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FOR/Maine

Global Market Analysis and Benchmarking Study
Phase 2: Product Ranking and SWOT Analysis

Final Report with Executive Summary and Recommendations

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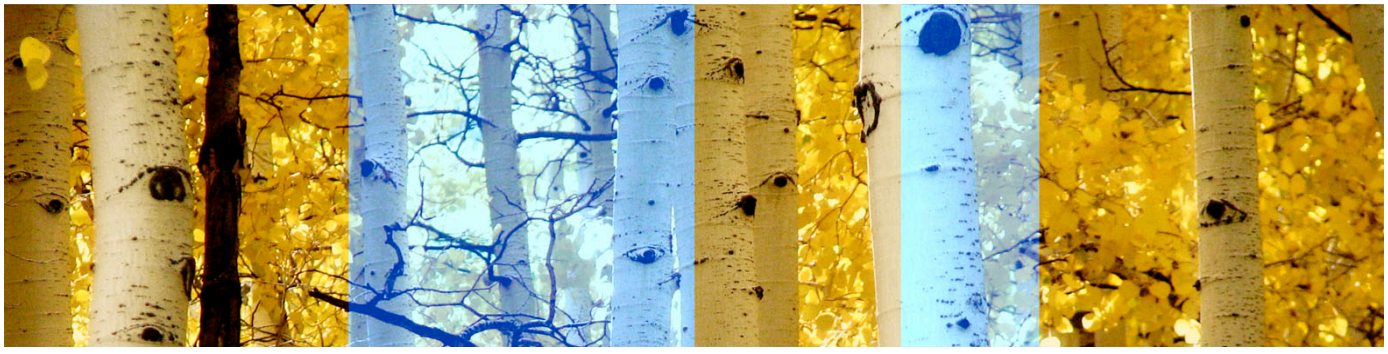

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EXECUTIVE SUMMARY

FOR/Maine commissioned this study as part of a strategic planning process to position Maine's forest industry for future market opportunities that leverage the state's forest resources, generate jobs and grow Maine's economy. The study was conducted in two phases: (i) a global market analysis for existing and emerging wood or wood-based products, and (ii) a benchmarking study to evaluate Maine's comparative advantage to produce and market such products.

The global market analysis covered 21 products selected by FOR/Maine in consultation with Indufor to ensure a balanced analysis of products at various points in their lifecycles – from emerging products with uncertain futures to established products in highly competitive markets. The selection emphasized products that can grow Maine's entire forest industry, utilizing available softwood resources, by-products and forest residues. The 21 products were analysed in terms of the current market sizes, expected growth, barriers to entry, competition, and opportunities or constraints to production in Maine. The products were then analysed for their fit within Maine in terms of utilization of Maine's softwood resources, labor productivity and product lifecycle. Based on these analyses, Indufor determined that the top six products for Maine were: sawn timber, dissolving pulp, OSB, nanocellulose, LVL and MDF.

In consultation with FOR/Maine, six products were selected for benchmarking against other regions: dissolving pulp, nanocellulose, LVL, MDF, cellulosic sugars (which provide a base for derivatives), and pyrolysis oil. These products were selected because they are newer to Maine than the existing products that are well understood by stakeholders – such as sawn timber and OSB – or that have seen recent investment like CLT. The inclusion of MDF was based on the market opportunities for sawmill residuals, and cellulosic sugars were included since they provide a platform for the production of many emerging biobased products. The benchmarking study compared Maine's relative position to eight regions where the products are currently produced: Canada (Ontario), China, Finland, Germany, Russia and the United States (Georgia, Minnesota and Oregon). Indufor then assessed each region's relative strength to produce and market the six products and conducted Strengths, Weaknesses, Opportunities and Threat Analysis (SWOT) for Maine on its top three products: dissolving pulp, nanocellulose and pyrolysis oil.

Maine's primary advantage is its plentiful supply of moderately priced softwood raw material available in an area with existing harvesting and logistics infrastructure. However, a major increase in pulpwood demand (in the range of several million tons per year) would inevitably erode both availability and raw material cost competitiveness. Therefore, a processing option that moderately increases the wood use is best suited for the area.

The labor cost competitiveness of Maine is internationally weak, but on par with other regions in the United States. Therefore, the focus in attracting new wood processing industries should be in products in which the labor cost component is small relative to product value. Labor cost constitutes only a relatively small share in dissolving pulp cost structure. While hardwood dissolving pulp currently dominates the growing viscose for textiles market, dissolving pulp derived from softwood is used predominately for acetates and ethers with increasing use for viscose production observed in the market. As the total market for dissolving pulp is growing at an attractive pace - specifically as a raw material in the textile industry (viscose) - softwood dissolving pulp may see increasing growth potential.

Maine has a more stable operating environment compared to China or Russia and similar to the other regions. Yet, the state has has consistently been ranked low for ease of doing business compared to other states.[1] In many respects the investment climate in Maine is similar to that of Finland several years ago. Forestry companies in Finland subsequently innovated and focused on the highest value products in order to counteract its high wood costs and labor costs. Maine's forest industry will very likely need to do the same. Therefore, nanocellulose, pyrolysis

[1] Forbes. 2017. Best States for Business.

oil and cellulosic sugar products appear to be attractive complements to the traditional wood industry.

Maine is also closer to very large population centers in the Northeast compared to most other regions, including Eastern Canada or the U.S. South. Therefore, Maine has an advantage in products that are not economical or suited for long-distrance transport have an advantage. Moreover, the sea freight cost from Maine to China was found competitive, which opens opportunities. Maine could improve its comparative advantage through investments in infrastructure and take full advantage of the proximity to end-markets. Investments in infrastructure would include improved railway network and sea ports. MDF, LVL and pyrolysis oil are considered regional products, whereas dissolving pulp, nanocellulose and cellulosic sugars are traded on the international markets. Pyrolysis oil as a replacement of heating oil is one such product that would benefit significantly from the large local markets. As technology improves and markets open, the use of pyrolysis oil for jet fuel product could expand the market for Maine. Improvements in logistics infrastructure would especially benefit MDF production placing Maine among the most attractive locations for MDF investment.

In attracting new wood pulp-based investments, Maine can make use of the existing pulp mills by repurposing them or integrating new manufacturing lines to the mills. Modernization of mills is likely to be less capital intensive and the start-up period is notably shorter than constructing a new mill. Maine has a disadvantage in that it is not a home to numerous large forest industry companies. Therefore, it lacks the lobbying power brought to many of the competing regions by large international forest industry companies (such as UPM, or Stora Enso in Finland, or Norbord in Ontario, Canada). On the other hand, it has the University of Maine Process Development Center, which works with many forest industry groups from various regions of the world. This can be an important avenue for introducing Maine to these companies. Additionally, Maine's large private forest ownership – compared to competing regions with fragmented or large public forest ownership – presents an opportunity to quickly take advantage of market shifts.

The state's traditional forest industry could be complemented by a a strong bioeconomy strategy. Improving Maine's enabling environment in the forest and bioeconomy sector through stimulus in the form of incentives, bioeconomy focused funds, R&D funding and low-interest rate loans could support such a transition.

Recommendations

The State of Maine has a long and proud history in the forestry industry in North America. Today, Maine remains an important supplier of a range of valued forest products and with expanding availability of logs over the coming years, it has the unique opportunity to become a leading forest products producer in North America.

Based on the analysis of market opportunities for Maine's softwood and biomass resources and the state's current competitive position, Indufor has produced the following recommendations for the FOR/Maine to consider in its next steps. Some of the recommendations are near-term and likely achievable, while others require bolder and longer-term concerted effort.

1. **Develop and communicate an ambitious bio economy strategy with enhanced access to financing for new investments**
   Market opportunities for new bio-products exist and are likely to grow in the medium to long-term, which means that Maine, as a location for new investments will be competing against other national and global competing locations. The EU, Canada and China are already implementing policies to strengthen the operating environment and incentivize bio-product investments. As an example, Finland's bio economy strategy was produced in 2014 and identified key steps and assigned responsibilities to government agencies, trade associations and research institutes. Maine has a narrow window to develop a state-wide bio economy strategy to assess external competitors and changes to be made in the state. Developing a bio economy strategy that has broad public support will require significant communications efforts to key constituencies and

potential investors. The state must also keep track of changes to the market and competitive landscape over time, by updating the current benchmarking study regularly and organizing annual or biannual meetings with the relevant stakeholders.

As part of the bio economy strategy, Maine can take a leadership position to stimulate demand and encourage investment. Many of the emerging products are currently more expensive to produce than their fossil-based counterparts. Maine can stimulate the market demand through ambitious mandates to use "made in Maine" cellulosic biofuels in all or part of the government vehicles, adopt building codes that promote the use of new wood products, promote the substitution of wood based plastics, or mandate that all state facilities use bioplastic products. Additionally, a mandate to phase out the use of conventional heavy fuel oil, to be replaced over time with pyrolysis oil, or promotion of compostable bags like PLA-based bags would increase overall market demand. Maine can also use its political influence at the national level to push for stimulus packages targeting bio-products and federal procurement policies. Providing marketing and commercialization support for its leading R&D projects like nanocellulose can help Maine position such manufacturing for growth.

While Maine does provide some tax credits for new job-creating investments and commercial production facilities, they could be enhanced to attract the substantial new investment required to make Maine a true competitor in the bio economy. Concessional finance with lower interest rates for high CAPEX projects might be required for converting existing mills to dissolving pulp production. New, creative forms of financing that blend grants with first-loss debt could attract more equity investment interest in the emerging products (cellulosic sugars, fuels and chemicals). Working with foundations or banks that have experience arranging such deals will be essential.

Lastly, communicating Maine's bio economy image to national and global audiences will be a key factor in success. The Nordics and parts of Canada are known globally to be eco-friendly investment locations. Maine will need to deliver clear messages on its intent to be a leading bio economy to compete.

2. **Identify and target commercial off-take contracts**
   Increasing consumer awareness of environmental sustainability has led leading consumer brands to commit to a switch from fossil-based chemicals and plastics to bio-based alternatives. Innovative bio-based products, such as nanocellulose, biochemicals and PLA, would be able to supply a number of markets. As many of these are intermediate products, partners include fuel, plastic, packaging, textiles, and polymer producers, among others. This creates a large potential for a captive offtake market, by which one large company could buy the majority or entirety of a plants' production.

   While overall volumes remain small, the products have a high added-value and, as such, are viable exports. Companies such as Unilever, P&G, Ikea, Coca-Cola and Lego have all committed to increase their consumption of bio-based plastics. Currently, bioplastics sell at an average premium of 15-40% over the price of conventional plastics. Thus, investing in market studies to identify potential off-take customers for these products, even in smaller volumes, would be a small investment with potentially large returns.

   Supporting small businesses to re-open previously shut-down mill sites from the pulp and paper industry to demonstrate and scale up biofuel technology would bring new jobs and prestige to the area. As some examples of demonstrated technology can now be found, the next step would be to find off-take partners willing to buy all or large portions of the product, particularly for existing pilot scale products, such as nanocellulose and cellulosic ethanol.

   Generally, understanding the market dynamics and global megatrends, such as the growth of the middle class in developing countries, leading to a rapidly increasing demand for hygiene products, or the growing demand for sustainable packaging materials through the onset of the on-demand and online consumer revolution, would highlight the opportunities for investment that would pique the interest of many large brand-owners and build investment confidence.

3. **Invest in infrastructure**

Maine has an advantage thanks to proximity to end-markets and competitive long distance transportation costs, however the benefit of the location is undermined by outdated (and degrading) infrastructure. Public support for infrastructure investment appears to be growing in the United States. To ensure that Maine stays competitive it must maintain rail, road and port infrastructure to cost-effectively reach regional and global markets.

4. **Make Maine "business-friendly"**
   Maine's historically low ranking for ease of doing business is tied to high corporate taxes and the complexity and stability of regulations. Given the current labor situation in Maine (not being a "right to work state"), negotiations with the labor unions to update and modernize the way in which people are employed are recommended. Modern industries require greater flexibility – both regarding hours/shifts, but also in terms of where and how people fulfil their role in the workplace..

   Likewise, the efficiency of employees can be improved as the global forestry industry embraces the automation and digitalization revolution. The shift towards greater automation requires upfront CAPEX investment by industries but is considered an integral part of evolving and keeping industries competitive. Thus, the need for large-scale retraining activities is urgent in many forest sectors. By creating investment support through tax rebates or favorable depreciation rates, Maine could increase the competitiveness of their existing forest industry and spur the economy, leading to increased employment opportunities. Grants for new solutions and research, education, re-training, upskilling etc. should be employed. At the same time, this necessary transition into automation will potentially displace some of the work force for which new employment opportunities can be created in innovative and emerging market segments, such as biofuels and biochemicals.

5. **Drive down energy costs and support bioenergy**
   While bioenergy is currently being utilized in Maine, the majority of this is utilized by the forest industry. Additionally, the use of bioenergy in combined heat and power (CHP) is low outside of the forest industry. As increased subsidization to bioenergy is likely to draw criticism from some political adversaries, other support mechanisms should be considered. For example, a minimum requirement for new state-owned facilities to utilize biomass for CHP would encourage not only the use of sawmilling residues, but also improve the carbon footprint of the heating sector. As Maine has a relatively high heating demand, the transition away from heavy fuel oil with biomass boilers and pyrolysis oil would be a large step towards meeting their renewable portfolio standards and targets. Pyrolysis oil would qualify as a Class I renewable source. This is an issue that can be turned into a major plus for the forest industry.

   Many forest industries have the potential to be either self-sufficient or energy positive when using mill and forest residues. Promoting the use and generation of this energy can be directly supported by the State of Maine. This could be in the form of attractive feed-in tariffs, carbon credits, support with investment costs for biomass power plants (integrated into processing facilities) and various other incentives and favorable regulation. If done well, Maine could use this as a major upside to the State and attract new bio-based industries, including but not limited to bioenergy and liquid biofuels. As a comparative example, Europe has made major achievements by mandating a minimum target level of renewable energy and renewable transport fuels, for which a penalty is incurred if these targets are not reached.

6. **Go Out and Attract Investment**
   Indufor suggests that Maine actively attract investment in the forest products industry by directly targeting potential investors. Potential investors should be identified, ranked and monitored, and those that are attractive and appear to be evaluating investments should be engaged, ensuring that a Maine location for their new investment will be considered and evaluated fairly based on detailed and accurate information on Maine's resource availability, operating costs and supportive regulatory environment.

1. INTRODUCTION

The product ranking was conducted by giving each short-listed product weights in relation to nine indicators (Table 1.1). The weights were given between numbers 1 to 5, where higher weight number equals higher importance of that particular factor in relation to each product. When determining the weight, the significance of each indicator versus other indicators were considered. The selected regions were scored against each factor afterwhich the score was multiplied with the respective weight to determine whether the region had comparative advantage or disadvantage against others.

On the raw material availability indicator, the weights were determined based on the raw material consumption of typical plant sizes of each product. For example, dissolving pulp mill requires significant volumes of wood raw material and thus has a higher weight. Accessibility to wood was also considered when judging the score. For example in Russia, despite the large volume potential, the volumes are spread out to large areas with mediocre or poor accessibility.

Raw material and labor cost weights were determined based on their relative shares from the end-product prices. Here, laminated veneer lumber (LVL) has high weight on raw material cost where raw material cost can typically comprise 50% to 60% of the total unit cost structure. In case of medium density fiberboard (MDF), the ranking considered also the general price levels of the countries because approximately 50% of the raw material costs comprise of chemical and other costs.

Labor skill weight was determined based on the general level of education and considering the level of specialized expertise required and available. For example, nanocellulose is considered state of the art technology which requires labor with specialized skill sets.

Freight and infrastructure refers to the logistics infrastructure and to the transportation costs to the relevant end-markets. Freight and infrastructure weight was determined based on the locality of the products. The products which are consumed locally were given higher weight.

Regulatory climate weight was determined based on the positioning of the product in the regulatory climate and related regulations. The regulatory climate of each region was based on analysis of regulations on forestry, environment, emissions and construction. For example, dissolving pulp and MDF manufacturing processes are known of substantial emissions and thus have higher weights.

Taxes were considered at low weight (1) to all products as the most significant tax is the corporate tax and is equal across the products.

The weight of enabling environment was determined based on the relevance of policies affecting specifically R&D and incentives in relation to the product. State of the art products were considered to have a higher relevance due to the dependency on public policies.

Energy was given weight based on the industrial energy cost and its relative share of the end-product cost structure. The significance of energy cost was considered low across the board.

Table 1.1 Weights per indicator per product

Indicator	Dissolving pulp	Nano cellulose	LVL	MDF	Cellulosic sugars	Pyrolysis oil
Raw mat. availability	5	3	3	3	4	3
Raw mat. cost	4	2	5	4	3	3
Labor cost	2	2	3	3	2	2
Labor skill	3	4	2	3	3	3
Freight/infrastructure	2	1	4	4	2	3
Regulations	3	2	2	3	3	3
Taxes	1	1	1	1	1	1
Enabling environment*	3	5	2	1	4	4
Energy	2	2	2	2	2	1

5 = very high importance, 3 = moderate importance, 1 = very low importance. (*) including policies, i.e. incentives, research and development (R&D).

After determining the weights, the selected countries and regions were scored for each product. The scores were given between numbers 1 to 5, where 5 indicates excellent, 3 average and 1 poor performance. The descriptive country reports and the results from the country benchmarking were used to determine the scores. The product ranking was conducted for those countries and regions shown in Table 1.2.

On country/region level and in certain areas, the short-listed six products score in the same way in relation to the nine indicators. For example, the characteristics of the pulp products are assumed to have only nuance differences between countries/regions.

Table 1.2 Products included in the analysis by country

Indicator	Dissolving pulp	Nano cellulose	LVL	MDF	Cellulosic sugars	Pyrolysis oil
Finland	x	x	x	x	x	x
Germany		x		x		x
North-West Russia	x		x			x
Canada, Ontario	x		x	x	x	x
US, Georgia	x		x	x	x	
US, Minnesota	x			x	x	x
US, Maine	x	x	x	x	x	x
US, Oregon				x		
China		x	x	x	x	

In the product ranking below, the higher score is always better. For example, if score on raw material is high it means that the raw material costs are low. In addition to the quantitative data, insights from the descriptive country reports were taken into consideration when judging the scores.

2. PRODUCT RANKING

2.1 Dissolving pulp

Typical size of a modern dissolving pulp mill is 400 000 metric tons per year (t/a), which equals a wood consumption of 2.2 million m^3. Consequently, the raw material availability is a critical factor. Maine's comparative advantages over other regions are raw material availability and cost. Maine has some 9.5 million m^3 of potential to increase harvests out of which 6.2 million m^3 is softwoods and of which 3.3 million m^3 is softwood pulpwood. Consequently, despite having sufficient raw material supply there is not as significant excess of raw material as for example in Canada. Though hardwood dissolving pulp has a stronger market for textile production, softwood dissolving pulp is increasingly used for textiles, acetates and ethers.

Maine is positioned well regarding raw material costs; softwood pulpwood prices are under the median. There is an existing pool of skilled labor in Maine, with experience in pulping processes, due to layoffs and downsizing in the pulp and paper industry between 2013-2016. However, the unemployment rate in Maine is very low, which can be interpreted to mean that most laid off employees have been hired into new positions elsewhere following the industry cutbacks. The University of Maine also contributes to the knowledge base of the state's workforce. Dissolving pulp is an internationally traded product and Maine is fairly well-positioned in transporting goods to various international markets with affordable freight rates along the East Coast of U.S. and Canada, but has also competitive sea freight costs to China and Europe. Maine was recognized to have room for improvement in regards to its rail system and in reducing delays in border crossings both at ports and inland. Maine's regulatory climate is considered average with no major regulatory restrictions in place. Enabling environment is also considered average with incentives and research institutions being on par with other states in U.S. because of being primarily funded by the federal government. Overall, Maine performs solidly in most areas of the ranking.

Maine's biggest comparative disadvantage in dissolving pulp production is the high labor cost. Maine's labor cost in pulp and paper manufacturing was found highest among the compared regions. However, the disadvantage is relatively small because the labor cost does not weigh in heavily with regards to dissolving pulp cost structure and because the productivity of pulp and paper employees is one of the highest in U.S. in comparison to the compared countries. Energy expenses are relatively high, which somewhat reduces the attractiveness of producing dissolving pulp, but also only to a small extent.

Table 2.1 Dissolving pulp comparative advantage score by country/region

Indicator	Weight	FIN	RUS (NW)	CAN (ON)	US (GA)	US (ME)	US (MN)
Raw mat. availability	*5*	2	2	4	2	3	2
Raw mat. cost	*4*	2	5	2	4	4	4
Labor cost	*2*	3	5	4	1	1	2
Labor skill	*3*	4	1	3	2	3	3
Freight/infrastructure	*2*	3	2	2	3	3	3
Regulations	*3*	3	2	3	4	3	3
Taxes	*1*	4	4	3	3	3	2
Enabling environment	*3*	4	1	3	4	3	3
Energy	*2*	3	5	4	4	2	3
Weighted score		**73**	**70**	**78**	**75**	**73**	**71**

2.2 Nanocellulose

A commercial nanocellulose manufacturing plant's capacity could be around 30 000 t/a to 40 000 t/a. The plant should be integrated to an existing pulp mill, which would provide the pulp raw material for the nanocellulose manufacturing process. The volume requirement of raw material is relatively low and Maine has easily the sufficient forest resources to supply the volumes for a pulp mill as required for the nanocellulose manufacturing.

Maine has comparative advantage on the wood raw material prices for pulp production and consequently for nanocellulose. The softwood pulpwood price is competitive in comparison to all other countries and regions in this study. However, the raw material cost is relatively less significant in comparison to the high end-product price. Maine is spearheading the research and development of nanocellulose, with University of Maine and its extensive selection of forest related programmes and degrees, its Forest Bioproducts Research Institute and especially the Process Development Center. All the above improve the availability of skilled labor providing a comparative advantage. Maine's enabling environment is considered average whereas the compared countries have aggressive bioeconomy strategies with significant incentives, funding, R&D and general policy support in place. Regulatory climate, freight and infrastructure score similarly as in the case of dissolving pulp.

Maine has comparative disadvantage regarding labor and energy costs. However, similar to other further processed pulp products, these cost items induce relatively small costs in comparison to the end-product value. Regardless of Maine's efforts to support research and development in nanocellulose manufacturing, the other countries are considered to have a comparative advantage due to major policy boosts in bioeconomy development through increased research and development as well as incentives.

Table 2.2 Nanocellulose comparative advantage score by country/region

Indicator	Weight	FIN	GER	US (ME)	CHN
Raw mat. availability	*3*	5	3	5	2
Raw mat. cost	*2*	2	2	4	1
Labor cost	*2*	3	4	1	5
Labor skill	*4*	3	3	4	2
Freight/infrastructure	*1*	3	4	3	4
Regulations	*2*	3	3	3	2
Taxes	*1*	4	3	3	3
Enabling environment	*5*	4	4	3	5
Energy	*2*	3	2	2	1
Weighted score		**76**	**70**	**72**	**64**

2.3 LVL

A modern LVL plant would be with a capacity of 100 000 to 150 000 m^3, which equals roundwood consumption of 210 000 to 315 000 m^3. Thus, the dependency on raw material availability is moderate. Maine has reasonable raw material supply of roundwood suitable for veneer production and finally to LVL, with an estimated additional sawlog harvest potential of 3.5 million m^3. However, the volume includes a mix of various species out of which some are poorly suited for veneer peeling.

LVL production in Maine receives a very neutral scoring in all areas. In comparison to other countries and regions the score is tilted towards the lower end of the scale. Maine does not have any conspicuous advantage over the other regions and countries. Maine does have a small comparative advantage over some regions because of the proximity to large end-markets in Toronto and Boston. However, noted problems in the condition of roads and lack of modernization in railway network result in average score.

Comparative disadvantages are evident with regards to labor costs and energy costs, which are high in Maine. Maine's labor cost is in the higher end accompanied with other states in U.S. In addition, the sawlog cost is at the higher end in Maine compared to the reference group. Georgia scores the highest for LVL, due to good infrastructure, non-restrictive regulatory framework, enabling policy environment and lower raw material and energy costs. Maine is not considered to have a competitive advantage in LVL.

Table 2.3 LVL comparative advantage score by country/region

Indicator	Weight	FIN	RUS (NW)	CAN (ON)	US (GA)	US (ME)	US (OR)
Raw mat. availability	*3*	2	4	4	2	3	2
Raw mat. cost	*5*	2	4	3	4	2	1
Labor cost	*3*	3	5	3	2	2	2
Labor skill	*2*	3	2	3	3	3	3
Freight/infrastructure	*4*	2	1	2	4	3	3
Regulations	*2*	3	2	3	4	3	3
Taxes	*1*	4	4	3	3	3	3
Enabling environment	*2*	4	1	3	4	3	3
Energy	*2*	3	5	4	4	2	4
Weighted score		**63**	**75**	**73**	**81**	**62**	**58**

2.4 MDF

A typical MDF plant would be with a capacity of 250 000 m^3, which equals roundwood equivalent consumption of 420 000 m^3. MDF plant can utilize a wide range of by-products, and therefore the dependency on raw material availability is considered moderate. In addition to sufficient pulpwood volumes, Maine does have a considerable sized sawmilling industry that can supply sawmilling residues to MDF production.

Similar to LVL production, Maine could have advantage of being located relatively close to large markets in the East Coast of North America. However, the identified problems with logistics infrastructure degrade the score to average. Regulatory climate is average and on par with the compared North American regions. All compared North American regions impose by minimum the regulations on the use of formaldehyde in children's products, whereas Finland and Germany have in addition stricter regulations on emissions.

Regardless of Maine's good supply of suitable raw material for MDF production, labor and energy cost decrease the attractiveness of MDF manufacturing in the state. Labor cost is the most pre-eminent factor that decreases the state's competitive edge compared to the higher-scoring countries and regions. There is not much difference in the enabling environment between Maine and the higher-scoring reference areas, but the overall assessment places Maine at an average scoring level compared to the others and does not recognize any significant competitive advantage.

Table 2.4 MDF comparative advantage score by country/region

Indicator	Weight	FIN	GER	CAN (ON)	US (GA)	US (ME)	US (MN)	US (OR)	CHN
Raw mat. availability	*3*	4	3	4	3	4	2	3	1
Raw mat. cost	*4*	2	3	2	3	3	3	1	2
Labor cost	*3*	3	3	3	1	1	2	3	5
Labor skill	*3*	3	4	3	2	3	3	3	3
Freight/infrastructure	*4*	1	5	2	4	3	3	3	5
Regulations	*3*	2	2	3	3	3	3	3	2
Taxes	*1*	4	3	3	3	3	2	3	3
Enabling environment	*1*	3	4	3	4	3	3	3	4
Energy	*2*	3	2	4	4	2	3	4	1
Weighted score		**61**	**79**	**69**	**70**	**67**	**65**	**66**	**70**

2.5 Cellulosic sugars

The current commercial cellulosic sugar manufacturing lines consume 600 000 t/a of green wood raw material, which equals approximately 575 000 m^3 of roundwood equivalent. Consequently, the end-product capacity is estimated at 96 000 t/a. The presumption is that the cellulosic sugar production would be added to an existing mill. With fairly high raw material volume prerequisite combined with relatively strict requirements on the by-product type and quality, the raw material availability is considered to have high importance for cellulosic sugar manufacturing.

Similar to LVL, Maine's scoring with cellulosic sugars is neutral, with two strong outliers; low-priced raw material and expensive labor. Energy prices shift the overall scoring to the lower half of the reference group. Maine does not have any specific weaknesses related to the possible production of cellulosic sugars, but other regions have advantages which Maine lacks; namely affordable labor, more favorable policies and regulatory climate. Energy prices are also a low-scoring factor, reducing the overall score to under the group average.

In order to gain comparative advantage in cellulosic sugars, Maine could improve its enabling environment with a strong and visible bio-economy strategy that would ideally include boosts in incentives and increase the funding in research and development particularly on how to further commercialize cellulosic sugars.

Table 2.5 Cellulosic sugars comparative advantage score by country/region

Indicator	Weight	FIN	CAN (ON)	US (GA)	US (ME)	US (MN)	CHN
Raw mat. availability	*4*	2	4	2	3	3	1
Raw mat. cost	*3*	2	2	4	4	4	1
Labor cost	*2*	3	4	1	1	2	5
Labor skill	*3*	4	3	2	3	3	2
Freight/infrastructure	*2*	3	3	3	3	3	4
Regulations	*3*	3	3	4	3	3	2
Taxes	*1*	4	3	3	3	2	3
Enabling environment	*4*	4	3	4	3	3	5
Energy	*2*	3	4	4	2	3	1
Weighted score		**73**	**77**	**73**	**69**	**72**	**62**

2.6 Pyrolysis oil

Typical size for a pyrolysis oil plan is 50 000 t/a, which equals a wood consumption of 250 000 m^3. Consequently, raw material availability is considered a moderately important factor.

Maine performs well in multiple areas of the ranking. Maine has comparative advantages in raw material availability, logistics infrastructure and performs well generally. With an ample supply of biomass and competitive prices, the production of pyrolysis oil can be a competitive product for the state. With the downsizing of pulp and paper industry the pulpwood price is becoming attractive. Biomass price is also competitive at around 25 USD/m^3, which is on par with Finland. Currently approximately a quarter of Maine's electricity generation comes from biomass generators, which mainly use wood waste products as feedstock. The state is also currently aiming to reduce petroleum consumption, which it is heavily dependent on for heating and transportation. Pyrolysis oil has the potential of substituting petroleum in heating and possibly in transportation, if processed further into biofuel. This raises Maine's score in the context of freight and infrastructure as Maine can produce the pyrolysis oil for local consumption.

Maine performs moderately in multiple areas. The policies to reduce the dependency on fossil fuels could raise Maine's scoring with regards to enabling environment, but the U.S. Environmental Protection Agency (EPA) has still not given final decision on the treatment of advanced biofuels and whether they qualify under the Renewable Fuel Standard (RFS). Maine's labor skill is considered average as the state has expertise in biomass based energy production. The raw material cost is competitive, but the pulp and paper industry is still significant in Maine and there are also pellet producers that keep the raw material cost at a moderate level.

Maine's comparative disadvantages in high labor and energy costs are less critical, as they attribute to a decreasing extent to the overall cost structure and are relatively low in comparison to the end-product price.

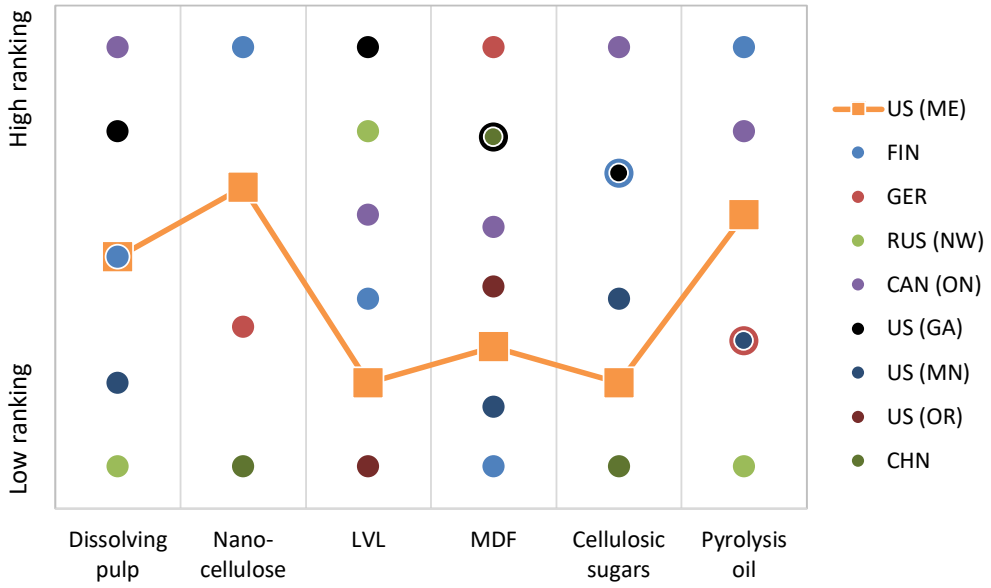
Table 2.6 Pyrolysis oil comparative advantage score by country/region

Indicator	Weight	FIN	GER	RUS (NW)	CAN (ON)	US (ME)	US (MN)
Raw mat. availability	*3*	3	2	3	4	4	3
Raw mat. cost	*3*	3	2	5	2	3	3
Labor cost	*2*	3	3	5	4	1	2
Labor skill	*3*	4	3	1	3	3	3
Freight/infrastructure	*3*	3	3	1	2	4	3
Regulations	*3*	4	3	2	3	3	3
Taxes	*1*	4	3	4	3	3	2
Enabling environment	*4*	4	4	1	4	3	3
Energy	*1*	3	2	5	4	2	3
Weighted score		**80**	**66**	**59**	**73**	**70**	**66**

2.7 Conclusions

Maine ranks relatively highest with regards to nanocellulose (2nd place), pyrolysis oil (3rd place), and dissolving pulp (shared 3rd place) (Figure 2.1). MDF score is sensitive to freight and logistics infrastructure, and consequently Maine could improve its position in MDF ranking by improving the logistics infrastructure and take full advantage of the close location to the large markets in the East Coast of U.S. and Canada. Maine's position could also be improved with regards to dissolving pulp, nanocellulose, cellulosic sugars and pyrolysis oil by further enhancements in the enabling environment. This would mean a strong bio-economy strategy supported with various incentive mechanisms to develop the forest and bioeconomy sector and to attract forest industry investors.

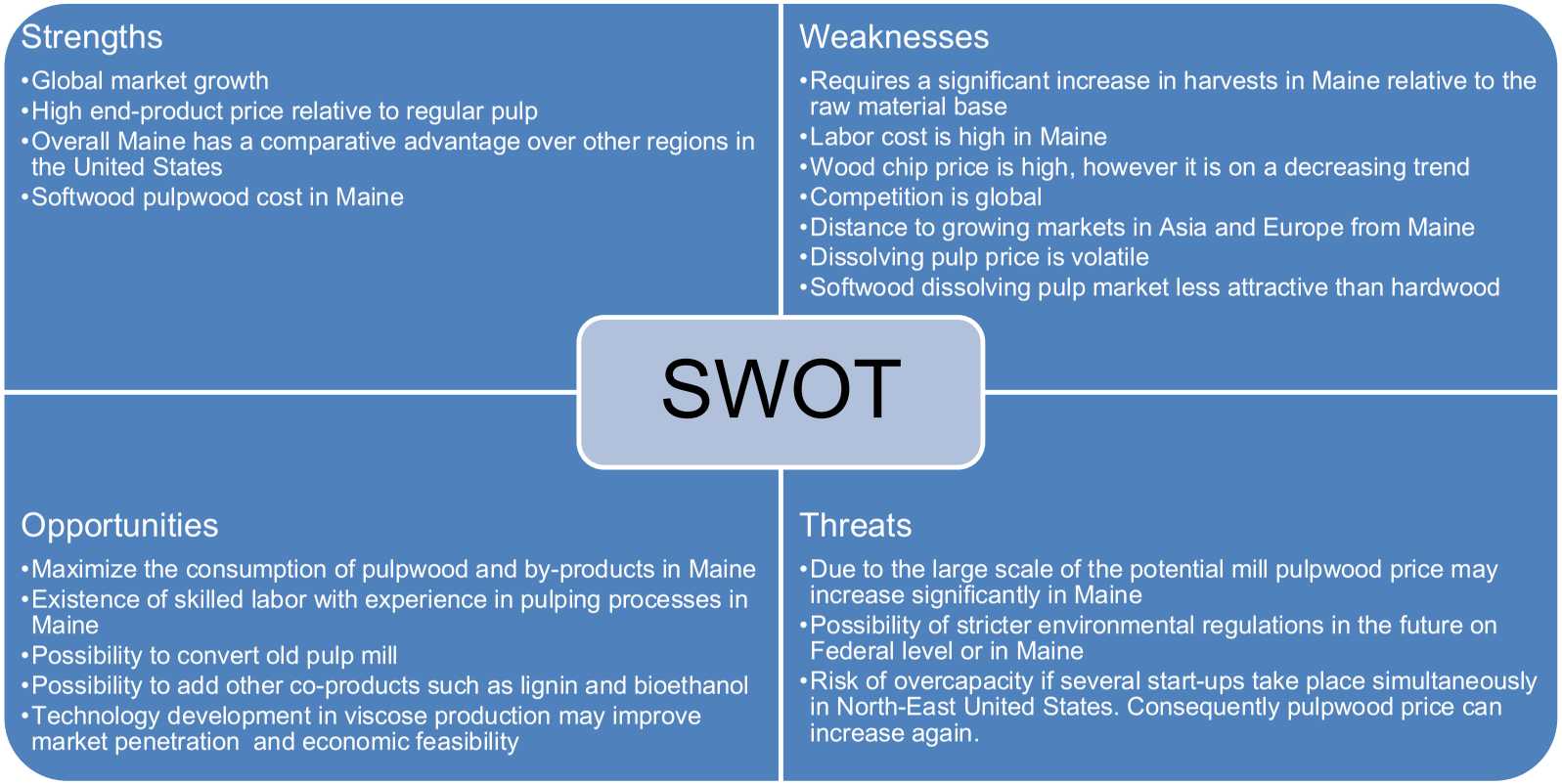
Figure 2.1 Ranking of countries by product



3. SWOT

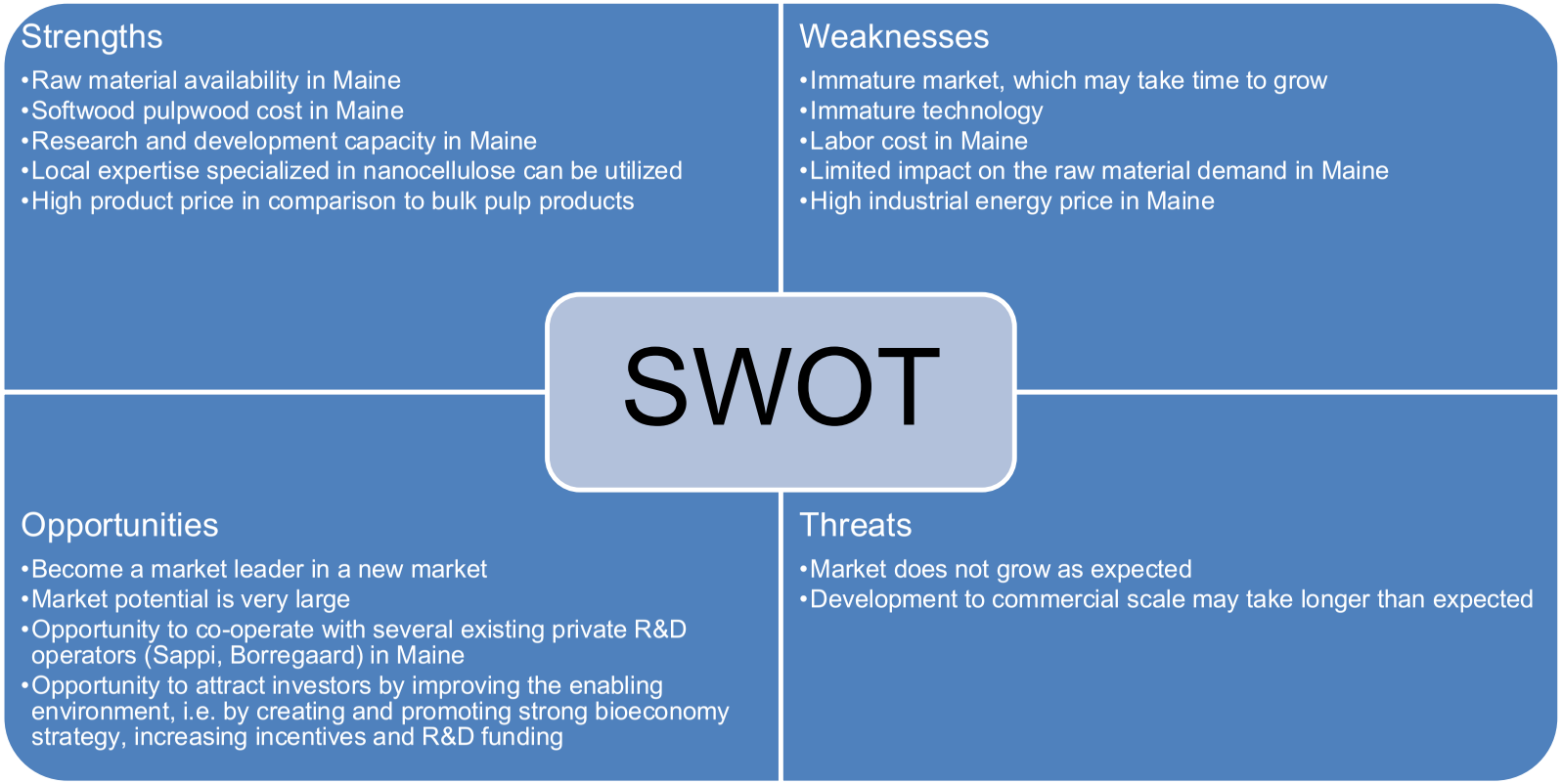
3.1 Dissolving pulp

Figure 3.1 SWOT of dissolving pulp manufacturing in Maine



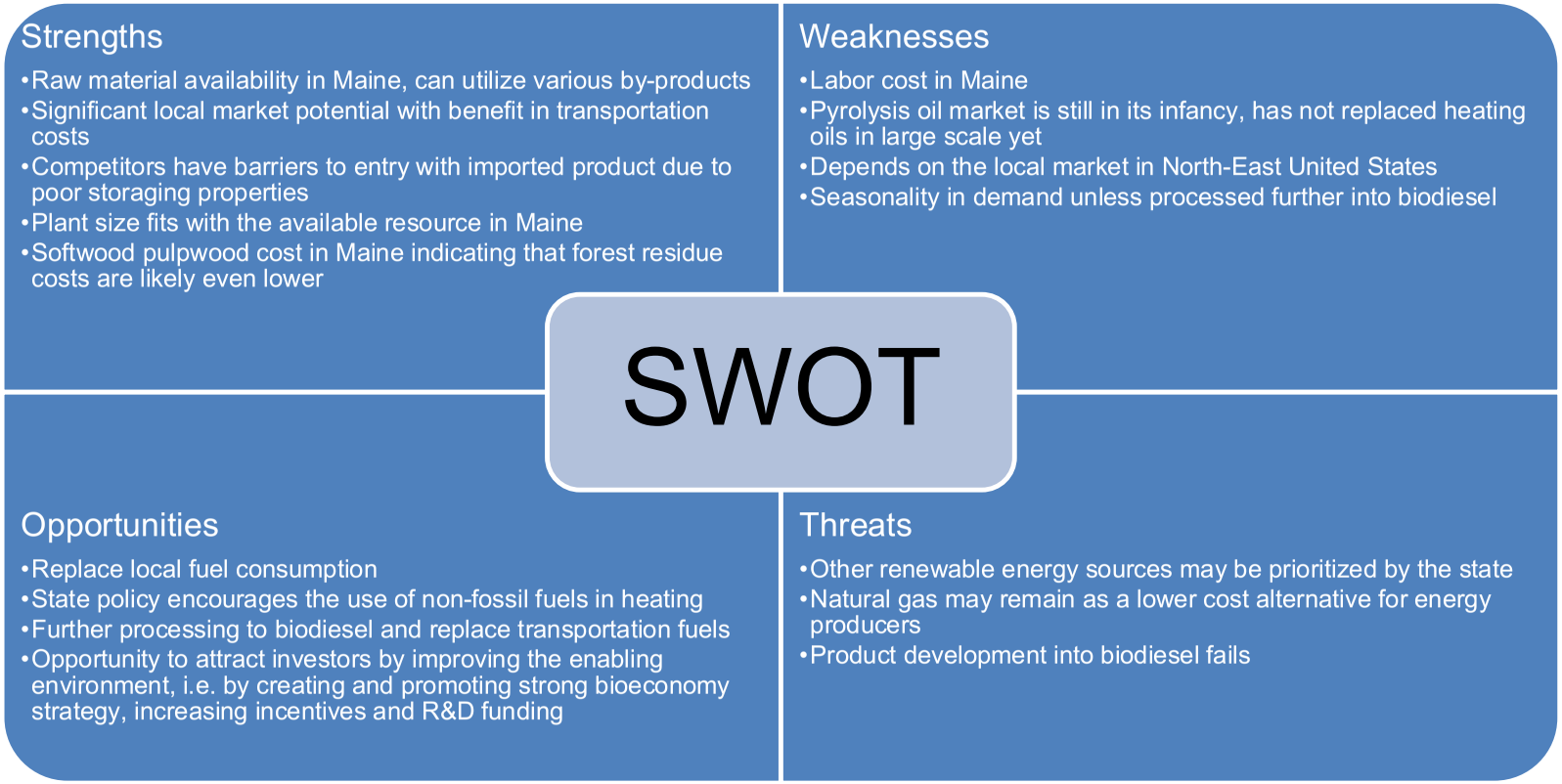
3.2 Nanocellulose

Figure 3.2 SWOT of nanocellulose manufacturing in Maine



3.3 Pyrolysis oil

Figure 3.3 SWOT of pyrolysis oil manufacturing in Maine



Indufor Oy

Esterinportti 2
FI-00240 Helsinki
FINLAND
Tel. +358 50 331 8217
Fax +358 9 135 2552
indufor@induforgroup.com
www.induforgroup.com

Indufor Asia Pacific Ltd

7th Floor, 55 Shortland St
PO Box 105 039
Auckland City 1143
NEW ZEALAND
Tel. +64 9 281 4750
Fax +64 9 281 4789
www.induforgroup.com

Indufor Asia Pacific (Australia) Pty Ltd

Flinders Lane
PO Box 425
Melbourne VIC 8009
AUSTRALIA
Tel. + 61 3 9639 1472
www.induforgroup.com

Indufor North America LLC

1875 Connecticut Avenue, NW
10th Floor
Washington, DC 20009
USA
www.induforgroup.com