characterization that establishes the containment characteristics and mechanisms present in potential reservoirs; (2) proven monitoring and verification systems capable of tracking the evolution of CO2 in the subsurface and either verify containment or provide triggers for remedial action; (3) mitigation or remediation actions to ensure that CO2 remains contained underground without endangering underground sources of drinking water or being released to the atmosphere; and (4) appropriate decommissioning procedures and long-term stewardship provisions. All of these steps and techniques can be performed today by research and commercial entities alike at a tiny fraction of the cost of capturing the CO2[1].

12. As a minimum prerequisite for determining sequestration options, Energy Northwest must first evaluate potential sites for the geological characteristics necessary for permanent sequestration. To identify such a site, Energy Northwest should (1) conduct a literature review summarizing existing knowledge of geologic near the proposed site, (2) complete a broad geophysical survey of regions identified as being potentially suitable for sequestration, and (3) engaged in seismic research and/or drilling to reveal the spatial, geographic, porosity, injectivity, and geochemistry characteristics of the potential site. Such research could likely be completed within 25 months and cost less than $7 million.

13. I outlined such a program for site characterization in the presentation I provided to Energy Northwest in June, 2007. Attachment B at 6 (bullet point overview of surveys needed

[1] An approximate cost of capture would be $30/tCO2, compared to no more than $0.5/tCO2 for monitoring and verification. [IPCC Special Report on CCS, Technical Summary, p. 28, 36]

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to select a suitable site). On page 19 of the Greenhouse Gas Reduction Plan submitted to the Energy Facility Site Evaluation Council on July 30, 2007, Energy Northwest appears to adopt almost word-for-word many of the bullet points outlined in my presentation, with some alteration of the timeline for these studies. The broad outline I provided to Energy Northwest was never meant to be a comprehensive or detailed treatment of the studies necessary to evaluate site characteristics. An acceptable site characterization proposal would identify at a minimum the regions and formations to be examined, present some basic geologic information about those formations, summarize existing information, explain what methods would be used for the study. Moreover, as I noted in my presentation, a site characterization study is merely a prerequisite toward sequestration, and "would constitute part of a robust sequestration plan as required by ESSB 6001." Attachment B at 7. Without the study, it is simply impossible to speak of a "sequestration plan" (which clearly implies certainty for the result) – the results of the study themselves would help to determine whether sequestration is an option available to PMEC by establishing that a site with sufficient capacity, injectivity and appropriate sealing characteristics is available for disposing of the CO2 emissions.

14. A robust program for monitoring CO2 in the subsurface is an integral component of sequestration. Such a program, typically referred to as Monitoring, Measuring, and Valuation ("MMV"), has the role of tracking the evolution of CO2 in the subsurface and either verifying containment or providing triggers for remedial action, while serving as a continuous source of data feedback for the reservoir models that should be used to predict CO2 behavior. A number of monitoring techniques and tools are readily available. Selection of the appropriate ones and specifics of their use is very site- and medium-specific, and should follow directly from the information that the site characterization study would reveal. Determining what

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monitoring techniques will be used is vital , since for sequestration to qualify as sequestration and not merely injection, MMV is a necessity. In addition to monitoring, mitigation and remediation procedures need to be clarified prior to injection to ensure that CO2 will remain contained underground without endangering underground sources of drinking water or being released to the atmosphere.

15. It is true that no integrated large scale power sector CCS project is operational today. However, this is mainly due to the current legal framework governing CO2 emissions, or in fact the lack thereof. As I outlined above, the constituent elements of CCS have been demonstrated at scale, and Energy Northwest is tasked with combining these elements and applying them in the context of the PMEC. FutureGen is another project that, if constructed, will combine the CCS elements and apply them to power generation. However, contrary to claims, FutureGen is not the sole gateway to CCS in the power sector, nor does it carry the burden of "proving" that sequestration is possible. It is a single project with a particular administrative structure that promises to reveal valuable operational and technological information. Along the same lines, the DOE's Regional Sequestration Partnerships comprise talented and dedicated individuals carrying out valuable work, but are constrained by lack of funding and capacity. The recent MIT study voiced concerns that have existed for a while, calling for a greatly accelerated program and increased budget for DOE's research. Putting together a project under the Partnerships' umbrella is one track that a developer may choose to follow, and also an option for the PMEC, but by no means the only one. Other industrial entities that include BP, Rio Tinto, NRG Energy and Excel Energy have also announced independent projects or plans that will generate near-zero emission power from fossil fuels, to name but a few.

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16. I share the view of many scientists, established experts, and corporations that there are no technological showstoppers to the deployment of CCS today – only policy, legal and economic hurdles. It is my firm belief that any barriers identified in the context of a project like PMEC can be resolved with collective action and over the appropriate timeframes. In a world where tackling climate change is a matter of urgency, constructing plants that do not capture and sequester their emissions is extremely ill-advised, when the technology exists virtually to eliminate those. I hope that the state of Washington will continue its leadership role on the front of clean power generation, exemplified by ESSB 6001, by honoring the spirit and letter of the law and setting the bar at a challenging but achievable level.

Executed this 24th day of October, 2007, at San Francisco, California.

GEORGE PERIDAS

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EXHIBIT B

A Presentation to the Energy Northwest Executive Board
Pacific Mountain Energy Center Workshop
June 20, 2007

George Peridas
Natural Resources Defense Council

Introduction

The Pacific Mountain Energy Center (PMEC) is a proposed Integrated Gasification Combined Cycle (IGCC) power generation facility that will use fuel flexible gasification technology and processes to produce in Washington State. The approximate size of the plant is 680MW, and the candidate fuels include Powder River Basin coal and petroleum coke ("petcoke").

In order to comply with Washington State law (ESSB 6001), which sets an emissions performance standard at the level of a Combined Cycle Gas Turbine plant (1100lb CO2/MWh), Energy Northwest is considering the option of geologic sequestration for a portion of the plant's carbon dioxide emissions. The present document examines the potential for geologic sequestration for this facility.

Geological sequestration options for PMEC

Geological sequestration in a nutshell

Regardless of the geological medium or the type of the candidate reservoir, the following factors are paramount when considering sequestration of CO2 in geologic formations:

- **Capacity:** (how big is the reservoir?) the target reservoir needs to be able to accommodate the quantities of CO2 that will be injected over the lifetime of a project or facility. A reservoir's capacity will depend on the porosity and thickness of the rock formation.
- **Injectivity[1]:** (how easily and at what rates can we inject in the reservoir?) the target reservoir needs to be able to withstand the sustained CO2 output from the generating source, which for baseload power plant will be fairly constant, without exceeding certain thresholds such as injection pressure and without fracturing. "Clogging up" of a reservoir would lead to the emissions from the plant having to be vented.
- **Effectiveness/risk:** (will the CO2 stay sequestered?) CO2 gets trapped into different rock formations through a variety of trapping mechanisms that depend on the rock itself.

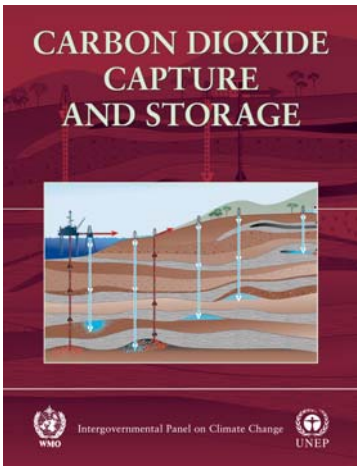
[1] Injectivity characterizes the ease with which fluid can be injected into a geological formation and is defined as the injection rate divided by the pressure difference between the injection point inside the well and the formation.

These mechanisms tell us a lot about how likely or unlikely it is for the CO2 to remain permanently in the reservoir. Additionally, the layout of the rock formation itself affects the effectiveness of the sequestration through the presence or absence of transmissive faults that might provide leakage pathways for the CO2, or through the presence of caprocks that would act as further barriers to the CO2 migration, reinforcing other trapping mechanisms.

- **Economics:** even if a reservoir has sufficient capacity, injectivity and would effectively trap the CO2, the engineering and operational costs need to be examined to ensure that they are acceptable.

<u>All of the above parameters can be predicted and measured accurately through well established methods and techniques: we are in possession of a considerable body of knowledge, operational experience from sequestration and related activities!</u>

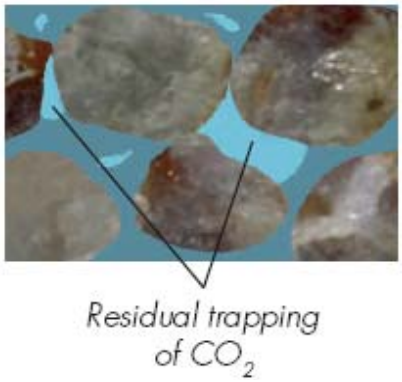
Sequestration in sedimentary formations: today's technology or tomorrow's aspiration?



Research on Carbon Capture & Storage (CCS) has been taking place for many years now, with major international conferences taking place since the early 1990s. Since then, our knowledge on the subject has greatly expanded, to the extent that the Intergovernmental Panel on Climate Change (IPCC) issued a special report on CCS in 2005. There is a substantial body of evidence, knowledge and peer-reviewed literature on CCS that enables us to speak with authority on the subject today. In many cases, we can speak with a very high degree of confidence. We can also identify the areas where that is not possible, and where additional research is needed.

In many ways, CCS is not new. All three stages (capture, transportation and sequestration) have been demonstrated and operated in large, commercial scale installations.

Regarding transportation, pipelines today operate as a mature market technology and are the most common method for transporting CO2. The first long-distance CO2 pipeline came into operation in the early 1970s. In the United States, over 2,500 km of pipeline transports more than 40 million tons CO2 per year from natural and anthropogenic sources, mainly to sites in Texas, where the CO2 is used for Enhanced Oil Recovery (EOR).

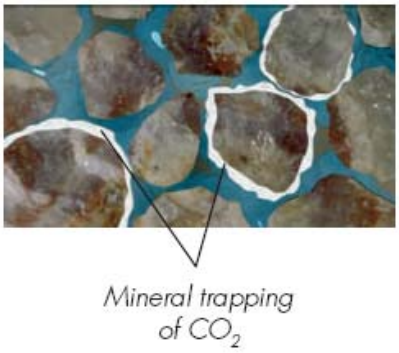


Source: International Energy Agency

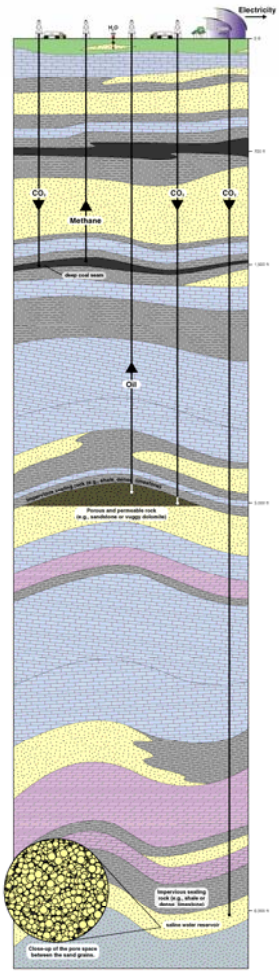
Some 35 million tons CO2 annually are injected in mature oil reservoirs for the purposes of EOR, a practice that has been around for several decades. The CO2 aids in retrieving oil that is otherwise stranded in reservoirs, which would be near the end of their economic life without such advanced techniques. Although the objective in this process is to maximize oil yields and not to sequester CO2, the two processes are fundamentally similar and share much of the same operational engineering.

Moreover, several commercial and research projects worldwide capture and/or inject CO2 in sedimentary geological formations. Of these, three stand out because of their scale and their widely publicized results: Sleipner in Norway, Weyburn in North Dakota/Canada and In Salah in Algeria. These projects have been operating since 1996, 2000 and 2004 respectively, and have been studied intensely. The results are showing that there is no reason to expect any CO2 leakage from these projects, and that the injected volumes are very likely to remain permanently sequestered in their respective reservoirs.

The projects just mentioned give us a great deal of confidence that CO2 can remain permanently sequestered in geological reservoirs. There are multiple trapping mechanisms for CO2. *Residual trapping* limits CO2 mobility in a formation through capillary forces, much like a sponge holds air that has to be squeezed out to let water in. *Solubility trapping*, whereby CO2 dissolves in the formation fluids, ensures that the CO2 is no longer buoyant and therefore tends to sink rather than rise towards the surface. *Stratigraphic trapping* occurs when overlying, impermeable rock formations prevent any upwards movement of CO2 from the underlying reservoir rock, effectively acting as lids. Appropriately selected injection sites will possess several layers of such caprocks, and thus multiple reinforcements to the other trapping mechanisms. Finally, *mineralization trapping* takes place when the CO2 over time forms carbonate minerals and essentially becomes part of the solid rock into which it was injected.



Source: International Energy Agency



A stratigraphic cross section of the Illinois Basin, showing multiple layers of caprock (grey). Source: Illinois State Geological Survey and the Midwest Geological Sequestration Consortium)

The IPCC report concluded the following:

"Observations from engineered and natural analogues as well as models, suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years. For well-selected, designed and managed geological storage sites, the vast majority of the CO2 will gradually be immobilized by various trapping mechanisms and, in that case, could be retained for up to millions of years. Because of these mechanisms, storage could become more secure over longer timeframes".

In support of that statement, a recent MIT study[2] concluded that:

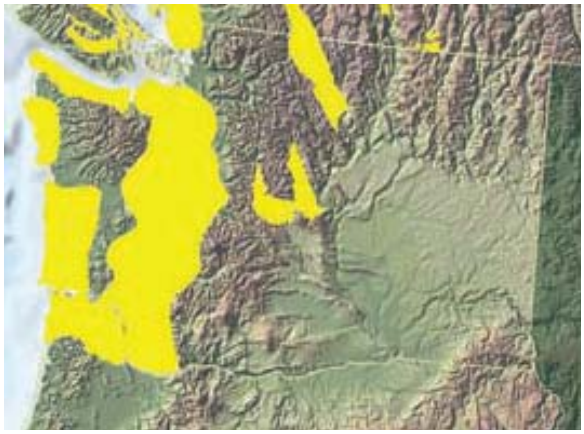
"Although substantial work remains to characterize and quantify these mechanisms, they are understood well enough today to trust estimates of the percentage of CO2 stored over some period of time – the result of decades of studies in analogous hydrocarbon systems, natural gas storage operations, and CO2-EOR. Specifically, it is very likely that the fraction of stored CO2 will be greater than 99% over 100 years, and likely that the fraction of stored CO2 will exceed 99% for 1000 years. Moreover, some mechanisms appear to be self-reinforcing. Additional work will reduce the uncertainties associated with long-term efficacy and numerical estimates of storage volume capacity, but no knowledge gaps today appear to cast doubt on the fundamental likelihood of the feasibility of CCS".

The remaining 1% is a number reserved by the IPCC to take into account any insignificant amounts of CO2 that might be vented during the operation of sites due to human factors over those very long periods, and does not reflect reduced confidence in the underlying geology or the ability of formations to retain CO2. There is every possibility that even this tiny fraction will not reach the atmosphere

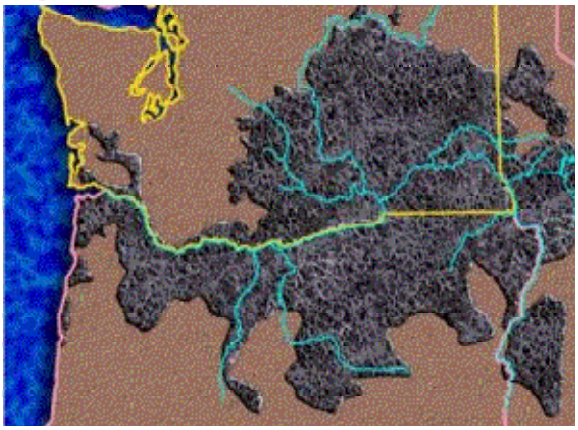
[2] "The Future of Coal – Options for a Carbon Constrained World". An Interdisciplinary MIT Study, 2007.

with proper site operation and regulation, bringing the total retained fraction to 100%.

Leakage is conceivable, but is unlikely for good sites, generally predictable, can be detected and remedied promptly, and is extremely unlikely to be of a magnitude that would endanger human health and the environment if the project is performed under adequate regulatory oversight and according to best practices. After all, it should come as no surprise that the same types of reservoirs that have stored hydrocarbons for millions to hundreds of millions of years, as well as naturally occurring CO2, are also capable of retaining CO2 injected by humans.



Deep saline formations in the WA area
Source: NATCARB



Extent of the Columbia river basalts
Source: USGS

Sequestration in basalts

Basalts are crystalline and glassy rocks with abundant iron, calcium, and magnesium rich silicate minerals. When these minerals are exposed to carbonic acid over time, they preferentially form new carbonate minerals, releasing silica while permanently binding CO2. Basalt formations therefore have the potential to sequester quantities of injected CO2.

Sequestration in basalts is a worthwhile research area, and the Pacific Northwest National Laboratory is pioneering efforts to expand our knowledge on the topic. However, sequestration in basalts is a different ballgame to sequestration in deep saline formations, oil fields or gas fields, where the vast majority of our experience and knowledge resides.

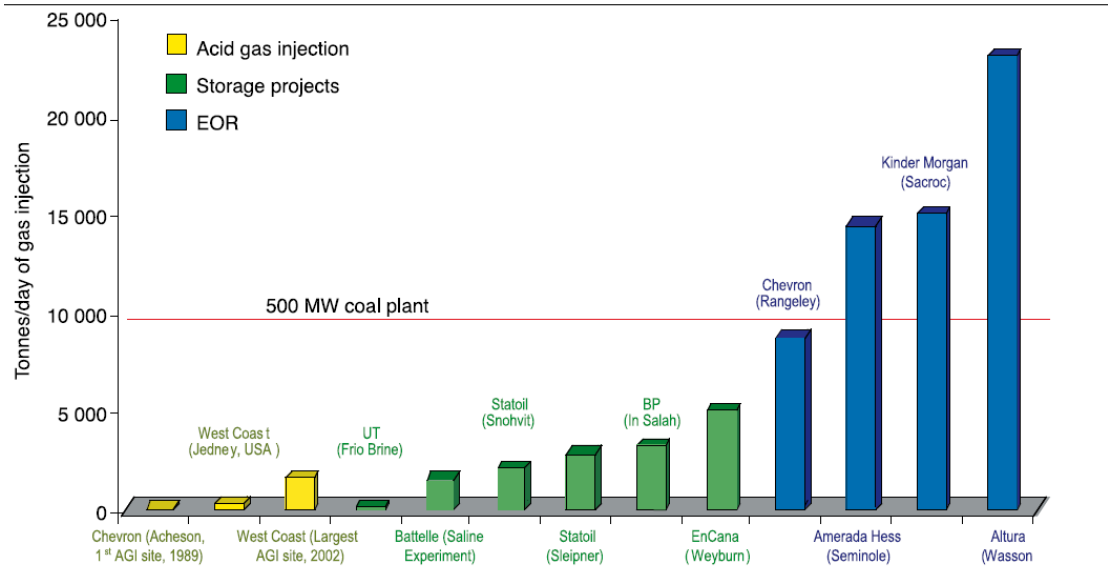
Presently, there are outstanding questions regarding large-scale injection in basalts:

- **We are not yet in a position to establish that CO2 injected in basalts will not leak.** Basalt commonly has low porosity, low permeability and low pore space continuity. Any permeability is generally associated with fractures through which CO2 may leak unless there is a suitable caprock. In other words, the CO2 would not be injected into the rock framework itself, but into fracture networks that are part of the overall rock formation. Establishing that these networks themselves will not lead to the surface is difficult, and evidence so far is inconclusive. Perhaps most importantly, we would be in uncharted territory when injecting such volumes of CO2 in basalts: there is no relevant industrial experience or knowledge as to how the formations would respond when pressurized.
- **The evolution of the CO2 plume once injected in the basalt cannot currently be predicted** with the same accuracy or precision as in sedimentary rocks. This adds uncertainty to the efficacy of an operation, and to the credibility of a "sequestration plan" in the case of PMEC.
- **Monitoring the CO2 once injected in the basalt is problematic.** Well-established methods that have been developed for sedimentary rocks do not lend themselves to use in basalts. Seismic monitoring, for example, becomes problematic because it is difficult to distinguish the CO2 in a high velocity, fractured medium such as basalt. Experiments with tracers have also highlighted problems.

These considerations led to IPCC to conclude that "[b]asalts may locally provide niche options for geological storage of CO2". It would not be advisable in our opinion for PMEC to consider sequestering 2-3 million tCO2/yr in basalts in the context of ESSB 6001 timelines and requirements. The unanswered questions on the efficacy of such an operation would present too large a business and regulatory risk. PMEC might want to consider, however, cooperating in the ongoing research on CO2 sequestration in basalts as a side operation, to aid progress on that front.

Sequestration options in deep saline formations for PMEC

The 2-3 million tCO2/yr that the plant would have to sequester lies in the range of the larger injections that have been carried out so far, either with sequestration as an aim, or for enhanced oil recovery. For typical geologies, 1 million tCO2/yr is an approximate estimate of the minimum injection volume of CO2 that would be sufficient to exceed critical geological thresholds, and as such to be able to predict the response of formations to larger injected volumes. The Sleipner, Weyburn and In Salah projects are all in the region of 1 million tCO2/yr, and as can be seen from the figure below, larger injections have been performed in EOR operations. Injection volumes from PMEC would not push the boundaries of existing knowledge or operations, even at higher capture rates exceeding 85%.



Source: IPCC

Are there suitable reservoirs to accommodate the emissions in the vicinity of PMEC? There are two main options that the developers might want to consider:

- **Option I:** West of the Cascade range, there are identified saline formations in the Central Washington Basin that could prove suitable.
- **Option II:** East of the Cascades, there might be suitable reservoirs under the flood basalts.

If suitable reservoirs were identified in those regions, PMEC could sequester its CO2 using the same techniques that are used in other sequestration operations worldwide.

Required steps and recommendations

Finding a suitable site

The most crucial aspect of a sequestration operation is to choose a good site that has adequate capacity, injectivity and seal integrity. In that respect, surveys would need to be carried out under both options mentioned above. The surveys could be done in a step-wise fashion as follows:

- An initial paper study summarizing existing knowledge and data could be conducted as a first step – approximate cost $200,000, duration 4 months.
- A broad geophysical survey of the regions in Option I, and possibly Option II would build on the initial study and utilize a variety of methods to obtain more detail – approximate cost $2-3 million, duration 9 months. This would probably include some combination of aeromagnetic, gravimetric, 2-D and 3D reflection seismic surveys, and would identify the thickness of viable strata, the structure of primary storage units, and the location of potential geological hazards (e.g. large faults).
- Using the results of the survey, detailed data could be obtained for the most promising reservoirs using seismic methods (to reveal the spatial and geographical characteristics) or through drilling wells (to reveal the porosity, injectivity and geochemistry of the formations) – approximate cost $3-4 million for a seismic survey or per well, duration 1 year.

Option I should be the preferred option, since more is known about the saline formations west of the Cascades, and a detailed characterization of those sites would not entail drilling through the basalt body, which can be slower and more costly. Option II is nonetheless also viable, and could be used as an alternative plan – the additional technical complexity of drilling through the basalts is by no means insurmountable, and the added development and operational costs would still be small in comparison to the capital investment for the plant (that would be on the order of billions).

The results of such a staged approach would not only be of use to Energy Northwest, but arguably of public benefit. Although the entirety of these services could be provided commercially, we believe that there is a strong case to be made for state assistance in these efforts, given that they will be revealing resources that would aid the state to meet its emissions performance standard and its greenhouse gas targets. The studies could be handled by the University of Washington, the State Geological Survey, the Pacific Northwest National Laboratory and the DOE regional partnerships.

Moreover, this staged approach, especially if carried out as a state-assisted public-private partnership and/or in conjunction with other proposed developments, would constitute part of a robust sequestration plan as required by ESSB 6001 that would enable the project to proceed in accordance to planned timelines.

Regulatory considerations

Under ESSB 6001, PMEC has a five year window in which to achieve sequestration at the desired levels to meet the standard. Energy Northwest also have the option to use "offsets" to meet the standard, but two issues are worth pointing out:

- Offsets would have to be in the form of "verifiable greenhouse gas emissions reductions from an electric generating facility located within the western interconnection" and would also have to be additional – other types of offsets do not qualify.
- Such offsets can only be used if a good faith effort to implement the sequestration plan has been made, and evidence to the technological and economic barriers that stood in the way of successful implementation has been provided.

Other types of sequestration, e.g. terrestrial, could be considered as allowed options by the Department of Ecology, and could be used as an option for PMEC if they are approved. For a variety of reasons that include the large volumes of emission reductions needed, permanence and additionality issues related to terrestrial offsets and the risks associated with relying on a sequestration option that depends on variable natural systems and that could be subject to changing regulatory requirements, we would advise the Board to make the engineered geologic sequestration option an integral part of the sequestration plan due to its reliability, predictability and the large operational experience to date.

Currently, sequestration is permitted under EPA's Underground Injection Control Program according to a guidance issued by the EPA. The guidance has determined that for injection in saline formations, permits shall be issued under "Class V – Experimental"[3]. This arrangement is likely to change as the Agency develops rules for commercial-scale sequestration, although the momentum appears to be lacking at the moment. It is possible that Congress will direct the Agency to proceed, however. Additionally, under ESSB 6001, the Department of Ecology and the Energy Facility Site Evaluation Council shall adopt rules to implement this section by June 30th, 2008. It is likely that those rules include criteria for site selection for sequestration, as well as monitoring and accounting provisions.

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[3] United States Environmental Protection Agency. "Using the Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects", March 2007. Available at: http://www.epa.gov/safewater/uic/pdfs/guide_uic_carbonsequestration_final-03-07.pdf

Complying with existing regulations is perfectly feasible. It is also in the interest of State agencies to adopt reasonable rules that both protect human health and environment, and also allow for the sound use of carbon sequestration. A robust site selection process is in the interests of developers in order to avoid unsuitable sites. Monitoring the evolution of the CO2 plume in the subsurface will provide confidence and public acceptance, as well as demonstrating that the sequestration is being implemented as required. Monitoring costs, again, represent a very small fraction of the project's operational and capital costs, and would probably amount to less than $0.5/tCO2.

Finally, operating the project as part of Phase III of the Regional Partnerships would potentially cover several needs: funding, research, implementation and credibility.

Conclusions

- Geologic sequestration technology and know-how are well proven and established enough to be used at PMEC.
- The preferred geologic medium is deep saline formations – sequestration in basalts is not ready for commercial-scale applications yet.
- In compiling a sequestration plan, Energy Northwest can engage in a step-wise investigation of geologic and technical options at modest cost.
- Such an investigation would arguably be of public benefit and could be performed as part of a public-private partnership, possibly with state assistance.
- A regulatory compliance plan would have to be prepared, and we anticipate the costs associated with sequestration to be low.
- Participation in Phase III of DOE's Regional Partnerships might be beneficial for PMEC, although it would also impose some constraints.

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