SCENARIO ANALYSIS:
THE TRADITIONAL AND EMERGING CANADIAN FOREST INDUSTRY

Table of Contents

List of Figures

Introduction

Canada's forest products industry has been a major economic contributor to Canada. However, during the last decade the industry has gone through, what many consider, the worst crisis in its history (Benoit 2008). A changing global marketplace has weakened Canada's competitiveness and this has resulted in mill closure, poor financial performance and thousands of direct job losses (Forest Products Association of Canada 2010b). These difficulties have lead to the beginning of a discussion on the need to re-think, re-engineer and re-tool. This will as a backdrop for the sector as it seeks to implement new business practices and implement new industrial pathways.

To help the process of re-thinking, this paper presents four possible future scenarios, each of which represents plausible futures being considered. These scenarios have impacts on both traditional and new industries mainly through exploring how energy, carbon and fibre pricing will impact on the industrial pathways being considered. This type of analysis, discussed in more details in the next section, has been extensively used in a range of industries (Vecchiato and Roveda 2010) and by different environmental institutions (Pelli 2008, Moss et al. 2010), providing decision-makers at different levels a broader view and an improved understanding of the business environment they could face in the future.

The scenarios described below outline key drivers that might affect the effectiveness of potential business strategies for the forest industry until 2020. We neither assess the likelihood of each of these scenarios nor define how specific future markets and products will evolve during this time frame. Hence we focus purely on the rationale behind each scenario by hypothesizing on how events might unfold to produce potentially different futures. The intention is to demonstrate to policy-makers the need for flexible strategies in the face of an uncertain global market. In this report we illustrate the impacts of the scenarios on the potential biopathways for the interior of British

Columbia and for Quebec. We assign numerical values (Appendix 1) to some key economic variables (energy, fibre and carbon) and show how different forest products would perform in relative terms. The biopathway model used to generate scenarios was initially developed by each case based on a preliminary market model developed by FPInnovations.

The Scenario Analysis Approach

The world is continuously responding to global changes. The recent economic crisis, the increasing societal concern of environmental issues and technological advances are all change agents and they do cast a shadow of doubt on the future. In this context, how can an industry plan its development if we do not know what tomorrow will bring?

Scenario analysis provides a strategic planning method aimed to help decision-makers make flexible long-term plans. It consists in the development and assessment of a set of structurally different but plausible futures, called scenarios, that includes the major uncertainties in the business environment (Wack 1985b). Through the assessment of multiple scenarios, decision-makers are forced to expand their thinking and overcome the false certainty of a single forecast while increasing their readiness for the range of possibilities the future may hold (Roxburgh 2009). It is worth mentioning that scenarios are not, and should not be interpreted as, predictions that may or may not be right. They are a means of improving our understanding of the long-term global consequences of existing or potential trends and their interaction.

Although predictive models have been successfully used in forest management, for example in optimal decision making, their usefulness seems more appropriate in stable conditions. In contrast, scenarios might be more suitable to explore broad uncertainties like the ones the forest industry is now facing, namely changes in the global market, emerging technologies, social concerns and climate change. Under these conditions, predictions may not provide the insight required to manage for such an uncertain future (Morgan et al. 2008).

The methodology has its origins in military studies in the 1950's (Kahn and Mann 1957), but it extended its application to business corporations in the following decades (Linneman and Klein 1979, Linneman and Klein 1983, Malaska 1985). The well-known case for the use of the methodology was with Royal Dutch Shell (Wack 1985b, Wack 1985a). They started to use scenario analysis in early 1970's, and served as a catalyst for the use of the methodology by a number of important companies. Through the use of scenarios, Shell anticipated the major disruption in oil supply in 1973-74 and 1979-81 and survived the energy crisis in a better way than other larger oil companies (Schwartz 1991). Scenario analysis continues as an important tool for strategic planning at Shell (Cornelius et al. 2005).

Another example of successful use of scenario analysis is the Enron Federal Credit Union, now called StarTrust. Since 1986, the credit union became fully supported by the Enron Corporation, one of the most profitable companies in the 1990's that suddenly collapsed in 2001. In 1999, despite the reluctance of the union managers, an "unthinkable" scenario was developed where the union no longer relied on Enron, its single corporate sponsor. Later, when Enron collapsed, the credit union was saved because managers had taken actions to be less dependent on Enron (Day and Schoemaker 2005, Schoemaker and Day 2009).

Just as these two examples illustrate, many major companies currently use scenarios in one form or another (Vecchiato and Roveda 2010, Daheim and Uerz 2008). In forestry, the methodology has been used by different institutions such as FAO and the European Environmental Agency, among others, to assess economic and environmental consequences of environmental policies (Pelli 2008).

The Millennium Ecosystem Assessment initiative also bases its analysis on the use of scenarios about the change of the ecosystem conditions in the future (Millennium Ecosystem Assessment 2005), and some conservation efforts have also used this approach (Sayer et al. 2008). Since 1990, the Intergovernmental Panel on Climate Change has used emission and climate scenarios as a central component for assessing climate change adaptation strategies (Moss et al. 2010).

A vast literature exists on scenario analysis (Varum and Melo 2010), but there is no unified methodology on how to build scenarios (Bradfield et al. 2005). As stated by Moss and Glorioso (2010), scenarios can be viewed as tools that bring together logic and intuition, and make use of qualitative and quantitative information to improve understanding of things (Figure 1).
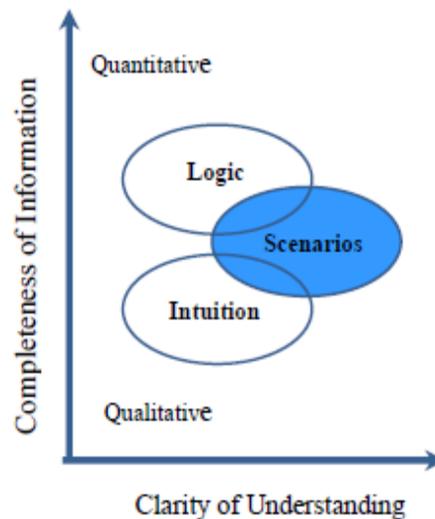

Figure 1. Scenarios bring together logic and intuition.

Most of the methods to build scenarios involves, to a varying degree, expertise, creativity and interaction among the participant entities. Less formal approaches include participative methods such as futures workshops and conferences. More formal techniques based on expert knowledge include cross-impact analysis, Delphi and expert consensus methods. Some authors have identified sets of steps that, although with different emphases and levels of detail, coincide in some aspects of the process in general terms (Huss 1988, Schoemaker 1993, Schoemaker 1995, de Jouvenel 2000, Mietzner and Reger 2005).

These steps might include the following:

(1) the definition of the problem and its scope (timeline, products, markets and geographic areas),

(2) the identification of key variables, trends and uncertainties (driving forces) that needs to be considered,

(3) the development of consistent and logic relationships among the variables and uncertainties previously defined,

(4) the creation of specific scenarios, and,

 (5) the analysis of the impact of these scenarios on the strategic decisions.

The lack of a formal methodology should not, however, preclude us from using scenario analysis as the assumptions underlying the scenarios seem to be more important than the specific methodological steps (Schnaars 1987). General guidelines on how to perform scenario analysis suggest the participation of creative, open-minded people as well as high level decision-makers or industry experts to develop the scenarios. The use of only a low number of scenarios (e.g. suggestions may vary from 2 to 6 scenarios) that ensures that the full range of possibilities is covered, the avoidance of assigning probabilities to different scenarios and the use of catchy scenario names are also suggested (Roxburgh 2009, Schwartz 1991).

Although some authors advocate the use of scenarios as tools for qualitative analysis only (see Schnaars (1987) for some discussion on this), certain interactions among the main factors describing in the scenarios can be formalized via quantitative models. In other words, models that guarantee internal consistencies of scenarios can consider quantitative variables (e.g., prices, growth rates, etc.) and produce valid outcomes of the main uncertainties without falling into becoming implausible scenarios (Schoemaker 1995). Once some uncertainties have been quantified, traditional decisions tool can be used to support the decision-making process.

Some decisions makers tend to base their decisions on a single predicted future to which quantitative tools are applied. At best they perform sensitivity analysis on crucial inputs, but rarely explore a broader view of the uncertainties. Hence, it is not evident what to do with the scenarios. Additionally, the development of relevant scenarios

requires a deep understanding and knowledge of the field under investigation, which emphasizes the selection of suitable experts and participants sometimes not easily available. All this makes the scenario analysis a very time-consuming practice.

Although a more scientific and formally structured methodology would make scenario analysis better accepted (especially by the academic community), its effectiveness in broadening the managers' perception of the business environment has been documented (Schoemaker 1993).

Description of Scenarios

In this section we explore some of the scenarios that could impact the Canadian forest products sector. The scenarios were developed within the framework of the Bio-pathway project. This is a project supported by the Forest Products Association of Canada (FPAC), FP Innovations, the Canadian Forest Service and Natural Resources Canada, among others. The analysis for each scenario evaluate the relative ranking of the traditional forest product industry with new products broadly referred to as bio-energy, bio-chemicals and bio-materials (Forest Products Association of Canada 2010a).

The identification of the scenarios is credited to two well-known experts[1] in the international forest sector. The main scenario inputs are, as mentioned, energy, carbon and fibre prices. The scenarios were given the following names: *The World Continues its Course, Repeated Economic Meltdown, Skyrocketing Energy Prices* and *Emerging Carbon Economy*. They are described in more detail in the next sections.

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[1] The two experts were Don Roberts, Vice-Chairman of CIBC Wholesale Banking, and Dr. Sten Nilsson, researcher at the International Institute for Applied Systems Analysis (IIASA).

Scenario A: The World Continues its Course

In the last 3 years the global economy has been affected by one of the most serious crisis of the last 7 decades. This has led, in recent years, to be one of the worst times in the forest industry history (Benoit 2008). Although the crisis is not over, global indicators suggest we are gradually coming back to pre-crisis levels. In this scenario, the assumption is that the crisis will pass in the next months and the main drivers affecting the industry will return to prices observed in 2007, in other words, *The World Continues its Course*.

Developed and developing countries regain the economic growth rates and general consumption levels observed during the period 2000-2006. In these conditions, US and Canadian housing-starts recover from the historical low levels of 2009 and push the demand and prices for lumber products and building materials upwards to pre-crisis levels. This recovered industrial activity also helps raising energy prices to an average level for the period 2010-2020 similar to the levels observed before the crisis.

As shown in Figure 2, the rate of return on capital employed (ROCE) of the different products is similar in both provinces, except for the production of pellets which seems to be a very bad investment in Quebec while producing moderate returns in British Columbia. In both provinces, emerging products (green bars) such as torrefied pellets, pyrolysis and acetate (via syngas) show the highest returns, but others like ethanol via fermentation and OSL are not profitable. Some traditional products (blue bars) such as newsprint, MDF and particle boards report negative returns. Note that only medium scale technology plants are considered for an easy graph interpretation).
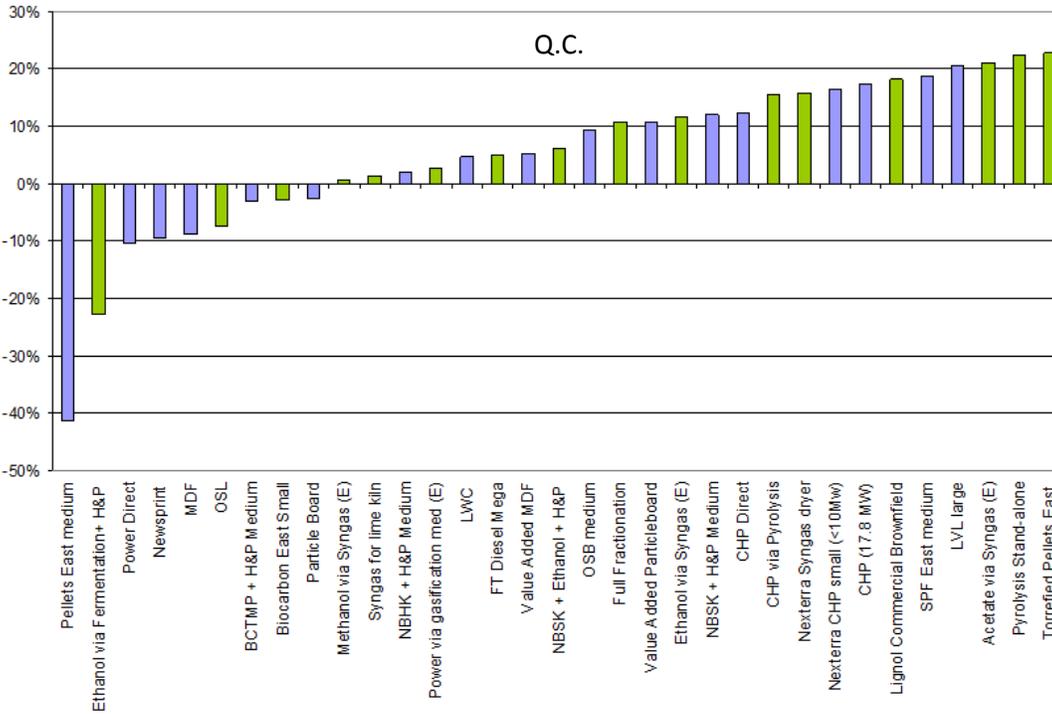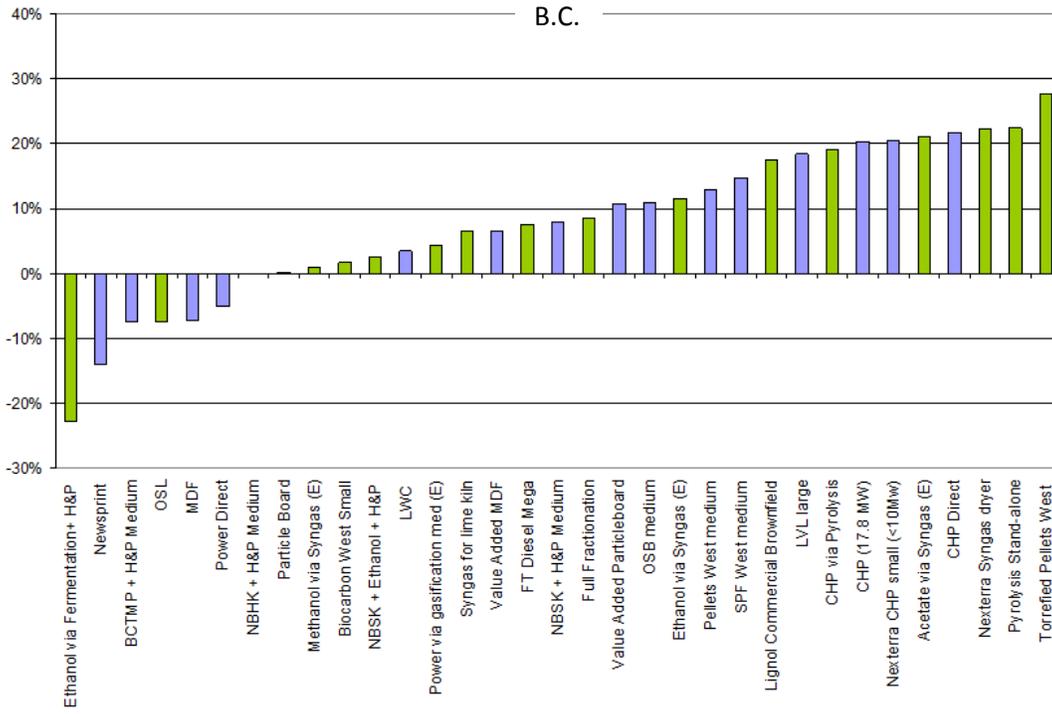
B.C.

Categories (left to right): Ethanol via Fermentation+ H&P, Newsprint, BCTMP + H&P Medium, OSL, MDF, Power Direct, NBHK + H&P Medium, Particle Board, Methanol via Syngas (E), Biocarbon West Small, NBSK + Ethanol + H&P, LWC, Power via gasification med (E), Syngas for lime kiln, Value Added MDF, FT Diesel Mega, NBSK + H&P Medium, Full Fractionation, Value Added Particleboard, OSB medium, Ethanol via Syngas (E), Pellets West medium, SPF West medium, Lignol Commercial Brownfield, LVL large, CHP via Pyrolysis, CHP (17.8 MW), Nexterra CHP small (<10Mw), Acetate via Syngas (E), CHP Direct, Nexterra Syngas dryer, Pyrolysis Stand-alone, Torrefied Pellets West

Q.C.

Categories (left to right): Pellets East medium, Ethanol via Fermentation+ H&P, Power Direct, Newsprint, MDF, OSL, BCTMP + H&P Medium, Biocarbon East Small, Particle Board, Methanol via Syngas (E), Syngas for lime kiln, NBHK + H&P Medium, Power via gasification med (E), LWC, FT Diesel Mega, Value Added MDF, NBSK + Ethanol + H&P, OSB medium, Full Fractionation, Value Added Particleboard, Ethanol via Syngas (E), NBSK + H&P Medium, CHP Direct, CHP via Pyrolysis, Nexterra Syngas dryer, Nexterra CHP small (<10Mw), CHP (17.8 MW), Lignol Commercial Brownfield, SPF East medium, LVL large, Acetate via Syngas (E), Pyrolysis Stand-alone, Torrefied Pellets East

8

Figure 2. The world continues its courses scenario

Scenario B: Repeated Economic Meltdown

Since 2007 the world's economy has experienced a profound crisis triggered by a liquidity shortfall of the United States banking system. Easy credit conditions of previous years fueled a housing construction boom and encouraged a debt-financed consumption. The increasing housing prices and credit boom attracted financial institutions and investors around the world to invest in the US housing market. Once money borrowers started failing to meet their mortgage payments obligations and entering foreclosure, housing prices declined and major financial institutions experienced significant losses. The damage of the financial system expanded from the housing market to other areas of the economy and loan types. Considered as the worst financial crisis since the Great Depression of the 1930's (Krugman 2010, Chossudovsky and Marshall 2010), it has resulted in the collapse of large financial institutions, the bailout of banks by national governments and downturns in stock markets worldwide, with total losses estimated in trillions of US dollars globally (International Monetary Fund 2010). Although some recovery has been observed in the first half of 2010, fears of a worsening of the situation still persist (Padoan 2010). We have called this scenario the *Repeated Economic Meltdown*.

In this scenario the fears of a double-dip recession materializes during the second half of 2010 or the first part of 2011. The massive US government economic stimuli that pushed the economy up in the previous months have ended, and eventual additional stimuli packages will only delay the next downturn. The excessive public debt observed in US and European countries has eroded the market confidence and increased the risk aversion of investors and company managers. Austerity and an undermined growth are unavoidable. Even though developing countries' economies have experience a significant growth during 2010, led by China, they are so dependent on exports to developed countries that this good patch ceases in 2011 and the years to come. Greek debt crisis is only the tip of a major structural problem that affects other European countries, and it produces a weakness of the euro versus the US dollar as it has been

observed in the last months (Nielsen and Zachariahs 2010). Already high unemployment rates (close to 10% in August 2010) in US (Bureau of Labor Statistics 2010) and Europe (European Commission 2010) continue to increase in the next 12 months and will only stabilize 2-3 years from now. Although some employment recovery happens after this period, consumers' new behavior favors savings and weakens consumption for a long time. As a consequence, the real estate market continues to decline, dragging house-buying and new house-starts rates to minimum levels and therefore reducing the consumption of traditional forest products such as lumber and panels. Fiber prices drop.

The reduced growth weakens the demand for energy, but the low investment in new oil explorations and developments of the last years also reduces the energy supply (International Energy Agency 2009a). The very low oil prices observed in 2001-2002 are not observed in the next years as the OPEC countries do not allow this to happen, but price levels below the last decade average are observed in the period 2010-2020. The long-term nature of electricity contracts protects the price from changes, and the need for major technical modifications to migrate from oil to natural gas also makes gas prices remain stable. The improved competitiveness of fossil-fuel energy due to low oil prices delays new developments in renewable energy projects, threatening emissions agreement to battle the global warming.

An overall reduction in the profitability of most of the products is observed in this scenario (Figure 3), as compared to Scenario A (Figure 2), although this profitability reduction is less severe in Quebec. Some products such as biocarbon, NBHK, CHP direct and BCTMP (Quebec) are favored under economic meltdown conditions. While torrefied pellets and pyrolysis increase their rate of return in Quebec, the opposite happens in B.C. As in Scenario A, pellets report very different returns in both provinces. Compared to the previous scenario, drastic reductions in the profitability of FT diesel (from about 5% to -30%) and SPF (from about 15% to -15%) occur in both provinces. As in Scenario A, only medium scale technology plants are considered for illustrative

purposes. Blue and green bars represent traditional and emerging products, respectively.
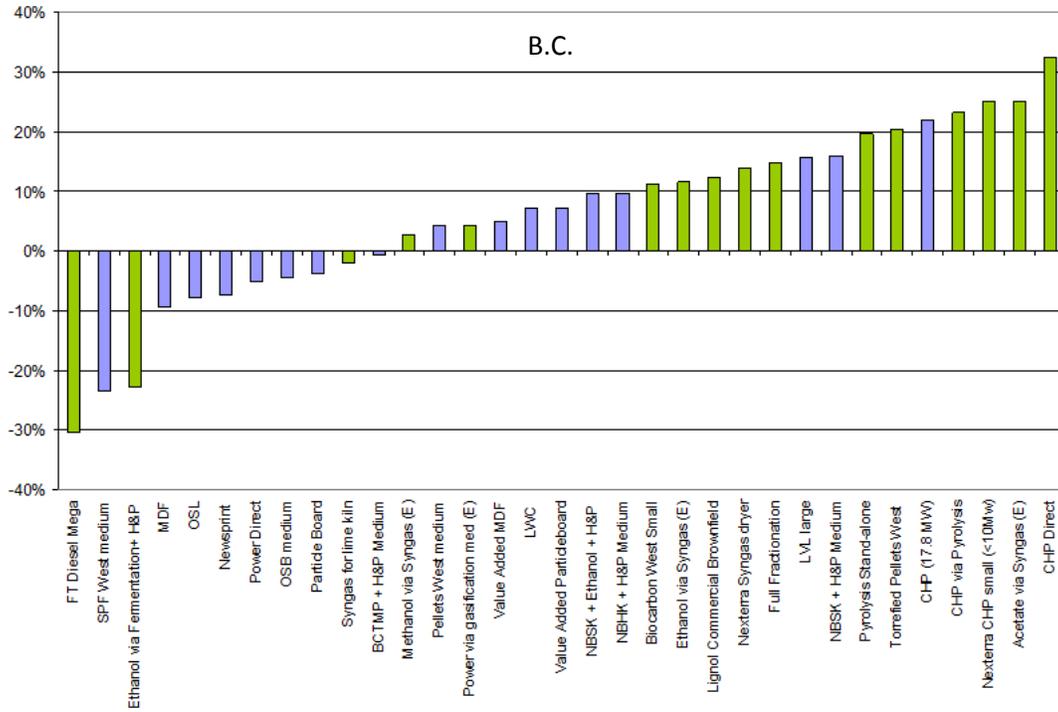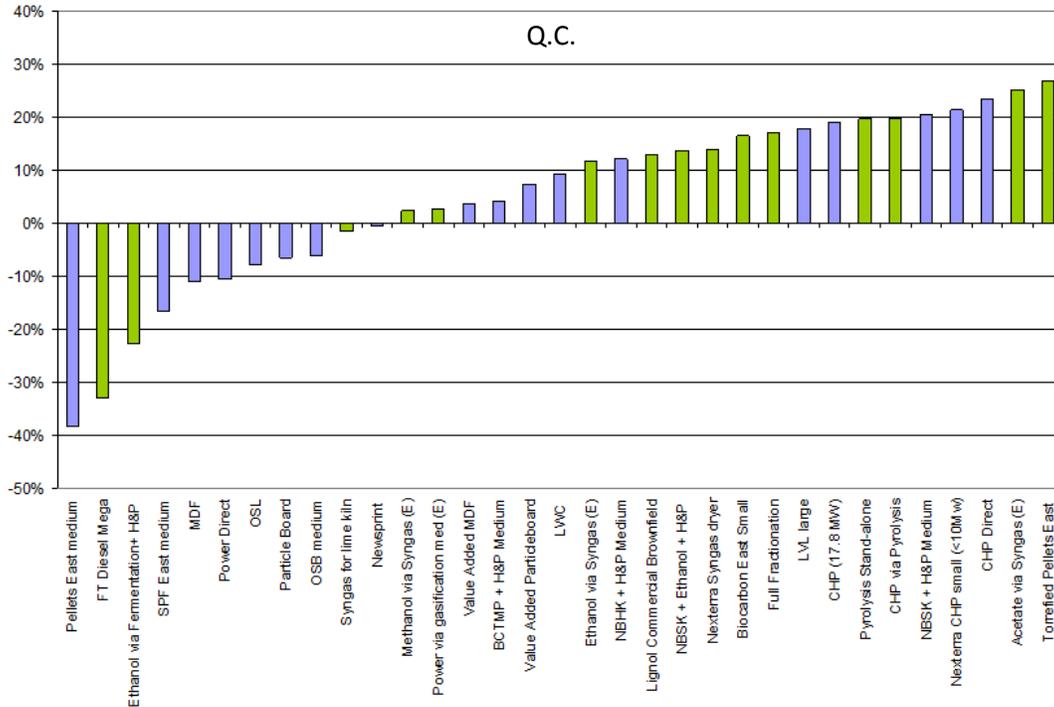
Figure 3. The repeated economic meltdown scenario

Scenario C: Skyrocketing Energy Prices

The consumption of energy in the last years has been largely influenced by the economic crisis experienced since 2007. A weak economic growth worldwide, the main driver of the energy consumption, translates into a 5.5% contraction in US demand for petroleum products by 2009 (Energy Information Administration 2009) and led the oil price to fall from a historical $147/barrel before the financial meltdown to around $30 at the end of 2008. Although current prices have stabilized around $75/barrel in recent months, *Skyrocketing Energy Prices* is a plausible scenario.

In this scenario the economic growth recovers in the next year pushing energy demand to levels even higher than observed before the financial crisis. Moderate growth rates in developed countries are by far exceeded by the economic prosperity observed in developing countries led by China and India. As these countries develop, industry, rapid urbanization and higher living standards drive up energy use, most often of oil.

Following the trend observed in the last decades, energy consumption continues to rise into the foreseeable future (International Energy Agency 2009b). For instance, China's 2009 energy consumption has outstripped U.S. according to the International Energy Agency (Hoffman 2010) and has seen oil consumption grows by 22.5% in the period 2005-2009 (Energy Information Administration 2010). India oil imports are expected to triple from 2005 levels by 2020 (Bush 2005), and the global oil consumption will likely rise by about 7% in 2020 from the levels observed in 2007 (International Energy Agency 2010b). Although this situation stimulates alternative supply and more efficient energy use during the next decade, it will not be enough to offset the growing energy demand (Shell International 2008) and puts upward pressure on oil prices.

Energy supply, on the other hand, does not match the expected rate of demand growth. The poor investment levels in oil and gas infrastructure of recent years limits the production and leads to a period of tight supply and higher prices (Jackson 2009, International Energy Agency 2010a). Moreover, the period of tighter credits, due to the current economic crisis, makes financing energy investment more difficult now (International Energy Agency 2009a).

Along with the high demand of the next decades and limited investment, "peak oil" theory supports the notion of an increasing price for fossil fuels (Owen et al. 2010, Sorrell et al. 2010). The peak oil theory refers to the point in time when the maximum rate of petroleum extraction is reached. It could be in the next decade (Maggio and Cacciola 2009, UK Industry Taskforce on Peak Oil & Energy Security 2010) if it has not already happened (Zittel and Schindler 2007). Once reached the resources start being depleted and extraction costs rise (Hamilton 2009).

In addition, there is an anticipated increase in fiber harvesting cost, due to high fuel prices, further reducing the profit margins for the traditional forest industry. In this situation, partnership becomes a key strategy in the survival of companies. High oil prices lead energy producers to make a play for fiber and increases the competition for the resource and the environmental pressure on forests.

Scenario C (Figure 4) indicates that the emerging products with the highest returns are energy products in contrast to the previous scenarios. Torrefied pellets, pyrolysis and acetate are displaced by FT diesel, CHP (17.8 MW and via pyrolysis), nexterra CHP and ethanol (via syngas). Although torrefied pellets and acetate profitability remains at levels over 10%, pyrolysis profitability in this scenario drops from returns of over 20% to -20% in both provinces in comparison to scenarios A and B. The high FT diesel profitability in this scenario (70% in both provinces) contrasts with the poor levels observed in scenario B. Clearly energy products are favored under this scenario.

Only the medium scale technology plants are considered for easier interpretation of the graphic. The blue and green bars represent traditional and emerging products, respectively.
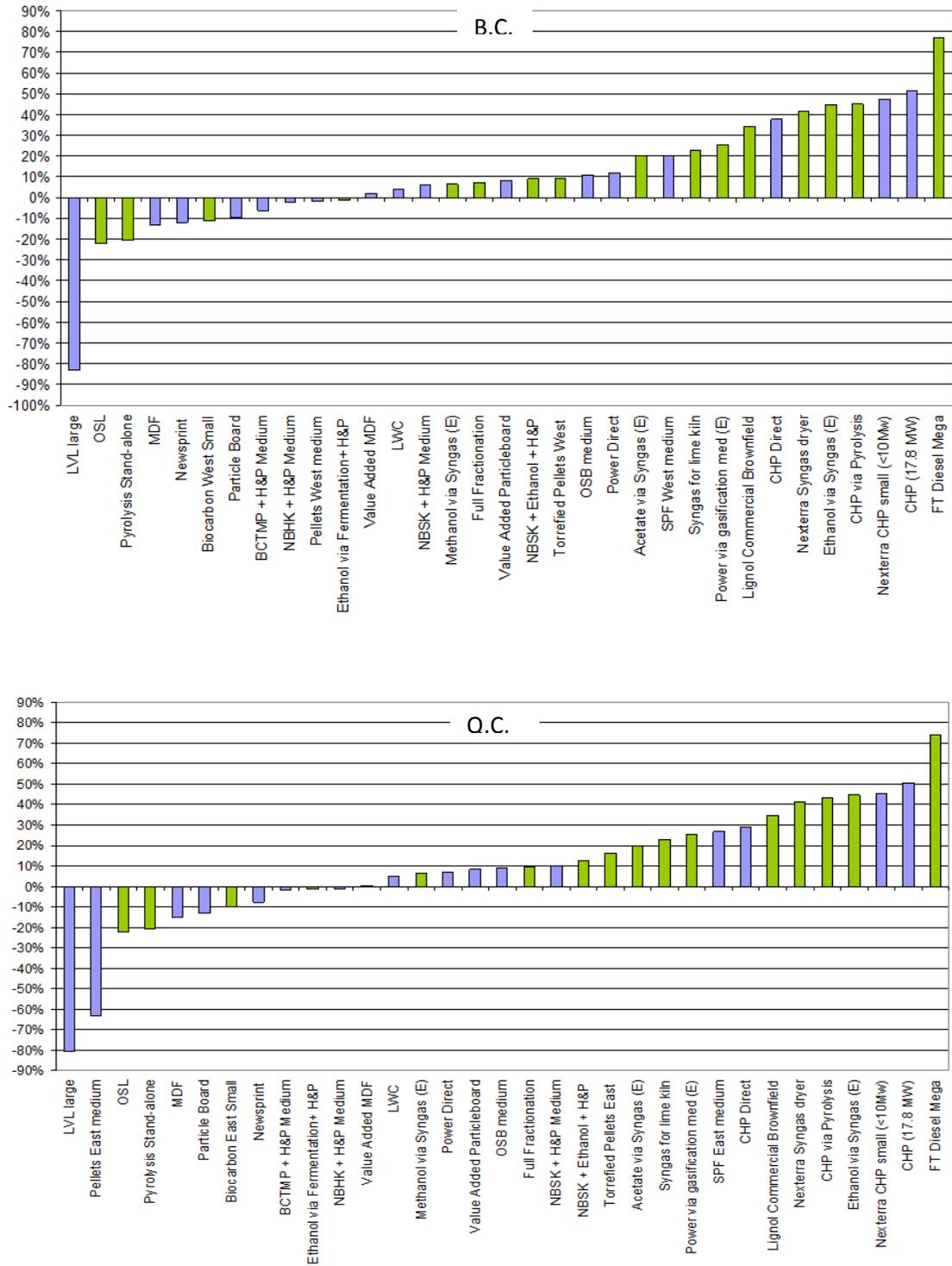
Figure 4. The skyrocketing energy prices scenario

Scenario D: Growing Carbon Economy

Global warming is an extensively accepted threat most likely caused by human activities (Oreskes 2004). The treat has led to increasing concentration of greenhouse gases (GHG). The main causes are considered to be the burning of fossil fuels and deforestation. In 1997 the Kyoto Protocol established a binding international agreement in which all the participating nations commit themselves to tackle global warming and greenhouse gas emissions. To date, 192 parties have agreed in an average of five percent reduction of their GHG emissions against 1990 levels by 2012, when a new international framework needs to be ratified (United Nations Framework Convention on Climate Change 2010). Billions of dollars in government investments in clean energy (REN21 2010), a strong growth of the carbon market since 2003 (Capoor and Ambrosi 2009) and an increasing interest in the use of renewable energy might make the next decade witness of an *Emerging Carbon Economy*, one in which business activities adopt resource efficiency and low carbon solutions.

In Scenario D, a dramatic growth in the pricing of carbon (administratively through taxes or through voluntary or compliance markets) happens after 2012. When this happens new initiatives to build worldwide and regional trading mechanism come into effect in the E.U. and U.S. (GBI Research 2010). A global carbon trading system is a fixture in the world economy in the next decades, and carbon becomes a commodity regulated worldwide. Government policies enforce the reduction of fossil fuel use in favor of other power generation alternatives among which biomass-based generation plays an important role.

For example, in the U.K., the recently launched (April 2010) Carbon Reduction Commitment Energy Efficiency Scheme (UK Carbon Reduction Commitment 2010), is a mandatory scheme for thousands of companies to evaluate, assess and report their energy usage and carbon emissions. Companies failing to report or exceeding emissions target face fines or carbon taxes. The increasing demand for carbon offsets continues and forest lands become a key resource to provide carbon solutions (McKinsey & Company 2009), with forest-related projects being even more cost

effective than green technologies (Figure 5). Forest lands increase their value due to this high demand of carbon offsets, particularly on private lands where ownership issues facilitate the transaction of carbon credits. Longer rotations, on the other hand, reduce the availability of fiber which contributes to an increase in the cost observed by the traditional forest industry.
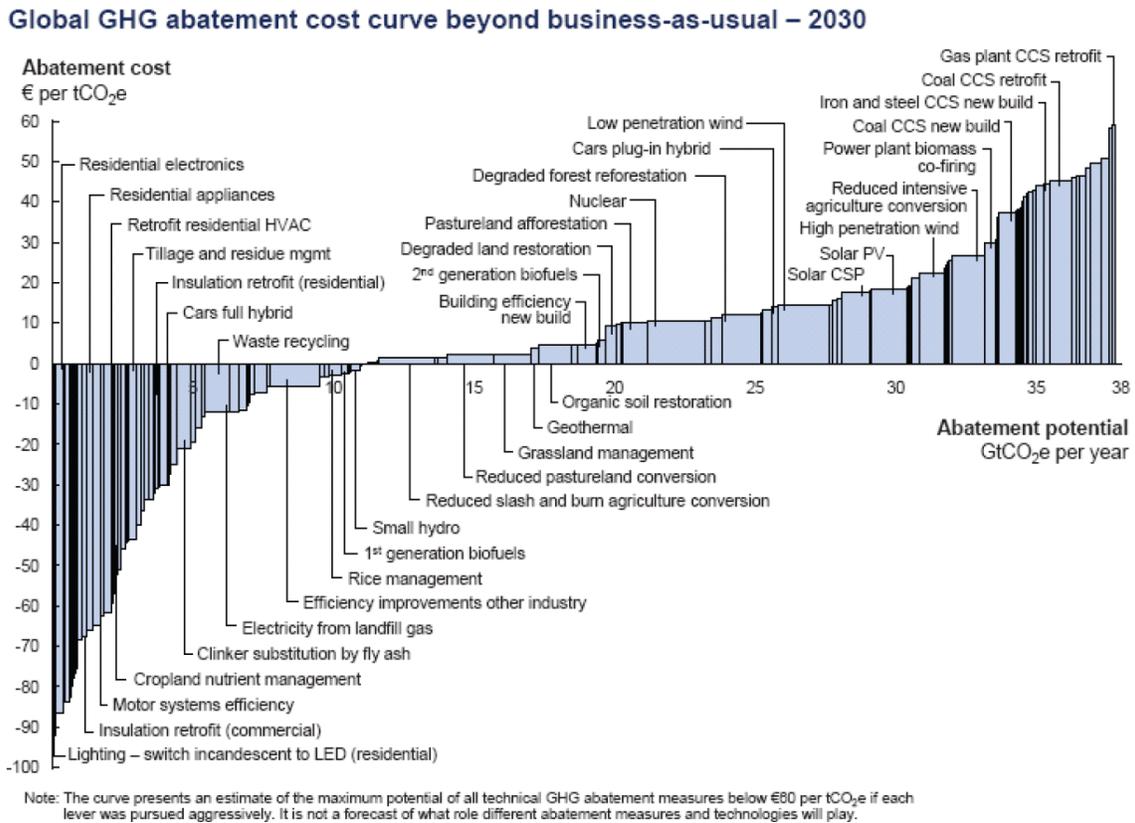

Figure 5. Marginal abatement cost curve for forest and green technology projects.

(Source: McKinsey & Company 2009)

Developed countries continue to increase their investments in clean energy developments and developing countries, although at a lower scale, follow this trend. Financial initiatives to attract investors, like the US$ 3 billion green investment bank initiative announced by the UK government (Reuters 2010), increases the incentive for

the private sector to enter this market. The current financial crisis has stimulated major companies to re-structure their operations making more efficient and greener supply chains. Worldwide economic stimulus to recover from the economic crisis mostly translates into the development and adoption of energy-efficient fuel technologies.

Clean energy technologies becomes cheaper. The price of bio-fuels declines as non-food feedstock, waste streams and algae become harvestable. People's attitude towards energy-efficient technologies is a key driver of new developments. The already significant global level of awareness of climate change (Pugliese and Ray 2009) extends in the next years, and consumers pressure companies to address environmental issues like low carbon emissions and energy efficiency. Companies that do not adapt to this new type of consumers expose themselves to serious losses in their values (Titley et al. 2009).

Under these circumstances emerging products are more affected than traditional ones, although torrefied pellets and acetate (via syngas) remain among the best positioned products in both provinces (Figure 6). FT diesel moves from the first place in ROCE in Scenario C to the lowest position with returns below -110%. Other than the case of pellets, no major differences between B.C. and Q.C. are observed. In this scenario the ROCE of all products is affected even more than in scenario B, since 15 out of the 33 products report negative rates of return due to the increased fiber cost imposed by the price of carbon. As with the other scenarios only medium scale technology plants are considered for an easy graph interpretation. Blue and green bars represent traditional and emerging products, respectively.
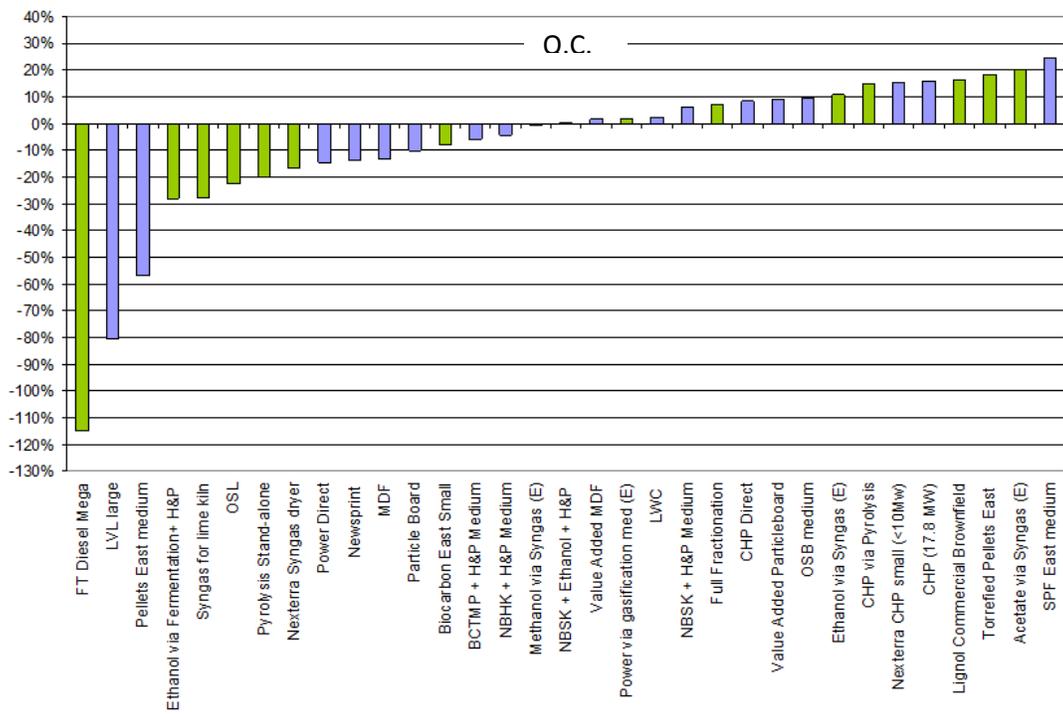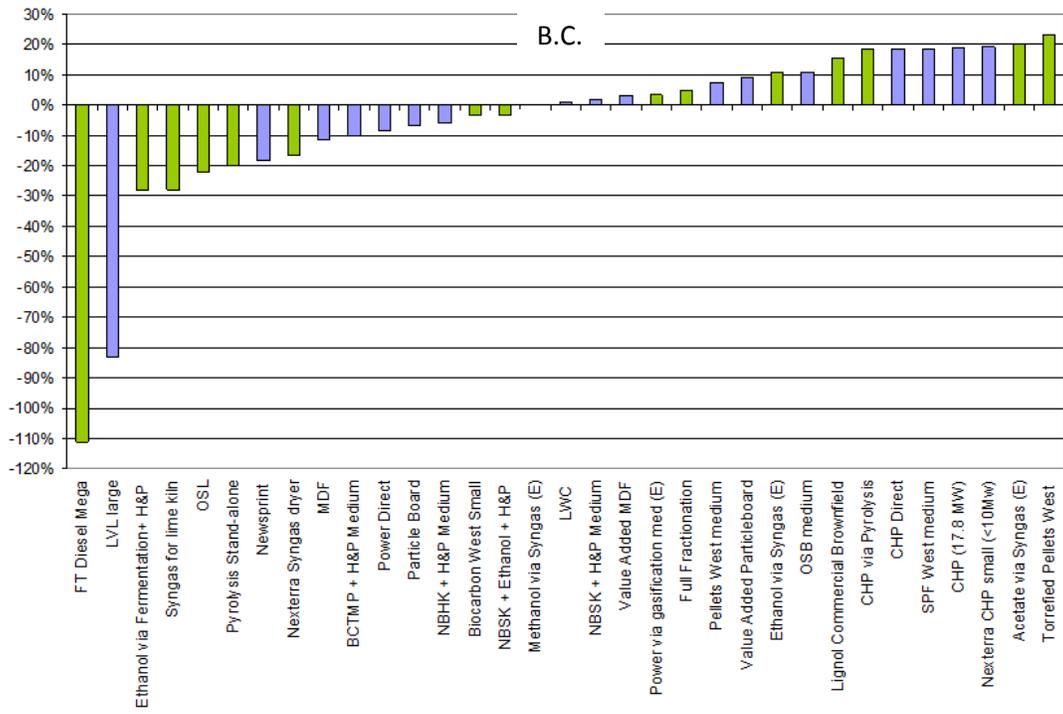
Figure 6. The emerging carbon economy

19

Linking Scenario Analysis with Operational Decisions

The scenarios presented in this paper are meant to represent global uncertainties in the decision system. Our approach has been to justify each scenario and then use the biopathway model from FP Innovations to illustrate the impacts on the current and emerging technologies and products being considered in the forest products industry.

In order to be more realistic and relevant, an important challenge is to translate these scenario specific and global scale pictures to local scale decisions through a coherent downscaling mechanism. Different approaches have been used in which information on a coarser scale is transformed and made available on a finer scale (van Vuuren et al 2010). They range from simple algorithmic downscaling that use little information at the local scale to more complex approaches that embrace different models that interactively link different scales. This is a more suitable scheme when distinctive local realities are present as in the forest industry throughout Canada. Other examples exist in Europe, where they explore the dynamic of future land use changes in Europe by integrating three different models (Verburg et al 2008).

A general framework that connects scenarios at a macro-level with lower scale decisions should at least contain three hierarchically assembled types of models (Figure 7): (1) a macro-model that accounts for the global drivers that govern the world trade and is able to explore the effect of different scenario settings on the forest products trading; (2) a national-level model that captures exogenous driving forces from the macro-model and allocates production to different areas along the country based on region-specific conditions, and (3) local models that under the framework provided by the national-level model look for concrete decisions at specific locations and at the different levels of spatial detail. Lower scale levels do interact with upper scale levels in a way that specific decisions have an impact on the national level performance that can therefore affect the driving forces at the macro-level. Hence a proper feedback mechanism among the different scales should be defined. The approach largely resembles the hierarchical structure used in forest planning (Weintraub and Cholaky,

1991), with the difference that in our case the use of scenarios extends the scope to a much larger scale with less emphasis in the temporal component of the analysis.
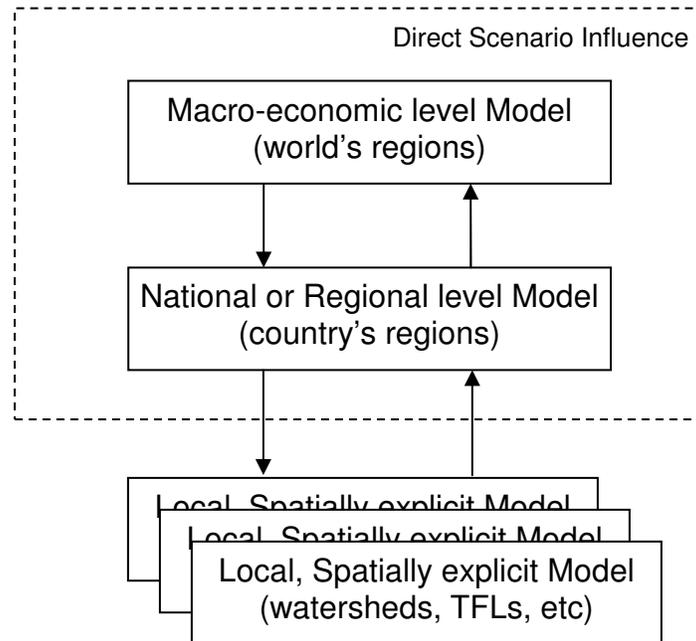

Figure 7. Integrating model for scenario analysis at different scales

Final Thoughts

We have described four possible future pathways that might have significant impact on the effectiveness of any strategy that the Canadian forest sector adopts for the next years. The proposed scenarios are not intended to provide an accurate picture of the next decade, but to create awareness of the level of uncertainty that decision-makers face when looking for a new strategy for the industry. The process of scenario analysis has proved in the past to be very helpful in many industries. As Wack (1985b) states, it is in changing and uncertain times that the real opportunities to gain competitive advantages through strategy emerge.

Preliminary results about the economic performance of traditional and emerging forest products under the four scenarios showed the significant impact that uncertain future

conditions may have on their profitability. However, some pathways proved to be less sensitive to future conditions. For instance, using a MaxMin rule to identify the pathways that maximize the minimum payoffs for all the scenarios, acetate via syngas, nexterra CHP, CHP 17.8 and CHP via pyrolysis proved to be the most robust technologies in both provinces with ROCEs greater than 15% and 19% in Quebec and B.C., respectively.

Other pathways showed very high volatility, e.g. FT diesel, LVL and nexterra syngas. This volatility increases the risk of failure of possible strategies that consider these products, but at the same time might report substantial benefits if the future unfolds favorably. Strategies that explore this tradeoff should be evaluated to design an optimal portfolio of investment that provides good risk-limited returns. For example, examining the correlation of ROCEs among all the pathways for the four scenarios, CHP 17.8 and torrefied pellets show a highly negative correlation (-0.92, which means they respond differently to the different scenarios) while providing a combined return of over 20% in all the scenarios for both provinces. This 20% return is not guaranteed for each of these technologies independently.

We recognize the need for further discussion on whether the main forces driving the future are or are not represented in the proposed scenarios. The behavior of the variables affecting the business decisions under each of the scenarios described also deserves discussion. For instance, how will exchange rates evolve or what the demand will be in 2020 are all questions that merit a further analysis. The scenario analysis process should in essence be participatory and open to an informed discussion. Dialogue among forest sector experts, managers and practitioners can help, not to predict the future but, to find systematic ways to look for alternative futures (Pelli 2008).

In addition to the scenarios themselves, how the scenario analysis approach may be incorporated into the decision-making process needs to be defined. Medium to long term decisions should consider this analysis as a valuable framework in which the impact of proposed actions can be evaluated. In this context, the use of decision-

making techniques suitable for highly uncertain environments would be beneficial if mathematical tools are used and flexible decisions are to be made.

Finally, long-term global strategies will affect operational and local decisions, so a proper spatial and temporal integration framework needs to be designed for Canada.

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Appendix 1

Summary of the main variables (same for both provinces) used in the market model, by scenario

Variable	Scenario			
	The world continues its course	Repeated economic meltdown	Skyrocketing energy prices	Growing carbon economy
Oil ($/barrel)	70	70 - 70	140 - 140	70 - 70
Nat. Gas ($/GJ)	6	6	10	6
Electr. ($/MW)	120	120	120	120
Softwood Sawlog ($/odt)*	139	139	178	167

* This is a representative fiber product; all other products changed their price in the same proportions.