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A Report for NWPCC

GHG Market Forecasting Services

Assigning Carbon Price Estimates to Alternative Policy Scenarios

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1 Introduction

This is the last of four summary reports prepared by EcoSecurities Consulting Ltd. (ECL) for NWPCC. The first three of ECL's reports provided NWPCC with:

- A literature review of carbon price forecasts based on alternative modeling approaches, targets, and timeframes.
- A compilation of mitigation supply curves reflecting estimated sectoral mitigation potentials and mitigation costs for the Western U.S., the U.S. as a whole, and globally.
- A review of carbon capture and storage information specific to the WCI region.

This final summary report addresses NWPCC's request for ECL's insight into the cost of carbon under three general policy scenarios:

- A "Pessimistic" scenario, in which the Western Climate Initiative and other regional initiatives operate in the absence of material national and international policy.
- A "Base Case" scenario, in which national and international policy measures target a return to 1990 emissions levels by 2030.
- An "Optimistic" scenario, in which aggressive national and international policy interventions are used to dramatically reduce global GHG emissions with the goal of stabilizing CO_2e concentrations at 550 ppm by 2100.

As documented in ECL's other reports, the impacts of numerous policy and market variables make it impossible to truly predict the future value (or cost) of carbon in a carbon constrained world. Even how to think about the question of future carbon costs varies based on the question being asked, since the impact of different market variables will vary across short-, mid-, and long-term time horizons, and also based on the specific policy mechanisms being used. The availability of "low-hanging fruit," for example, is key to near-term carbon market analysis, while assumptions about economic growth are not. Over the longer term, however, current estimates of "low-hanging fruit" become much less important to anticipating the cost of carbon, while assumptions about population and economic growth become pivotal. As a result tools like static supply and demand analysis can generate useful near-term insight, while over the longer term macroeconomic modeling becomes key to any projection of how the economy will respond to alternative carbon constraints.

Any GHG market forecasting exercise must recognize that carbon markets are fundamentally different from other commodity markets. It is clear that the *demand* for GHG emission reductions is determined largely by policy decisions; what makes the GHG market so unusual is that the near- to mid-term market *supply* of emissions reductions will also be largely determined by policy decisions. Relevant supply curve policy variables range from specification of which mitigation sectors can participate in carbon trading, to determination of how project-based "additionality" is defined and implemented. These and other supply variables can fundamentally

affect the market supply curve for emissions reductions, and hence GHG credit prices. In addition, the economics of reducing GHG emissions in many sectors can be materially affected by future prices for fossil fuel feedstocks. Table 1, for example, illustrates that a technology like wind energy, assuming set capital and operating costs, can go from being an expensive carbon mitigation option at low natural gas prices, to a cost-effective technology in its own right at higher natural gas prices.

Typical Project	Natural Gas Price		
	$2.00/MMBtu	$4.00/MMBtu	$8.00/MMBtu
Coal Mine Methane Capture	$5.77	$0.79	Negative
Large-Scale Wind Energy	$47.08	$8.50	Negative
Coal-to-Gas Fuel-Switching*	$15.12	$72.44	$187.07
Pulverized Coal CO_2 Capture**	$279.99	$220.86	$102.59

*Assumes coal prices stay constant.
**Lost electricity sales are assumed due to the energy penalty associated with CO_2 capture.

Table 1: Mitigation Project Costs per ton of CO_2 (2007$) Given Different Values for Natural Gas Prices

The bottom line is that there can be no such thing as a "correct" forecast of future carbon market prices. That said, market forecasting under conditions of uncertainty is nothing new. Energy companies, for example, routinely forecast oil and gas prices even while knowing that these forecasts will not be "correct." In the carbon arena, ECL can work with policymakers and companies to generate a Best Available Forecast that reflects their judgments regarding a wide range of policy and market variables. By incorporating their own "world view," into the policy and market scenario building process, as well as their own perceptions of and sensitivity to carbon risk, the results can provide decision makers with an informed foundation for strategic planning and capital investments in anticipation of a carbon-constrained world. Note that different companies and policy makers, with different views of the future, and different sensitivities to carbon risk, can appropriately arrive at very different Best Available Forecasts.

This report does not seek to provide NWPCC with a Best Available Forecast of carbon prices. To do so would require the in-depth exploration and specification of one or more policy and market scenarios around which a Best Available Forecast would be built. This process has not taken place. Instead, NWPCC has asked ECL to provide a high-level view of potential carbon prices under the three generally specified scenarios identified above.

Although the results presented in this report are not based on detailed market scenarios, they do reflect ECL's approach to and experience with carbon market forecasting. This approach is briefly documented in the following sections of this report, to provide context for the scenario results presented at the end of the report.

2 The Context for Near-Term Carbon Price Forecasting

EcoSecurities Consulting Ltd. has actively tracked the GHG market for more than a decade, extensively researched mitigation options and costs, and closely tracked ongoing policy development at the national and international levels. Based on ECL's experience, a number of variables need to be considered in any effort to forecast future carbon prices.

- *Context Variables:* Those variables that drive the priority and shape of public policy on climate change. They include the developing science of climate change, public opinion, and the international political context related to multilateral cooperation.

- *Mitigation Demand Variables:* Those variables that determine the demand for GHG credits in a future mitigation market. They include economic and emissions growth, the impact of voluntary emission reduction programs, the severity of regulatory emission reduction mandates, the timing of mandates, the role of developing countries in global mitigation efforts, the treatment of sinks, and compliance and penalty regimes.

- *Mitigation Supply Variables:* Those variables that influence the supply of emission reductions available to meet compliance mandates. These include the fungibility of reductions from different sectors and crediting systems, the technical potential of sectors to deliver emission reductions, additionality and quality standards that limit market participation to "real" reductions, whether credit banking is permitted, treatment of sinks and potentially impermanent reduction options, and expectations regarding the future market. Almost any of these variables could dramatically affect the supply of credits under many market scenarios.

- *Project-Level Transaction Variables:* Those variables that determine the transaction costs involved with creating credits in the GHG market. They include baseline and other documentation requirements, approval and certification processes, adaptation or other tax levies, guarantee requirements, and costs associated with project monitoring and verification.

- *Technology Variables:* Those variables that change the shape of the supply curve over time, and comprise the many factors that influence the evolving cost-effectiveness of different technologies. These factors include changes in related commodity prices (e.g. natural gas and electricity) and the emergence of new emissions reduction technologies (e.g., long-term geological sequestration).

In principle these variables could factor into creating different carbon prices in different emissions trading systems that operate simultaneously. In theory there could be operational carbon trading systems functioning in the Pacific Northwest, nationally, and internationally. Each of these programs could, in principle, have different market clearing prices owing to different operating rules and differing access to cost-effective emissions reduction opportunities. From the standpoint of projecting carbon prices in a carbon-constrained world, however, trying to anticipate a range of geographically or sectorally specific trading markets simply adds too much

complexity to an analysis of future carbon prices, and the uncertainty bands around such projections would render the projections themselves of questionable value.

For these reasons ECL believes that a broad-based look at GHG markets is likely to generate the most useful policy insight into the economic implications of future carbon constraints. An international carbon market-clearing price, for example, reflecting a market that is able to take advantage of the broadest array of emission reduction options, should reflect a reasonably conservative estimate of the economic impacts associated with any given level of carbon emissions constraint. While local decision makers could choose to constrain access to the international market to drive carbon prices higher, we suspect that with enough time political pressures will shrink any major differential between the market-clearing prices in parallel domestic and international GHG trading systems.

For purposes of this report, carbon markets over the next 20+ years can also be broken into three distinct phases.

- *Phase 1*: 2008-2012 reflects the timing of the first commitment period of the Kyoto Protocol. Countries will sort out their compliance strategies during this phase, and the GHG market will endeavor to develop a solid foundation for future phases. The near-term market will be enormously affected by additionality standards, implementation barriers, and market psychology in terms of both demand and supply. Although economic modeling can cover this timeframe, macroeconomic modeling is unable to account for most of the variables that will be important to how the market actually behaves. As a result, we rely primarily upon supply and demand analysis for this phase.

- *Phase 2*: 2013-2020 reflects a transition phase, when targets will initially govern the GHG market for the Kyoto Protocol's second commitment period (or other agreed-upon international agreement). Supply variables like market establishment rates and ramp-up potentials should not be as critical as in the short-term, while factors including economic growth and associated GHG emissions will become more important. Yet realistic supply and demand scenarios can still be structured and, as a result, it makes sense to continue use of the supply and demand approach while at the same time integrating macroeconomic modeling results.

- *Phase 3*: 2021-2030 is a period where climate change policy objectives could extend well beyond existing regulatory targets, and be integrated into a wide variety of other aspects of our energy economy. The implications of economic growth for GHG emission reduction objectives and the potential changes in technology costs (particularly in terms of renewable energy sources and mitigation technologies like geological carbon sequestration) will be large. As a result, the uncertainty bands around supply and demand forecasts in this phase become much larger. This situation makes it more appropriate to rely increasingly on macroeconomic market modeling while at the same time recognizing the limitations of such models in terms of predicting the appropriate prices to use in carbon risk-management efforts.

3 Building Blocks of Market Demand and Supply

To forecast near-term carbon markets, a number of important supply and demand "building blocks" can be identified. Each of these building blocks has the ability to materially affect carbon market clearing prices through its impact on the demand for or supply of emissions reductions.

3.1 The Building Blocks of Credit Demand

Credit demand in future carbon markets will depend on a number of factors and the relative importance of different demand variables will likely vary over time. Beyond the quantitative targets themselves, and the timing of their implementation, key building blocks of demand include:

- *State, Regional, or Country Participation in the Trading Regime.* Of the industrialized countries, the United States constituted by far the largest expected demand under the Kyoto Protocol, yet it is currently not a part of the system, with huge implications for the demand for emissions reductions. Even countries not party to the Protocol, however, could potentially affect international credit demand and prices through domestic initiatives that proceed separately from the Protocol, whether voluntary or mandatory.

- *The Political Issuance of "Free Credits."* This includes Russian and Former Soviet Union (FSU) Hot Air in the first Kyoto Protocol commitment period, which could have a tremendous impact on the need for incremental project-based credits. To the extent this Hot Air is held for future commitment periods, or additional "free credits" are issued as a result of the political negotiations around the future of the Kyoto Protocol, this variable will continue to be very significant.

- *The Demand for Extra-Territorial Offset Credits.* The higher the proportion of an overall target that is required to be met through "local" policies and measures within capped regions and sectors, the smaller the demand for project-based reductions outside those regions and sectors. This would tend to raise the price of a localized trading system, while lowering the international market-clearing price for offsets.

- *Economic Growth as a Contributor to GHG Market Demand.* This includes primarily industrialized countries in the near-term, but potentially includes developing countries in the future. Rapid economic growth significantly increases the difficulty of meeting any given target.

- *How National Forest Sinks are Accounted For.* Forest and soil sinks can have a significant effect on national targets, and affect remaining project-based demand.

- *The Likelihood of Government Compliance with Targets.* Although not commonly discussed, this variable should be taken into account, and will certainly be considered in the market psychology on the supply side of the market. If countries ultimately decide it is too difficult or

costly to comply with targets such as those in the Kyoto Protocol, they might well fall short, or agree later on the ability to "borrow" from future commitment periods. This could have a significant impact on project-based credit demand, even in the near term.

It is relatively easy to define these building blocks of demand. What is more complicated is to assess how these building blocks will combine to form credit demand in the context of any given policy and market scenario, and how demand is likely to vary over time.

3.2 The Building Blocks of Supply

As in the case of demand, it is relatively easy to define the building blocks of GHG market supply. What is more complicated is to assess how these blocks will combine to form the supply curve available to the GHG market under a given policy scenario, at a given point in time. The key building blocks are summarized here:

- *Market Psychology.* This is a crucial supply variable as long as market demand itself is relatively uncertain, and susceptible to a variety of decision-making processes. A report published in December of 2008 by the U.K.-based Carbon Trust, entitled *Global Carbon Mechanisms: Emerging Lessons and Implications*, calculates that the GHG mitigation supply jump-started through the Kyoto Protocol will exceed likely post-2012 demand. This could significantly influence decision-making around the development of new projects and emissions reduction technologies.

- *Rules Governing Trading Systems' Market Mechanisms.* For the Clean Development Mechanism (CDM) of the Kyoto Protocol, additionality standards, crediting periods, and the specification of what mitigation sectors are included or excluded from consideration has been key to determining project-based credit supplies, and the same is likely to apply to other markets.

- *Baseline "Creep."* Under the current rules of the CDM, projects either have a 7-year (renewable up to three times) or a 10-year (non-renewable) window to generate CO_2 reductions. Many projects will therefore come to an end during the second market phase. Others will seek to be renewed for another 7 years. The protocols for how this is done, and the potential for "baseline creep" in which most project activities are assumed to become business as usual in the future, could have a significant effect on market supply of qualifying reductions.

- *Technical and Implementation Barriers.* A number of barriers—development lead times, for example, or project review requirements—will have a major effect on credit supply.

- *Project Economics.* Project economics are a function of capital and operating costs, risk-adjusted hurdle rates, and project lifetimes over which a project can earn GHG credits. Project economics can also change over time as technologies evolve or achieve economies of scale.

- *The Cost of Electricity and Fossil Fuels.* These costs are important to the supply curve facing many mitigation sectors. Different relative energy prices can significantly affect the cost-effectiveness of certain technologies for reducing emissions. Table 1 above, for example, showed how natural gas prices can affect the cost per ton of CO_2 for several GHG emissions reduction options.

- *The Availability of GHG Project Financing.* The availability of financing for GHG emission reduction projects will be crucial to the development of a robust supply of such projects. Such financing, however, can be constrained in the face of significant uncertainties regarding future credit demand and supply.

3.3 Implications of Credit "Quality" for GHG Markets and Prices

The market variable that has received the most attention in press coverage of carbon markets to date is the "quality standard" being used in defining what counts as an emissions reduction for GHG credit generation purposes. In addition, the wide range in market prices associated with GHG reductions over the last several years, ranging from pennies to more than $50/ton, largely reflects the lack of clear standards for what constitutes a "creditable" reduction, and the fact that carbon commodities of very different quality are currently available to buyers in carbon markets.

Ultimately, a clear set of credit quality standards will hopefully be established under any trading system that allows emission reductions from unregulated sectors to "opt in" to the trading system. Such standards would not be required if CO_2 emissions were regulated only at power plants, and if only CO_2 emissions reductions at power plants were eligible for crediting (because everything remains under the cap). But as soon as reductions can be introduced from other sectors, other gases, and other countries, where those reductions are not under the same emissions "cap", "credit quality" becomes of paramount concern in terms of preserving the environmental integrity of the original emission reduction targets. Some attributes of emission reductions commonly characterized as elements of credit quality include:

- *Additionality*. Probably the single most important offset project quality criterion in today's market, "additionality" refers to the extent to which a project activity diverges from (or is "additional" to) business as usual. The conceptual goal is to credit only projects producing reductions that would not have happened in the absence of carbon markets, since those are obviously the reductions that we want to incentivize through carbon markets. But while easy to understand in principle, additionality is very difficult to apply in practice.

  Because there is no single "right" way to measure additionality, a wide variety of additionality tests have been proposed, ranging from simple "project in/project out" tests that largely ignore the question of what was BAU, to financial additionality tests that ask for proof that a reduction is not the financially-preferred project alternative. None of the proposed tests are perfect, and the challenge for policymakers in setting an additionality hurdle is to strike a balance between the goal of minimizing the number of BAU credits that slip over the hurdle

and are credited, with the goal of minimizing the number of "real" reductions that are excluded from being credited (since this will tend to restrict supply and drive up prices). The policy challenge for designing future GHG trading systems is to identify the standards and the methodologies by which these competing objectives can be balanced.

- *Quantifiability*. The degree to which the GHG reductions from a project can be reliably quantified, including the ease with which a project baseline can be identified and quantified. Many otherwise attractive offset projects generate emission reductions that are difficult to measure and quantify.

- *Permanence*. Whether or not emission reductions will last over time. This criterion is most often applied to forestry and land-use projects where sequestered carbon may be re-released into the atmosphere through human or natural disruptions, and the reductions potentially lost. Creating fungibility between non-permanent and permanent reductions is proving difficult.

- *Leakage*. The degree to which GHG reductions may be counteracted by compensating actions or feedbacks external to a project's immediate boundaries. The emission reductions associated with shutting down a factory, for example, would be subject to "leakage" if the factory's production simply shifted to another factory.

- *Direct or Indirect Reductions*. Whether the reductions generated by a project occur at the emission source (direct), or away from the emission source (indirect). Many project sectors, including end-use energy efficiency improvements and renewable energy, produce indirect reductions that actually occur at power plants far removed from the project. Such a situation creates credit ownership and double-counting problems that become very important in a regulated carbon market.

How policymakers choose to define emission reductions credits will have a significant impact on the available supply of emission reductions and ultimately the cost of achieving emissions targets. Denying credit to projects that reduce emissions indirectly, for example, or whose reductions are difficult to measure precisely, could sharply restrict the supply of emissions reductions available to carbon markets. Most importantly, the manner in which policymakers guide the development of additionality testing will be critical to future GHG markets and market-clearing prices in those markets.

4 Carbon Prices Under Three Policy Scenarios

NWPCC asked ECL to consider carbon values under three potential policy scenarios:

- A "Pessimistic" scenario, in which the Western Climate Initiative and other regional initiatives operate largely in the absence of material national and international policy.

- A "Base Case" scenario, in which national and international policy measures target a return to 1990 emissions levels by 2030.

- An "Optimistic" scenario, in which aggressive national and international policy interventions are used to dramatically reduce global GHG emissions with the goal of stabilizing CO2e concentrations at 550 ppm (2x pre-industrial levels) by 2100.

As previously noted, ECL has not worked with NWPCC to specify these scenarios in the detail required to generate Best Available Forecasts. Instead, ECL has drawn upon a range of data sets and prior modeling to provide NWPCC with the scenario profiles provided below. The dollar figures expressed in this report are in 2007 dollars.

4.1 "Regional Initiatives Dominate" (Pessimistic) Scenario

This scenario assumes that very little headway is made regarding national and international climate management policy, leaving U.S. emissions reduction efforts regionally focused and enforced through localized mechanisms such as the Western Climate Initiative (WCI). This scenario also assumes that "proxy" measures aimed at providing an economic stimulus, e.g. clean energy measures, may dominate the policy agenda rather than GHG emissions reductions per se.

- *Implied Magnitude of Reductions:* The Western Climate Initiative is seeking to reduce emissions to 15% below 2005 levels by 2020. For the WCI region, this amounts to approximately 125 million tons of reductions from a business as usual baseline in 2020[1]. Emissions reductions are also being pushed under this scenario through other regional initiatives, but this demand is not clearly quantified.

- *Key Variables in Projecting Carbon Prices:* Political acceptability of carbon prices is likely to be pivotal to this scenario. Almost regardless of what the supply and demand profiles look like, it simply wouldn't be politically acceptable for WCI ratepayers and residents to be paying a high price for carbon in the absence of coordinated national and international policy.

- *Price Forecast:* We project a carbon price of $10-20/ton in the 2020-2030 time frame, that might well be primarily expressed as a subsidy for "green" projects like renewable energy, and that would drive access to whatever sources and types of offsets would allow this price to be achieved. There is not likely to be a real link between the implementation of regional policy and the achievement of a firm emissions reduction target. Any specific target is simply too easy to modify over time to assume that it will drive carbon prices to be much more robust than those projected here. The scenario also does not assume any changes in the nature of the policy measures being implemented that would lead to significant changes in the price forecast between 2020 and 2030.

[1] Based on 2020 greenhouse projections by the EIA.

4.2 "1990 Emissions by 2030" (Base Case) Scenario

This scenario assumes that climate policy is primarily national in scope, with emissions reduction targets and market mechanisms being geographically defined. Emissions targets are assumed to be either: 15% below 1) 2005 emission levels or 2) 1990 levels by 2030. The targets and the structure of market mechanisms are assumed to be relatively rigorous.

- *Implied Magnitude of Reductions:* In 1990 U.S. emissions totaled 6.2 billion tons. A national "business as usual" baseline suggests 2030 emissions of 8.5 billion tons. A target of a 15% reduction from 2005 emissions, or a return to 1990 emissions by 2030, each requires approximately 2.3 billion tons of reductions.

- *Key Variables in Projecting Carbon Prices:* Given the definition of the scenario, we assume that supply and demand are the key variables in establishing a market clearing price for GHG emissions reductions, and that offsets would deliver up to half of the necessary reductions.

- *Price Forecast:* Based on the demand for reductions as indicated above, and by the mitigation cost curves developed separately by ECL, we would project a carbon price of $20-50 for this scenario in the 2020 to 2030 timeframe. Depending on how the mandates are implemented the price could rise early and level out, or climb over time.

4.3 "Atmospheric Stabilization" (Optimistic) Scenario

This scenario assumes that climate change mitigation becomes a higher global political priority than it is today, and that political rhetoric around the climate change issue is matched by political action. Stabilizing atmospheric concentrations of GHGs by 2100 will require that global emissions ultimately be reduced by some 70% *from today's levels*.[2] The world's energy economy would have to be fundamentally transformed. . This would reasonably start with adoption of post-Kyoto targets that go significantly beyond the targets adopted for the first commitment period, and that quickly encompass all major emitters including developing countries.

- *Implied Magnitude of Reductions:* Global emissions today total almost 40 billion tons of CO2e. A global "business as usual" baseline suggests emissions in 2100 of as much as 100 billion tons. Stabilizing atmospheric concentrations of GHGs in the atmosphere might require limiting emissions in 2100 to approximately 10 billion tons of CO_2e, suggesting a 90% reduction from the business as usual baseline.

[2] The Intergovernmental Panel on Climate Change has carried out extensive modeling of what would be required to stabilize atmospheric concentrations of GHGs at different levels by different dates, using alternative baseline and other assumptions. The figures presented here reflect a very simplified view of this larger body of work.

- *Key Variables in Projecting Carbon Prices:* The reductions being sought in this scenario are so large that they suggest a large-scale transformation in the world's use of energy. This in turn will require the imposition of a material carbon price signal that incentivizes this transformation, and the development and implementation of a wide range of new "reduced carbon" technologies, from carbon capture and storage to transportation systems that are fully electrified. The magnitude of the needed price signal is most appropriately derived from macro-economic analysis, an overview of which has been separately provided to NWPCC. Beyond the level of any given price signal, however, the timing of the price signal is a key predictive variable. The earlier a price signal is imposed, the easier it should be to achieve the ultimate targets (by giving the system more time to react). But there will always be political pressure to start with a low price signal under the assumption that 1) a much higher signal can be phased in later for political reasons, or 2) that the needed price signal is actually lower than a lot of economic modeling suggests.

- *Price Forecast:* We assume for purposes of this price forecast that climate change quickly becomes the policy priority required under this scenario, and that a material price signal is imposed on the economy almost immediately, whether through a carbon tax or a cap-and-trade market clearing price. Based on the assumption that ultimate achievement of the stabilization goal is the true priority, we would see a carbon price of $30/ton in 2020 as a reasonable step towards stabilization, with that price ratcheting up to $50/ton in 2030.

5 Conclusions

The results presented here should only be seen as indicative, and reflecting a complicated set of underlying assumptions. A lot simply isn't yet known about how the economy and technology development efforts will respond to a carbon-constrained world. There is at least some possibility that, given the appropriate incentive structures, low-carbon technologies will appear more quickly and more cheaply than is generally assumed. The Catch-22 of the situation is that such technologies are much less likely to appear if there is not a clear signal that carbon reductions will in fact have a significant value in the future.