UNIVERSITÉ DE MONTRÉAL

RELATIONSHIP BETWEEN ENERGY USE AND BUSINESS PLAN: A WOOD INDUSTRY CASE STUDY

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RÉSUMÉ

De la fin du 19eme siècle à nos jours, l'industrie, et plus précisément son organisation, à beaucoup évolué. L'environnement socio-économique a toujours été un facteur primordial de l'élaboration de systèmes d'organisation industrielle. Aujourd'hui, suite à l'expérience positive du Toyotisme en tant que processus de fabrication et de son efficience, certains changements dans le développement des affaires sont tout de même à prévoir. En effet, la préoccupation croissante pour un respect de l'environnement change la façon dont les produits sont conçus. D'ailleurs, l'arrivé du pic du pétrole pourrait être le responsable d'un changement rapide sur l'économie mondiale. Dès lors, des systèmes relativement nouveaux mais bien connus tels que les *Contract Manufacturers* et le *Consortium Modulaire* apparaîtront comme de bonnes alternatives au système actuel et devraient permettre une évolution appropriée de l'organisation industrielle. Une étude de cas sur une compagnie sur le domaine du meuble en bois a été faite. Une analyse de coût, basé sur des informations saisi sur le terrain, donne une bonne compréhension du coût de transport. Une analyse de cycle de vie a montré les impacts de chaîne logistique sur l'environnement. Plus tard, des changements ont été suggérés visant l'intégration de chaîne logistique et la réduction de l'utilisation du transport. Toutes les années, plusieurs études sont réalisées dans le cadre d'optimisation des chaînes logistiques par tout dans le monde. Cette étude a été réalisée pour comprendre à quoi ressemblera la prochaîne organisation industrielle.

ABSTRACT

Throughout economic history, industries and more precisely the way in which they are organized has evolved. Social economic environments have always been the primordial factor for the development of a specific industrial organization. Nowadays, followed by the positive experience of Lean Production as production process, changes in business development have to be forecasted. The increase in environmental awareness, has changed the way products are conceived and generally how their transformation impacts the system. Furthermore, possible peak oil production and extraction could be responsible for a rapid change on how world economy functions. Relatively new but well known systems such as Contract Manufacturers and Modular Consortium emerge as alternatives for the actual system, they will undoubtedly introduce changes in the actual industrial organization. A case study of a company in the wood furniture industry was made. Cost analysis, based on data gathered on the field, conveys full understanding of transportion costs. A life-cycle assessment presents the environmental impacts of the supply chain. Moreover, changes were suggested to integrate the supply chain and reduce transport use. Every year, several studies are made in order to optimize supply chain all over the world. This study was performed to provide specific guidance of how the next generation of industrial organization will look like.

CONDENSÉ EN FRANÇAIS

1. Introduction

Les règles et les théories de l'industrie ont évolué et changé au cours de toute l'histoire de l'économie. L'environnement socio-économique a été la raison principale de leurs changements.

Le scénario actuel dans les affaires dépend d'une série de facteurs. Cependant, un mode prédomine (voire exclusif), celui lié à l'environnement socio-économique et qui est choisi pour sa performance économique (Lung, 2005). Il est en effet bon de souligner que les mesures prises par les grandes compagnies ont un impact non seulement sur la santé économique du pays mais également sur la manière dont les pays sont classés dans l'économie globale.

En conséquence, la fin du 20e siècle et le début du 21e siècle ont vu le développement massif d'une mondialisation des marchés avec la naissance de centres hyperspécialisés et, dès lors, l'avènement de la logistique industrielle. Ceci a été rendu possible par une disparité des coûts de la main d'oeuvre, l'ouverture des frontières et les faibles coûts de transport.

Les entreprises se sont transformées pour tenir compte de cette organisation : délocalisation, recentrage sur les cœurs de métier, regroupement et concentration pour bénéficier d'économies d'échelles, etc.

Nous avons observé un déplacement massif vers les pays à faible coût de main d'œuvre, et majoritairement vers la Chine, de la plupart des industries de l'Amérique du Nord. Ce changement a été réalisé afin de permettre une réduction des coûts de fabrication, tout en sachant que les coûts de transport restent négligeables en comparaison avec les économies obtenues.

Il est manifeste que les questions environnementales n'étaient, dans le passé, pas prises en considération. La manière dont les compagnies organisaient leurs plans d'affaire était principalement basée sur le service (produit) lui-même et non sur l'impact créé par la transformation. Or, actuellement, les ressources naturelles en général et donc l'énergie, deviennent de plus en plus rares. Ainsi, la façon dont les plans d'affaire sont traités par les grandes compagnies change pour prendre en considération l'importance croissante du respect de l'environnement.

À cela il faut ajouter l'arrivée possible d'un pic du pétrole dans les prochaînes années qui aura un impact sur notre vie en général. En effet, depuis des années, le pétrole est utilisé comme notre source la plus importante d'énergie. Ses dérivés font partie de nos vies. Malgré tout, cet élément à été négligé. Notre forte dépendance au pétrole, qui est inconsciente pour la plupart, est pourtant bien réelle.

Dès lors, les changements menés par la société vers un plus grand respect environnemental et un possible pic du pétrole, vont rapidement transformer l'environnement socio-économique mondial et, par conséquent, l'organisation industrielle.

La plupart des travaux en logistique portent sur l'optimisation d'une organisation industrielle existante. L'émergence des nouvelles organisations industrielles amène des problématiques très différentes en termes de chaîne logistique. Doit-on s'attendre à ce que les nouvelles donnes que sont la préoccupation de l'environnement et la raréfaction des énergies fossiles introduisent une généralisation de ces approches ? Si oui, nos modèles actuels de chaînes logistiques risquent de ne plus répondre au réel besoin des entreprises.

2. Respect environnemental

Il est sans nul doute important d'insister sur la préoccupation sans cesse plus intense pour un réel respect de l'environnement et poussant les différents acteurs de ce monde à prendre en considération de manière efficace et effective les questions touchant notre planète. Les changements climatiques et la destruction de la nature sont des exemples de problèmes à traiter pour lesquels certaines réglementations strictes ont été élaborées, appuyées par des pressions du marché.

Les ressources pouvant être considérées comme d'importance supérieure pour le développement de la société ont pendant longtemps été employées de manière non-appropriée, et ce principalement pendant le 20e siècle. Relevons que l'impact négatif de cette utilisation était sous nos yeux depuis le début. Cependant, la population ne s'est sensibilisée que depuis peu à la pénurie de l'énergie et des ressources, à la pollution et aux problèmes économiques et sociaux. Ce changement nécessaire de mentalité des consommateurs force les industries à suivre la tendance et à évoluer vers une politique de développement durable.

Certains pays ont, en conséquence, établit une législation interne stricte qui conduit à l'apparition d'une nouvelle ère industrielle (Smink, 2006). Ces changements obligent les compagnies à évaluer tous les impacts sur l'environnement, à se conformer aux normes établies et à écouter la voix des consommateurs pour élaborer un produit respectueux de l'environnement. En outre, faisant suite à des changements du marché, les actionnaires ont fait pression sur les compagnies afin de diminuer les incidences sur l'environnement.

Il en résulte que les grands organismes mondiaux ont modifié leur attitude et ont forcé aussi un changement en aval de la chaîne d'approvisionnement (Koplin, Seuring and Mesterharm, 2006). Des méthodes d'évaluation des impacts de cycle de vie ont été développées. De plus, de grandes bases de données ont été créées, par endroit, pour estimer l'impact de la production, l'utilisation et le rétablissement (retour de produit). Ceci permet une analyse des secteurs pour permettre des améliorations.

En Europe, certains pays ont déjà légiféré pour un système tenant les constructeurs d'automobiles responsables de la fin de vie de leurs produits (Smink, 2006). Dès lors, ces tendances forcent les compagnies à créer des réseaux de logistiques inverses pour traiter les produits, à remplacer certains matériaux par d'autres qui peuvent être facilement réutilisés après leur fin de vie, et reformuler leur production pour faciliter le processus du re-usinage.

3. Augmentation du coût du transport (Pic du pétrole)

Le pic du pétrole (*Oil Peak*) est le point où la moitié du pétrole disponible connu dans un fût a été consommée. Ce point est suivi d'un déclin dans l'extraction qui apporte un état irréversible d'élévation en coût de tout ce qui circule sur le marché : le voyage, le chauffage, l'agriculture, le commerce, et tout objet fait de plastique.

Des menaces, qui proviennent essentiellement de la hausse des prix du pétrole, influencent fortement le coût des transports. Ce changement risque de révolutionner la manière dont les grandes compagnies contemporaines abordent la logistique.

Nous observons, selon différentes études, que nous approchons d'un choc du coût du transport. L'élévation continue de la consommation pétrolière suivie de l'augmentation de l'extraction, nous mènent à une question : Quand la capacité de production de pétrole va-t-elle atteindre sa limite ?

En 2004, le US Office of Petroleum Reserves a indiqué que: " les réserves de pétrole du monde sont épuisées trois fois plus rapidement qu'elles ne sont découvertes " (The

Guardian, 2005). L'augmentation de la production et le manque de découverte ont des conséquences évidentes.

En 2006, Colin Campbell a présenté des statistiques qui montrent que selon les 65 plus grands producteurs de pétrole dans le monde, 56 ont déjà dépassé leur *peak-production*, (Production maximum) et sont maintenant en déclin. Comme déjà précisé, les réserves de pétrole sont consommées beaucoup plus rapidement que leurs découvertes. De plus, la demande de pétrole dans le monde qui était déjà en constante augmentation, voit maintenant apparaître l'explosion de la demande chinoise. Nous pouvons, de ce fait, nous attendre à une augmentation du prix du pétrole qui se répercutera logiquement sur les coûts du transport. Selon l'étude de M. Campbell, l'arrivée d'un pic de production a été cachée par la puissance de l'industrie pétrolière et il n'y a en réalité aucune autre conséquence possible qu'une crise prochaîne.

En janvier 2007, le Président des USA George W Bush a présenté son septième *State of the Union Address*. Avec une apparente compréhension du problème, il a demandé au congrès de le soutenir dans une réduction de l'utilisation d'essence aux USA de 20% dans les 10 ans à venir.

En juillet 2007, l'agence internationale de l'énergie (IEA) a communiqué un rapport dans lequel une crise pétrolière est prévue. La capacité disponible de l'OPEP diminuant aux niveaux minimaux en 2012. Comme rapporté, d'ici 2009, le point où la croissance de la demande de pétrole surpasse la croissance de la capacité de l'OPEP, sera atteint.

L'investissement continu dans la capacité de raffinerie permettra d'augmenter la possibilité de l'industrie de traiter le pétrole lourd en combustibles légers pour le transport. L'augmentation de la production de biofuels quant à elle aidera à satisfaire la demande. Cependant, ces améliorations ne seront pas suffisantes. Dans le rapport de l'IEA, la consommation d'éthanol correspondra seulement à environ à 6% de la demande globale d'essence, alors que l'utilisation de biodiesel représentera légèrement plus de 1% d'une demande globale.

Intensifié par la demande chinoise, qui est prévue augmenter de 5.6% en moyenne par année, la demande globale de pétrole devrait elle augmenter de 1.9mb (Barils) /d (2.2%) en moyenne par année, pour finalement atteindre 95.8 mb/d en 2012 (IEA, 2007).

La partie la plus importante de la croissance de la demande est dans le domaine du transport dans les pays de l'OCDE (Organisation de coopération et de développement économiques) ou non-OCDE. En 2012, selon l'IEA, les carburants pour le transport compteront 65.3% de la demande totale de l'Amérique du Nord, en particulier, 45.1% au Canada. De plus, l'essence sera le carburant principal utilisé, représentant 31.4% de la demande totale au Canada.

Durant les 150 dernières années, l'industrie pétrolière s'est développée en devenant l'un des domaines les plus lucratifs au monde. Quand cette industrie énorme rencontrera le pic du pétrole, toutes nos vies en seront affectées et, dès lors, la manière de mener les affaires en général. Des sources alternatives d'énergie devront être développées afin de maintenir tout système stable. Les compagnies auront certainement besoin d'un plan d'action rapide pour traverser avec le moins de problèmes possible cette période incertaine où les prix du pétrole vont croître.

4. Nouvelle Organisation Industrielle

Aujourd'hui, le dimensionnement des chaînes logistiques (*Supply Chain Management*) consiste à choisir entre plusieurs alternatives en calculant une fonction de coût avec les valeurs courantes de l'énergie, des matières premières et des ressources humaines. Or il est vraisemblable qu'à court ou moyen terme, d'une part certains coûts peuvent être amenés à varier rapidement (coût du pétrole impactant directement les coûts de transport) et d'autre part, les exigences des consommateurs vis-à-vis des impacts environnementaux risquent de changer considérablement.

La future organisation industrielle partira probablement du système juste-a-temps pour aller vers un respect de l'environnement et vers une réduction de la dépendance aux transports (pétrole). Les propriétaires de marques pourraient commencer à n'être rien d'autre que des concepteurs, et non plus des fabricants, avec une relation directe avec le *Contract manufacturer* (CM) ou par un *Consortium Modulaire* (MP).

5. Contract Manufacturers (CM)

Le concept du CM avait évolué, dans l'industrie électronique, depuis la fin des années 90, suite aux mauvais résultats des grandes compagnies. Quelques usines aux USA ont commencé à être vendues pour les compagnies dont la seule activité était la fabrication.

La tendance a été suivie par beaucoup des compagnies (Ericson, Nokia, NEC, etc.), en déverticalisant et pouvant ainsi se concentrer sur des activités de conception et laisser la production à un "contract manufacturers" pouvant de cette manière permettre des économies d'échelle.

Cependant, avec l'augmentation de l'externalisation de la production dans les CM régionaux, quelques difficultés de gestion des relations entre les fournisseurs dans différents endroits dans le monde surviennent. Les consommateurs principaux commencent à exiger des CMs, la fabrication globale et le support de génie. La réponse donnée par les CMs a été l'ouverture de plusieurs usines dans le monde (Sturgeon, 2002). Dans certains cas pour rendre ce changement possible, le CM a dû verticaliser la compagnie en raison du faible approvisionnement local.

Concernant l'utilisation de CM, les compagnies propriétaires de marques pourraient changer le volume de production dans des périodes courtes sans devoir augmenter le nombre d'usines ou d'équipements. De plus, l'utilisation des CMs développe une concurrence sur le marché en ayant la même compagnie produisant les produits d'entreprises différentes.

La raréfaction des énergies fossiles amène à la création d'une nouvelle organisation industrielle. L'approche par *Contract Manufacturers*, avec sa production locale, représente une réduction sur les besoins de transport par rapport à l'organisation industrielle actuelle. En plus, la réduction des émissions, à cause du transport, partout dans la chaîne logistique semble donner une approche plus respectueuse pour l'environnement que l'approche actuelle. Par contre, une analyse de cycle de vie est encore nécessaire pour comprendre les réels impacts. D'ailleurs, l'approche par *Contract Manufacturers* réduit la concentration des usines en Chine où la plus par d'énergie électrique est généré par le charbon qui est extrêmement polluant.

6. Consortium Modulaire (*Modulaire consortium*; MC)

Dans le but de réduire le coût et développer un type plus flexible d'organisation, la modularité a été développée de différentes manières. Les fabricants sont passés à un système de conception par module et, maintenant, commencent à laisser certains de leurs coûts de production à leurs fournisseurs et ceci au travers des systèmes fréquemment appelés consortium modulaire (MC).

Le consortium modulaire crée un rapport unique entre le constructeur d'automobile et les fournisseurs primaires. Dans cette nouvelle organisation d'industrie de l'automobile, toutes les opérations d'assemblage sont commandées par les fournisseurs primaires. Les fournisseurs primaires sont des grandes compagnies qui fabriquent des modules.

Cette nouvelle technique de fabrication a été en grande partie employée dans l'usine de Volkswagen (VW) à Resende, au Brésil, et à Smart à Hambach , Allemagne. Dans l'usine de VW au Brésil, où 19 modèles de camions et 5 modèles d'autobus sont assemblés, les fournisseurs primaires sont responsables des opérations d'assemblage. VW est responsable seulement du contrôle de qualité et du développement de produit. La production des fournisseurs est située directement à coté de la chaîne de montage principale. Les modules sont fournis dans l'ordre dans la chaîne de montage principale, réduisant ainsi l'inventaire et le temps de production. La proximité d'organisation a permis de créer un langage partagé entre les divers groupes d'employés (Lung et Frigant, 2002).

En situant tous les fournisseurs à côté de l'assemblage principal, le consortium modulaire réduit le transport entre l'usine du fournisseur et l'assemblage principal, devenant une approche plus intéressante que l'organisation industrielle actuelle. Le consortium modulaire réduit les émissions par la réduction de l'utilisation du transport. En plus, la façon comme les usines s'organisent dans cet approche pouvait devenir extrêmement intéressant comme organisation dans le cadre des usines de recyclage et démantèlement nécessaire dans le traitement de fin de vie.

7. Lien entre contract manufacturers, consortium modulaire, l'impact sur l'environnement et coût du pétrole

Dans les majorités des industries au monde, les distances entre le fournisseur et la fabrication et entre la fabrication et le client sont considérables. Toutes les organisations industrielles susceptibles de diminuer les volumes et les longueurs des transports sont sujettes à une réévaluation intéressante en cas d'augmentation du prix des carburants fossile ou de prise en compte plus stricte des impacts environnementaux.

L'utilisation de *Contract Manufacturers* qui ramène les productions plus proches des clients peut réduire les volumes transportés. La proximité provenant des organisations comme Consortium Modulaire réduit considérablement le transport et donne une chance au système juste à temps pour réduire son impact.

Un changement considérable pourrais être un mélange entre les deux formes d'organisation. *Contract Manufacturers* organisé par Consortium Modulaire dans différentes liens au Monde.

Finalement, tous les changements d'organisations doivent être suivis par une analyse de cycle de vie pour qu'un bilan entre la réduction d'impact (transport) et l'augmentation d'impact (créations des nouvelles usines / délocalisation) soit fait.

8. Méthode d'analyse de la chaîne logistique

Le but de la méthode de recherche est de connaitre, pour une chaîne logistique donnée, les origines des impacts environnementaux et les impacts énergétiques (coût) liés aux choix de localisation effectués. Ces valeurs doivent permettre de simuler les impacts environnementaux et énergétiques.

L'hypothèse de départ est que nous n'étudions pas une modification des produits ou des processus de production, mais seulement une étude de l'impact des décisions logistique. Un des enjeux de la méthode est donc de définir le périmètre de l'étude, en incluant tous les éléments susceptible d'influencer les décisions logistique et en excluant tous les éléments qui sont indépendants des décisions logistiques.

Il ressort que notre méthode n'a pas pour but de connaitre l'empreinte environnementale complète de la chaîne de production d'un produit, ni la part exacte du prix du produit relevant des coûts énergétique, mais seulement de connaitre la partie de ces informations susceptible de varier en fonction des décisions logistiques.

Les étapes de la méthodologie sont :

1. Sélection d'une famille de produit
   a. choisir les produits les plus important pour le chiffre d'affaire de la compagnie

2. Construction de la chaîne logistique complète
   a. prendre des informations pertinents

3. Définition des limites de l'étude
   a. limites géographique (choix d'un sous ensemble de la chaîne globale)
   b. limites de la nomenclature (branche coupées)

4. Pour chaque nœud (compagnie) de la chaîne logistique, analyser
   a. les coûts énergétiques
   b. les coûts main d'œuvre
   c. la part induite par les produits étudiés,

5. Pour chaque lien entre les nœuds (transport)
   a. étudier la nature (fréquence, type de camions, type de contrats)
   b. étudier les volumes concernés

6. Synthétiser l'ensemble
   a. analyse des coûts
   b. analyse du cycle de vie (Software Simapro)

7. Définir et analyser des scénarios alternatifs.

Les étapes seront expliquées dans le projet.

9. L'industrie du meuble en bois

Les produits qui ont été étudiés sont une chaise et une table en bois. Ces produits sont fabriqués par une compagnie au Québec.

L'industrie du bois au Québec est extrêmement importante pour l'économie de la région. Sa taille couverte par les forêts donne à la région la chance d'explorer du bois en maintenant son développement soutenable.

Le plan d'affaires de la compagnie C1 (Compagnie étudié) a toujours donné des profits. Par contre, l'industrie à la région a toujours manqué des partenariats. C1 a été toujours guidé vers la verticalisation.

Le chemin du produit est le suivant :

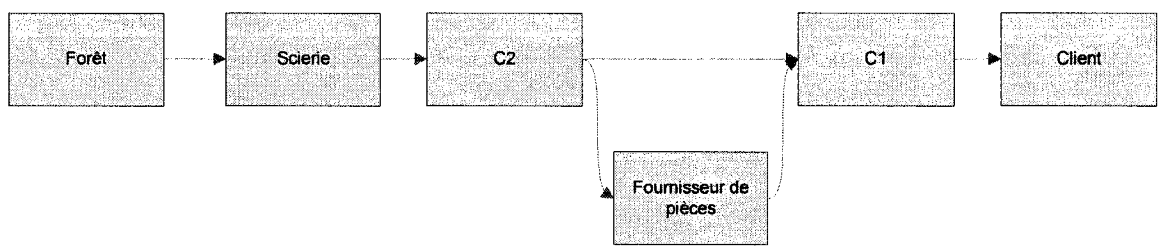

Figure C.1 - Chemin du produit

C2 est une division du groupe C1 que achète du bois, le fait sécher et le revend au fournisseur de pièces. Le but de C2 est de contrôler le prix et la qualité du bois qui est utilisé dans C1. Les scieries sont localisées au Québec et au Nouveau-Brunswick. Tous les fournisseurs de pièces ainsi que C1 et C2 sont localisés au Québec. Le transport entre eux est entièrement fait par camion. Les clients sont au Canada et au États-Unis.

Une grosse quantité d'énergie est utilisée dans le système. Les sources d'énergie sont : électricité, gaz, rebut de bois et pétrole (transport). Le transport entre C1 et ses clients se montre extrêmement coûteux à cause du bas volume transporté. La qualité des produits et le marche visé forcent les produits à être transportées déjà assemblées.

10. Résultats et solutions possibles

Le flux des produits, l'analyse des coûts ainsi que les résultats de l'analyse de cycle de vie nous montrent quelques possibilités de changement sur la chaîne logistique et sur la relation entre C1 et ses fournisseurs de pièces. Les changements possibles pour C1 sont :

1. Réduire le transport des chaises assemblées
2. Réduire l'utilisation de gaz dans les usines
3. Réduire la distance entre C2 et les scieries
4. Rapprocher toutes les joueurs dans la chaîne logistique
5. Rentrer au marcher chinois
6. Créer des partenariats avec la concurrence locale

Les résultats et solutions seront expliquées dans le projet.

11. Conclusion

Force est de constater que durant toute l'histoire de l'économie, la base des plans d'affaire prenait en considération le coût, la qualité et la vitesse de la livraison mais cependant pas les impacts sur l'environnement. La transformation des matériaux, comme résultat du processus, a été négligée. L'influence négative sur l'environnement n'a pas été prise en considération, alors même qu'elle était bien connue par le public (consommateurs). Néanmoins, la tendance qui a guidé les industries pendant longtemps est actuellement en train de changer.

Les nouveaux règlements et le respect des consommateurs envers l'environnement ont créé une nouvelle tendance qui risque de faire évoluer différemment le monde des affaires. En ajoutant à cela la probable crise pétrolière éminente, nous arrivons à une lutte inévitable pour la naissance d'une nouvelle organisation industrielle.

Le Toyotisme (système "juste à temps") qui a été la base pour les grandes industries devra être passée en revue et probablement changée. L'augmentation de son utilisation du transport ayant pour résultat un impact terrible sur l'environnement ainsi que sa dépendance pour un transport bon marché (pétrole bon marché) devront être prises en considération.

Nous sommes dès lors encouragés à croire que la nouvelle organisation industrielle sera basée sur la théorie des *Contract Manufacturers* (CM) et sur le consortium modulaire (MC), toutes les deux avec de stricts contrôles sur les impacts environnementaux.

En conclusion, en prenant l'industrie automobile comme exemple, l'organisation industrielle est partie d'une production artisanale (1880) où les compagnies n'étaient pas verticalisées, pour arriver au Fordisme (1908) avec un système totalement verticalisé créé par Henry Ford. Ensuite, la production en série a changé pour le Toyotisme avec presque aucune verticalisation. La croissance des systèmes CM et MP s'avérera justement être le retour en arrière avec une structure ressemblant à la production artisanale, mais clairement plus productif.

L'acceptation du CM et du MP par les industries mènerait à une production locale diminuant le transport. Cependant, bien que le transport puisse diminuer, il y aurait une augmentation d'utilisation de matériel et d'énergie électrique pour la construction et pour permettre aux usines de fonctionner à travers le monde. Dès lors, un besoin se créera de futures analyses de cycle de vie comparant différents scénarios entre différentes industries.

La plupart des projets de recherche créés actuellement, sont basés sur l'optimisation de l'organisation industrielle actuelle. Dans ce projet, nous avons cherché les alternatives possibles en termes d'organisation industrielle, en termes de coût et d'impact, toujours basées sur les transformations de la société qui changent les directions des affaires.

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LIST OF ABREVIATIONS

ASPO - Association for the Study of the Oil peak and Gas

CM - Contract manufacturer

FBM – Foot board measure

GDP – Gross domestic product

IEA – International Energy Agency

LTL – Lower than truck load

mb – Million barils

MC - Modulaire consortium; *Consortium Modulaire*

MW – Mega watts

NAFTA – North America free trade agreement

NYMEX – New York mercantile exchange

OCDE - Organisation de coopération et de développement économiques

OPEP – Organization of the petroleum exporting countries

p - One single unit of a certain process

PMP – *pied measure de planche*

TL – Truck load

UNCTAD - United Nations Conference on Trade and Development

UNIDO - United Nations Industrial Development Organization

VW – Volkswagen

LIST OF ANNEXES

CHAPTER 1 - INTRODUCTION

1.1. Motivation and background

Throughout economic history, industries have changed their theories and rules. Socio-economic environment has been the main reason for this change. Peter F. Druker, a management expert, defined the imperative of change in business as follows:

"...built in the theory of the business must be the ability to change itself. Some theories are so powerful that they last for a long time. Eventually every theory becomes obsolete and then invalid. It happened to the GMs and the AT&Ts. It happened to IBM. It is also happening to the rapid unravelling Japanese keiretsu."

Actual scenarios of business depend on a series of factors. However, there is just one dominant (if not exclusive) organisational mode that will be linked with the social-economic environment and selected for its economic performance (Lung, 2005). Actions taken by huge global organizations impact not only their financial health but also the way countries position themselves in the global economy.

As a result of this, the end of the 20th century and the beginning of the 21st century have witnessed a huge universalization of brands along with the rise of hyper specialized centers and the advent of industrial logistics as a consequence. This has been possible due to labour cost differences among countries, the increase of trade agreements and inexpensive transportation costs. These factors have modelled the social-economic environment.

Companies have changed in order to adapt to this organization: outsourcing production, centralising around specialized centers, re-grouping and concentrating to enhance economies of scale, etc, have emerged as a consequence

Outsourcing production to countries with inexpensive labour cost, mainly towards China, mostly by North American companies, has been widely observed. These changes were made in order to reach low production costs; knowing that transportation costs were negligible in comparison with the economies made.

Moreover, environmental impacts were not considered. Companies have created their business plans based on product (service) itself and not taking into account the profound impacts created by the transformation. Natural resources in general and consequently the energy sources have grown increasingly scarce. The world moves into a new way of doing business in which environmental concern plays an important role.

Furthermore, a possible arrival of peak oil extraction in the next few years would cause a dramatic impact at a worldwide scale. For years, petroleum has been used as the most important source of energy. Its derivates became part of our lives. However, our oil dependency has been neglected.

Finally, society changes towards an increasing environmental respect and possible peak oil will rapidly change the social economic environment and consequently industrial organization.

A considerable amount of logistics research aims to achieve an optimization of existent industrial organization. The rise of new organizations moves us to totally different problems in terms of logistics. Should we wait until new factors such as environmental changes and peak oil introduce changes in actual industries? If it is the case, our actual logistic models could no longer respond to the needs of many companies.

1.2. Scope of Research

Over the years, business plans have been designed as a direct consequence to both industrial organization and economy. Industrial organization is based on the type of product (Relationship weight and size) and location of their market (Energy supplies and proximity to markets).

The goal of this project is: to create a tool (Method) allowing different industries to easily define their next business plan based on the increase of environmental impact concerns and oil prices.

Our methodology was developed based on a company located in the south-eastern of Quebec in Canada. The company is an active player in the wood furniture industry. The analysis of its operations helped us to identify the main aspects of our method.

Two major possible changes guided our study: increase in environmental impact concerns and high oil prices. The environmental footprint of a product can be strongly linked with its energy use, which is a consequence of its business plan. Despite the fact that energy is used in various forms through the supply chain, it is oil that most likely haze the greatest impact.

Moreover, an analysis of three major industries (Different weight and size) was conducted to forecast possible incoming changes in our case study. The three industries chosen were:

- Automobile industry (1000kg; 20000CAD),
- Household appliance (100kg; 1000CAD),
- Laptop computers (5kg; 1000CAD).

The analysis of the three industries helps to understand the dynamic of the actual industrial organization and their related business plans. The Quebec's wood industry is then used for further comprehension on how companies in the region can start strategically planning their future.

Supply chain analyses are extremely depend of a huge amount of data and are extremely time-consuming. The objective of this project is to create a methodology to analyse supply chains based on their energy use and environmental impact.

The case study gave us the possibility to validate the methodology and identify different possible strategic planning options. The reduction of transport use and environmental impact are the main change factor.

1.3. Organisation of this study

This report consists of six chapters and four annexes. Chapter 1 gives an overall idea of the subject as well as the objective of this research. Chapter 2 explains the context involved in this research including all trends that were considered as change factors for the economy. Chapter 3 involves a literature review were three major industries (automobile, laptop and household appliances) were analysed in order to search for past strategic solutions for supply chain changes. Also, chapter 3 explains the wood furniture industry, object of research, in general. Chapter 4 explains the methodology used to study and analyse the company (case study), presenting all tools needed in future researches. Chapter 5 starts by presenting the industry where our case study company is. Further, chapter 5 explains how the methodology was applied in this specific case. Finally, chapter 5 present possible solutions to prepare the company to both a future energy crisis and a rise in environmental legislations. Chapter 6 gives a conclusion to our research by reviewing its main important aspects.

CHAPTER 2 - CONTEXT

Today, the rise of two major phenomena is seen as change factor for the actual industry in general: a tendency to acts in respect to the environmental and the arrival of a possible oil peak.

2.1. Environmental Respect

It is well known that nowadays the world is moving towards more respectful environmental actions. With the rise of many concerns about climate change, new strict legislations have been created and market pressures have been made (Baptiste and Pires, 2008).

Moreover, for years, and mainly on the 20th century, people have used in a non-controlled manner all resources that could be considered as valuable for the development of the society. The impacts of this use have been on the publics eyes for a while. However, today, people are becoming sensitive to the scarcity of energy and resources, to pollution and to economic and social problems. This necessary change in mentality by costumers forces industries to follow the trend and evolutes towards a more sustainable world.

A strict internal legislation in certain countries has leaded the world to a new industrial era. This change force companies to assess all its impacts on the environment, to adequate to standards and to costumers desire for an environmentally friendly product. Also, followed by the markets change, stakeholders have introduced some degree of pressure on company's action to decrease its environmental impacts (Baptiste and Pires, 2008).

Therefore, large worldwide organizations have changed their attitude and have forced a change downstream their supply chain either. Moreover, methods of assessing life-cycle impacts have been developed. Large databases have been created, by location, to estimate the impact of production, utilisation and recovery; and then analyse areas for improvements (Koplin, Seuring and Mesterharm, 2007).

Mainly guided by its huge impact, automotive industry has been the most impressive pilot of change. Transformation has been made to design, manufacturing processes and logistics (Zhu, Sarkis and Lai, 2007). Moreover, automobile industry, mainly in Europe, was the target for some of the first strict legislations in the matters.

European countries already have regulations to let automakers in charge of the end-of-life of their products (Gerrard and Kandlikar, 2006). Therefore, this trend force companies to create inverse logistics to treat products, replace certain materials for some others that can be easily recycled after their end-of-life, and reformulate their production to facilitate the process of re-manufacturing (Lambert and Riopel, 2003).

2.2. End-of-life Legislations

Every year, end of life vehicles generate between 8 and 9 million tonnes of waste which should be managed correctly (European Commission, 1997). End-of-life legislations, which have been recently introduced in some countries, aim to increase the recovery of materials minimizing the impact of waste in the environment (Gerrard and Kandlikar, 2006). The recovery options are: recycling, re-use, energy recovery. The main goal is to develop a stage of sustainable development in which products are environmentally friendly from its raw material until its return from the main costumer to the factory. Objectives and certain directives were created to reach the main purpose.

End-of-life vehicle regulations have been created in many different countries, however, its main root is in Europe. European regulations were first created in 2000 with its ELV Directive and have, nowadays, goals for achieving 95% recoverability and 85% recyclability for all its produced vehicles by 2015 (Gerrard and Kandlikar, 2006).

These legislations impose changes not only on the end-of-life of vehicles but also on design. Automakers are forced to reduce the number of hazardous substances, increase the use of recycled materials and design vehicles that facilitates the dismantling, recovery, recycling and re-use.

The main constraint of implementing actions toward product end-of-life treatment is the need for inverse logistics. Inverse logistics is the process of returning the product from the consumer back to the factory to be treated. Some studies have been held in an attempt to develop of a theory for its implementation: Carter and Ellram (1998), Brito and Dekker (2002), Rogers and Tibben-Lembke (1998), etc. Large incertitude from amount and degree of use of products that can be returned to the factory causes difficulty in planning and forecasting (Lambert and Riopel, 2003).

2.3. Green Supply Chain

End-of-life regulations and market forces create the need for what is called green supply chain. This new supply chain is characterized by the respect for the environment, trying to increase efficiency in all its processes, creating sustainable development. It is important to say that long-term economic success can only be reached nowadays with sustainable development.

Some automakers, previously certified by ISO14001, started to require from its suppliers to be also certified. Actions, in this direction, have been largely implemented in China (Zhu, Sarkis and Lai, 2007). Also, OHSMS18001 certification and Euro II standards are often followed by the industry. Volkswagen asks its suppliers to ensure the same requirements for its sub-suppliers along the supply chain (Koplin, Seuring and Mesterharm, 2007) preserving a whole sustainability for the supply chain.

In Denmark, car-owners have to pay an annual environmental fee of €12, which is collected by insurance companies together with fee for compulsory liability insurance. Car-owners, who deliver a car for recycling to an authorized car-dismantler, will receive a certificate of destruction. On the basis of this certificate, they will receive approximately €237 from the recycling fund (Smink, 2006).

2.4. Oil Crisis

For years, petroleum has been used as the most important source of energy. Its derivates have become part of our lives. However, our dependency on oil is sometimes neglected. The continuous rise in oil consumption followed by the increase in extraction, lead us to one question: When are the oil supplies going to end?

In 2004, US Office of Petroleum Reserves said: "world oil reserves are being depleted three times as fast as they are being discovered." The increase in production and the shortage in discoveries have its obvious consequences. Later, a famous retired oil business man, Colin Campbell, who now works with the Association for the Study of the Oil peak and Gas (ASPO), said the oil peak for the world, is close (The Guardian, 2005).

The "oil peak" is the point at which half the total oil known to have existed in a field has been consumed and the maximum oil production rate is encountered (Wikipedia, 2008e). This point is followed by a decline in extraction that brings an irreversible state of rise in the cost of everything from travel, heating, agriculture, trade, and anything made of plastic.

In August 2006, Mr. Campbell released a study for ASPO, where among the 65 largest oil producing countries in the world, up to 56 have passed their peak production and are now in decline. Amazingly, in 1956, M. King Hubbert, a world authority on the estimation of energy resources, predicted that production in US would peak between 1965 and 1970, and according to many studies including the one of Mr. Campbell, production in US did peak in 1971. According to Mr. Campbell's study, the oil peak's arrival has been hidden by the strength of the oil industry and there is no other end then a soon crisis. "...the five main producers of the Middle East can not in practice offset decline elsewhere beyond 2010, when they would be supplying about forty percent of the World's needs," Mr. Campbell said (Fig. 2.1).

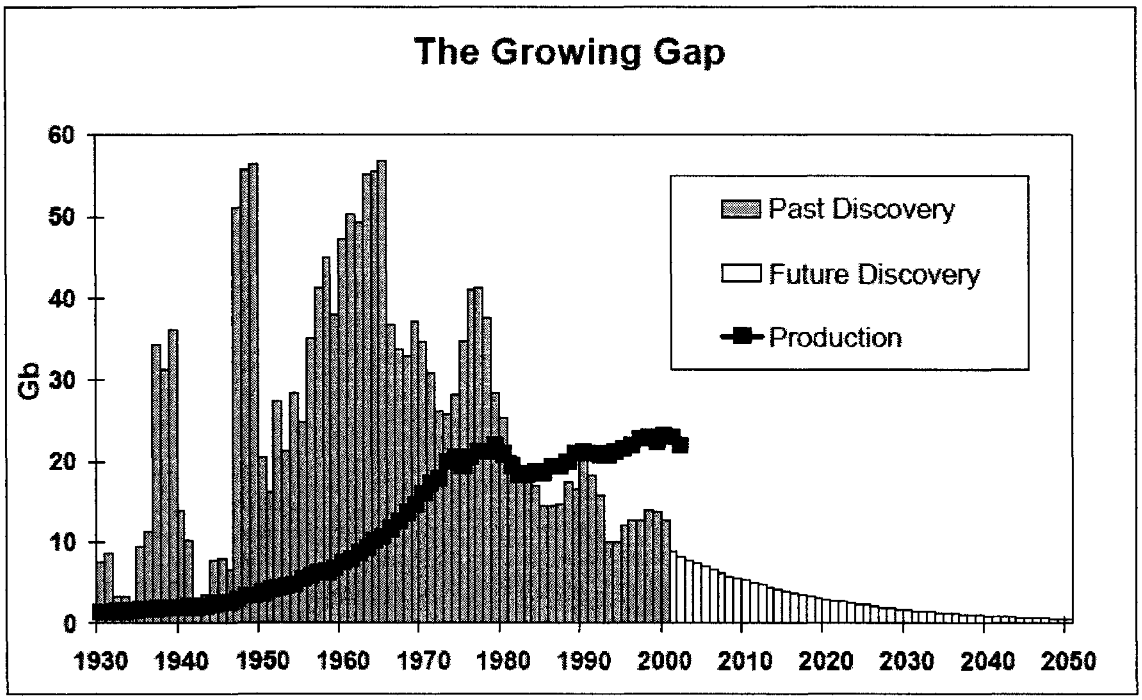

Figure 1.1 - Discovery trends with past production and extrapolated future discovery (Campbell, 2003)

In April 2006, George Soros, a global financier, said to the Fortune magazine, "I'm very worried about the supply-demand balance, which is very tight," in an article called "Ready for $262 a barrel oil?". In March 2007, Mr. Soros had already invested of 900

Millions USD to build factories of ethanol in Brazil. "We are facing a global energy crisis which is very complex because it has many ingredients, starting with global warming and the peaking of oil," says Mr. Soros to the Newsweek magazine.

In January 2007, US president George W Bush delivered his seventh State of the Union Address. In an apparent understanding of the situation, he asked Congress to support him in a reduction of the gasoline usage in the US by 20% in the next 10 years.

In September 2003, the standard crude oil on the NYMEX was under 25 USD / barrel and since August 2005 it has never been lower than 50 USD / barrel having a record of 144 USD / barrel being quoted today (Autumn) for 100 USD / barrel (Fig. 2.2). This trend could not be explained simply by hurricane threats to oil platforms or fires and terrorist threats at refineries but could be by the oil peak that has already or will soon be reached.

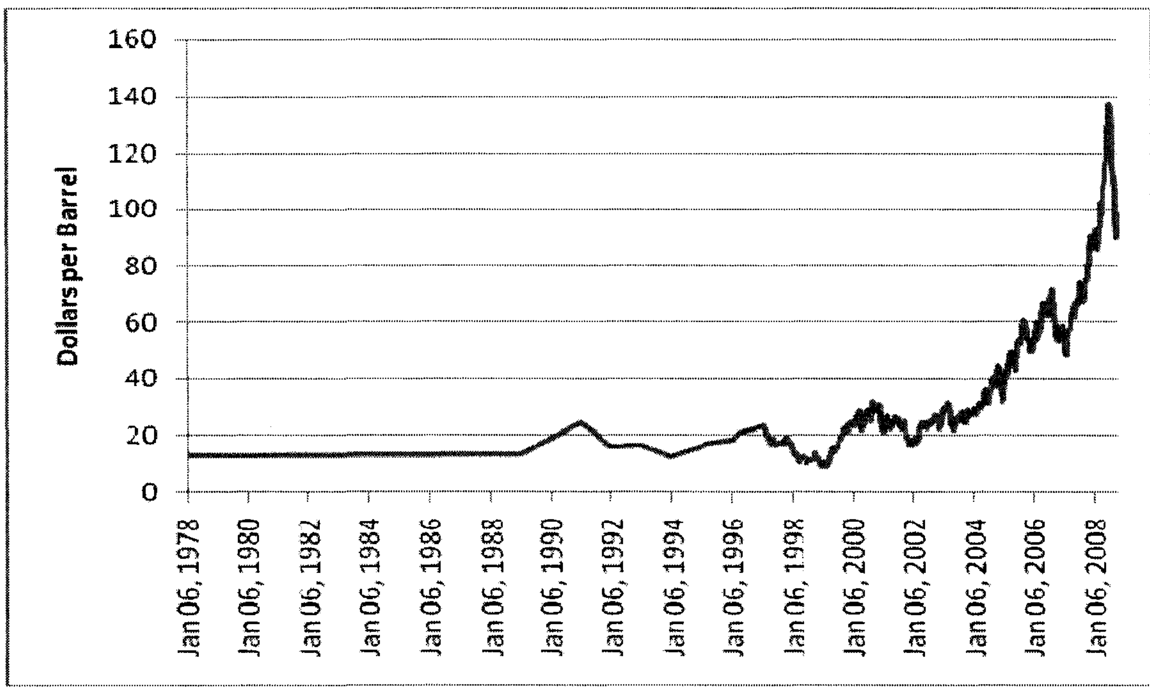

Figure 2.2 – Historic crude oil price (EIA, 2008)

In July 2007, International Energy Agency (IEA) released a Medium-term Oil Market Report where an oil crisis is seen beyond 2010, with OPEC spare capacity declining to minimal levels by 2012 (Annex A). As reported, by 2009, the point at which oil demand growth surpasses the growth in OPEC's oil capacity is reached.

Despite the fact that continuous investment in refinery capacity will increase industry's capacity to process heavy oil in light transport fuels; and the growth of the biofuels industry that would help to meet demand, the improvements might not be sufficient. By 2012, the production of biofuels will still be marginal compared to the total oil demand. According to the IEA report in 2007, by this date, ethanol consumption will only correspond to about 6% of global gasoline demand, while biodiesel use will represent slightly more than 1% of global gasoil demand.

Moreover, tightness in natural gas markets, also forecasted for the same period, will pressure oil market. Industries that have substituted oil towards natural gas will have to walk back toward oil.

Moreover, the oil demand that was in constant increase has been largely affected by the explosion of the Chinese demand (Annex A). Therefore, the increase of the oil price can be expected influencing the transport cost.

Intensified by Chinese demand, that is projected to increase 5.6% a year on average, global demand for oil is expected to rise 1.9mb/d or 2.2% per year on average, reaching 95.8 mb/d by 2012.

China doubled its consumption in the last 10 years and is poised to overtake Japan as the second-largest oil consuming economy after the United States. In 2007, Skeer and Wang presented a forecast of the impact of China in world oil prices by 2020. In a very likely scenario of high transport growth, the impact might roughly range from \$0.76 to \$1.04 per barrel with adequate investment or from \$3.30 to \$4.60 if investment is limited.

The bulk of the demand growth is due to transportation in either OECD or non-OECD countries. By 2012, according to IEA, transportation fuels will be accounting for 65.3% of total North America demand, in particular, 45.1% in Canada. Additionally, gasoline will be the main fuel demanded, representing 31.4% of total demand in Canada.

According to IEA, at least until 2012, the new production will keep outpacing the decline in production on some fields. The global decline in production is assumed to be of 4%, suggesting that 3.2 mb/d of new production must be found each year just to stand still. Most part of the new production has been recently generated by biofuels.

Canada is placed as second in global proven reserves behind Saudi Arabia. Moreover, non- OPEC countries such as Brazil, Russia, Kazakhstan and Azerbaijan are also expected to increase production. However, the growth will be offset by sizeable declines in North Sea. Despite the fact that some production growth can be seen in non-OPEC countries, the OPEC is expected to increase production by 1.1 mb/d each year just to maintain existing capacity.

For 150 years, the oil industry has developed itself, becoming one of the most lucrative businesses in world (CNN Money, 2008). When this huge industry encounters the close oil peak, all our lives will be affected, as well as the way we do business. Alternative sources of energy will have to be developed in order to maintain all the system steady. Companies will certainly need a fast action plan to pass through this uncertain time of increasing oil prices, without considerable problems.

2.5. Transport cost facts

As an obvious consequence of its nature, transport cost has always varied in direct response to oil price changes.

Many studies, including Armstrong (2002) from Michigan University, quoted the transport cost as being somewhere around 10% of worlds GDP. However, there are a number of reasons to disbelieve on it. The most important reason is that part of the data from import export, is not well reported or not reported at all. Once some data is missing, the FMI replace them by using statistics of the partner country considering the transport cost as 10%, leading to major problem. Also, the time frame can play an important role: an export registered in a certain year may be registered as an import just in the following year, after its trip (Daudin, 2003).

One of the main reasons, for a higher price for maritime transport coming from Asia to big markets such as US and Europe, is the impressive need for containers in order do keep the heavy flow in these directions. The exponential grown of Asian economies is driving trade heading eastward to an expressive increase. This trend can probably lead to an even bigger price gap needing to be taken in account as a small negative aspect of outsourcing or offshoring in China's direction.

In 2006 the maritime freight transport rates for the major liner trade routes were reported by UNCTAD as followed:

Table 2.1 - Maritime freight rates on the major liner trade routes 2004 – 2006 (UNCTAD, 2006)

($ per TEU)

	Trans-Pacific		Europe-Asia		Transatlantic	
	Asia–United States	United States–Asia	Europe–Asia	Asia–Europe	United States–Europe	Europe–United States
2004						
First quarter	1 850	802	733	1 686	778	1 437
Change (%)	-2.2	-1.0	-2.8	1.4	-6.7	-2.2
Second quarter	1 863	819	731	1 738	788	1 425
Change (%)	0.7	2.1	-0.3	3.1	1.3	-0.8
Third quarter	1 946	838	735	1 826	810	1 436
Change (%)	4.6	2.3	0.5	5.1	2.8	0.8
Fourth quarter	1 923	806	769	1 838	829	1 471
Change (%)	-1.1	-3.8	4.6	0.6	2.3	2.4
2005						
First quarter	1 867	800	801	1 795	854	1 514
Change (%)	-2.9	-0.7	-4.2	-2.3	3.0	2.9
Second quarter	1 845	781	821	1 794	872	1 611
Change (%)	-1.2	-2.4	2.5	0	2.1	6.4
Third quarter	1 906	815	815	1 778	918	1 691
Change (%)	3.3	4.3	-0.7	-0.9	5.3	5.0
Fourth quarter	1 878	815	825	1 709	983	1 769
Change (%)	-1.5	0	1.2	-3.9	7.0	4.6
2006						
First quarter	1 836	818	793	1 459	985	1 832
Change (%)	-2.2	0.3	-3.9	-14.6	0.2	3.6

Notes: Information from six of the trades' major liner companies. All rates are all-in, including the inland intermodal portion, if relevant. All rates are average rates of all commodities carried by major carriers. Rates to and from the United States refer to the average for all three coasts. Rates to and from Europe refer to the average for Northern and Mediterranean Europe. Rates to and from Asia refer to the whole of South-East Asia, East Asia and Japan/Republic of Korea.

Studies examining customs data consistently find that transport costs pose a barrier to trade at least as large as and frequently larger than tariffs (Hummels, 2007).

An appropriate way of evaluate ad-valorem (Cost of shipping relative to the value of the good) impact of transport cost come from certain importers that collect freight expenditures as part of their import customs declarations. The ad-valorem transportation cost for a product depends from a series of facts: distance, weight/value ratio and type of service. Hummels and Skiba (2004) estimate that a 10 percent increase in product price leads to an 8.6 percent fall in the ad-valorem.

An important impact to be studied in our study is the relationship between transport cost and consumption. A decrease in costs of international trade from 20 percent to 10 percent of the shipping value is found to be equivalent to a permanent increase in consumption of 3-4 percent (Ravn and Mazzenga, 2004).

2.6. Relationship between Gasoline prices and oil prices

A priori, one would expect that the eventual passthrough rate would exceed 100%. That is, it could be expected that a 1¢/L change in crude prices would result in slightly more than a 1¢/L change in gasoline prices. Crude oil is by far the largest input into the production of gasoline, but one barrel of crude oil does not produce one barrel of gasoline. Other by-products from the production process, such as heavy fuel oil and bunker fuel, sell at a discount to crude oil. Therefore, refiners must recover these losses when they sell high-value products such as gasoline and distillate (diesel fuel, jet fuel and heating oil) (Natural Resources Canada, 2006).

As was expected, the results show that crude oil price changes have a very large influence on Canadian gasoline prices and these changes are passed quickly and completely through to gasoline prices. Over the past five years, a 1¢/L change in crude oil prices has resulted in a 1.17¢/L change in Canadian gasoline prices (ie. a $1US/bbl change in crude oil prices has resulted in a 1.02¢/L change in Canadian gasoline prices). The adjustment time is very rapid with over 50% of the price adjustment occurring instantaneously following the change in crude oil prices with the adjustment process completed within a one-week period.

There are four key components that together combine to form the retail price of gasoline: crude oil costs, taxes, refining margins and marketing margins. While changes to any one of the gasoline price components can influence prices considerably, much of the volatility in gasoline prices over the past five years has mainly been a reflection of the volatility in world crude oil prices. World crude oil prices have tripled since early 2002 from approximately $20US/bbl to around $60US/bbl, increasing petroleum product prices worldwide, and Canada was no exception. Canadian average gasoline prices increased by more than 35¢/L during this time period. Although this price increase is substantial, it would have been worse for Canadian consumers, if not for the dramatic appreciation in the Canadian dollar. Estimates show that Canadian gasoline prices would have been as much as 16¢/L higher in June 2005, if the Canadian dollar had remained valued at $0.62US. Nevertheless, consumers are starting to take notice of the impact of these price increases and, while not immediately evident, over the longer term will be reflected in consumer driving habits and vehicle purchase decisions (Natural Resources Canada, 2006).

2.7. Electricity Generation and Impacts

The energy mix as well as the projections for the future has an important impact on the choice of the new industrial organization. Different forms of electricity generation have different impacts on the environment. For years, the electric country mix of a country has been chosen for many sorts of reasons but environmental respect. The new industrial organization has to understand the extension of the impact generated by its electricity source.

Higher world oil prices have encouraged a shift from oil-fired generation to natural gas and nuclear power and have reinforced coal's important role as an energy source. Today, relatively high world oil prices in combination with concerns about environmental consequences of greenhouse gas emissions are raising renewed interest in nuclear power and renewable energy sources as alternatives to the use of coal and natural gas for electric power generation (Energy Information Administration [EIA], 2007b).

2.8. Industry location: the role of energy cost

Many reasons can guide an industry to develop around a specific location. Among those energy resources certainly has an important role. The cost and availability of primary energy resources are likely to be especially important for firms that are intensive users of energy in producing or distributing their products.

Moreover, scale economies and government policy are part of the decision on where to locate (Lung, 2003). Scale economies are usually brought by locating in an area where formerly the industry was already placed. Government policies traditionally have influenced many industries to place in a certain area.

Furthermore, industries are highly motivated to locate in areas of natural endowments. Energy-intense industries tend to be placed in areas of high electricity generation, where a cost advantage is usually offered by the government (ALCAN located at Lac-St-Jean, Quebec).

The environmental respect that has been created for many years, guides to a trend of locating industries close to renewable sources of energy such as water, wind and sun electricity generation.

2.9. Actual and future generation

Data from US, Canada and Mexico show that energy mixes vary a lot in North America. Moreover, the future projections for electric generation indicate very different attitudes as well.

In US, most part of electricity generated comes from natural gas, coal and nuclear accounting to 88 percent of capacity in 2005. In the same year, the installed capacity was 1,067,010 MW with a planned capacity for 2010 of 94,429 MW (EIA, 2007a). Some areas in US where restructuring efforts have been undertaken rely heavily on power purchased on the wholesale markets to fulfill their load-serving obligations. Most part of the planned capacity is based on natural gas and coal as well, not having any important change towards an environmental respect. The use of coal to generate electricity is the single biggest air polluter in US. Natural-gas-fired power plants are projected to increase through 2020, as recently constructed plants are utilized more fully to meet growing demand.

In Mexico, despite the fact that hydroelectric power is well developed, the coal and natural gas plays an important role on the country mix. However, differently than US, natural gas has been much more used than coal. The planned capacity for the next few years won't significantly change the environmental impact.

Canada had 118 gigawatts of installed electricity generating capacity in 2004. The country produced 573 billion kilowatt hours (Bkwh) of electric power in 2004 while consuming 522 Bkwh. Some 58 percent of Canada's electricity generation comes from hydroelectricity, followed by conventional thermal (25 percent), nuclear (15 percent), and other renewable (2 percent) (EIA, 2007b). Despite the fact that generation from gas and from coal is projected to increase, plans for a more environmentally friendly country mix have been created. Moreover, the hydroelectric capacity from the province of Quebec and plans to expand wind-power move the country towards an increase in respect for the environmental.

CHAPTER 3 - LITERATURE REVIEW

There are two factors in a product that certainly play with transport tariffs: Value and weight. Among many, automobile industry creates one of the most cost intense product to transport. Laptop computers create high opportunities in transport for its industry. In between, household appliance stays somewhere around the break-even point of profitability. As all these three products have different value and weight, their industries feel the impact of transport cost increase in different moments. For this reason, these three industries were taken as a review of past strategic changes that could be useful for future consideration in the wood furniture industry.

3.1. Automotive Industry

Different forms of production have been applied for certain social-economic reasons in automotive industry, such as: Craft production, Fordism, Toyotism and modular production nowadays (Fig. 3.1).

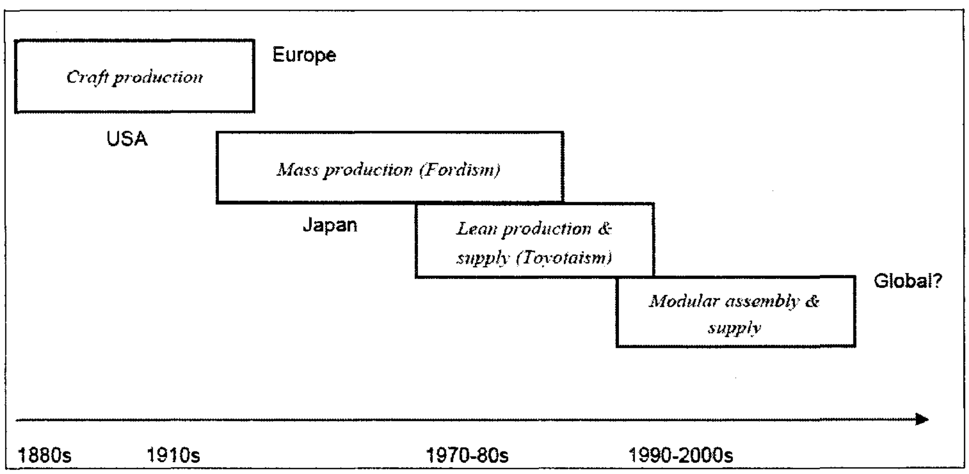

Figure 3.1 - The historical succession of dominant modes of production (Lung, 2005)

3.1.1. Social-economic factors X Industry Organization

Craft production (1880) was characterized by low production volumes and a wide variety of models to reach the level of expectation of a wealthy clientele. The market's competition was not regulated by the price but by its quality.

By this time there was no real need for someone to have an automobile. Its advantages were not yet known as cars were built to become part of the luxury of very few costumers. Production costs were high and didn't drop with the volume. Cars were made as prototypes each of them being a unique product. The workforce was highly skilled and participated of each part of the manufacturing process.

Mass production (1908) had a remarkable milestone, the development of the Model T by Henry Ford. Since the beginning, with the Model A, Ford had tried to develop a product where interchange ability of parts and simplicity of attaching them to each other could be done. Twenty models later with the Model T, his goal was achieved.

Moreover, the development of the continuous assembly line was a remarkable improvement for the production. By this time, Ford's production became global plummeting production costs and consequently the price.

The mass production was implemented in societies that could accept a product with very few models, not being exclusive anymore. By this time, with the increase in petroleum discoveries and a society struggling for a better life made this industrial organization possible in US.

Nevertheless, with Ford's decision to design, engineer and produce his parts in Detroit and assembly around the world, it wasn't long before this solution created yet another problem. One standard product couldn't suit all world markets.

Even though the ideas of mass production had been available for European companies for years, it wasn't the right social-economic period for them. Economic chaos and narrow nationalism existing there during 1920s and early 1930s, along with strong attachment to the craft production traditions, prevented them from spreading very far (Womack, Jones and Roos, 1991). The progress of mass production in Europe started by the end of 1930s, stopped during the World War II and achieved its peak by the end of 1950s.

However, it wasn't a time for diffusion of mass production in Japan. Japanese market's demand for diversity and dearth of available resources (raw materials, space, workforce, etc.) induced carmakers here to seek innovative modes of organization anchored in the general principle of a downstream-driven production (pull system) (Lung, 2005).

Henry Ford's mass production drove the auto industry for more than a century and was eventually adopted in almost every industrial activity in North America and Europe. Now, however, those techniques, so ingrained in manufacturing philosophy, are thwarting the efforts of many Western companies to move ahead to lean production (Womack, Jones and Roos, 1991).

Lean Production (Toyota Production System) was born from the search for a right industrial organization in Japan. The severe damage caused by the war and willing of work force not to be treated as simple variable costs or as interchangeable parts, forced automobile companies in Japan to take a different route from the American one.

In some ways, the economical crisis in Japan had leaded Toyota in the development of a much more prudential process than the former mass production. Lean production came from the constant development of mass production regarding the Japanese crisis.

The process development started by a reduction on the size of batches, reducing the cost of inventory. Moreover, responsibilities of tracing error and stopping the production line were given to employees.

Moreover, a supply chain was created where first-tier suppliers were fully responsible for the development of the main parts of the automobile. Also, suppliers were considered partners being supported by Toyota's structure. Consequently, first-tier suppliers created the same relationship with second-tier suppliers. The well-known just-in-time (Kanban) was designed to integrate d the system, significantly reducing costs.

Therefore, with such a system in hands, Toyota was able to deliver as many products as huge mass-producers as GM, having half the size. Product design took half the time as it often would for the same budget (Womack, Jones and Roos, 1991). The flexibility from lean production gives the possibility to change quickly the assembly line for new products, changes that would take months of closed factory in mass production.

As we saw with craft production, each car was one-of-a-kind custom-build to the wishes of its owners. The arrival of Henry Ford completely changed the scene by increasing the production volume and drowning variety. Alfred Sloan, from GM, increased variety modestly. Lean production recreated the idea of costumer's choice in the automobile industry.

The huge capacity of lean production systems to create diversified number of products and still meet production volume lead our thoughts to simple question: Are we heading back to craft production?

After the World War II, Japanese companies started to recover creating huge company blocks, similar to the Zaibatsu (From the first era of industrialization in Japan), called Keiretsu. Major companies of each group joined a group of companies that owns some of its partner's shares. Each Keiretsu has a bank, a trading company and an insurance company to finance the group. Another form of Keiretsu consists of an upstream supplier and downstream distributors affiliated with a large manufacturing or commercial firm.

The idea of Keiretsu came after major companies, afraid of being bought by foreign groups and distrust on the stock market, sold equities to each other.

As a result production will become local, having less dependence on transport. A life-cycle analysis would be necessary to compare the influence on the environment for decreasing the need for transport but having to build many factories around the world.

At the same time US industry started to learn from the Japanese how the Keiretsu worked, the aura of the system was losing its power in Japan. The recession in the Japanese economy in the 90s, subcontracting companies were finding themselves unable to depend on traditional single long-term relationships. Moreover, lifetime employment was changing (Lin, 2003). Once again, social-economic factors were leading an unprecedented change on the whole structure.

3.1.2. Market trends

It is well known nowadays that US and Japan dominate most part of the world motor vehicle production. This dominance has been steady for a long time. However, with the increase on free trade agreements we can observe more and more the decentralisation of production to places that can either keep providing market proximity or add lower labour costs.

High vertical integrated companies that could be seen in the automobile industry in its early stages with Ford can hardly be seen nowadays. Probably the risk linked with vertical integration can not be afforded in a world in constant changes and by an industry with massive investments. Moreover, the control of a highly vertical integrated automobile firm, becomes unimaginable and decrease its influence with distance from headquarters (Grossman and Helpman, 2004).

Other trends from the recent past are the reduction in number of suppliers and the emphasis in quality issues. The advent of the idea of a supplier being a partner, has driven automakers to a consistent reduction in number of suppliers creating a more integrated and reliable system of production. Moreover, the quality aspects brought mainly by Japanese automakers, have changed the way America and Europe are producing cars.

Different ways of investing in new locations can always be seen. Part makers can have a plant were all components will be produced or can have just a final assembly factory, importing parks from its main plants location.

In the automobile industry, usually the size of a company is not related to its degree of internationalization. Small size part makers are the most internationalized companies in the market. Countries such as US and Germany are the most common destination for companies.

However, Bottazzi (2001) showed firms, in the early stage of an industry tend to be geographically concentrated and then disperse as the industry matures, proving that there is a transient period in industry development.

3.1.3. Automobile industry in North America

Since the beginning of the North American Free Trade Agreement (NAFTA), production of automobiles and auto parts in North America started to shift drastically from US to Canada and Mexico. These two US trade partners started to be seen as a strategic location for North America markets as Spain, Portugal and Eastern Europe were for Europe. However, the decentralisation has not broken the increase of US automobile production.

The decision to locate those factories in those specific areas can be explained by its solid work force capacities, market proximity and complete supply network. Furthermore, workforce's technical competencies in Canada have always been able to produce products as high quality as in US. Mexico, however, being still an economy in transition will see its automobile market growing in a highly unstable manner.

The size of the potential market is always an important determinant for investment decisions. Also, import legislation of the destination country is usually an aspect to be watched. Politic and economic uncertainties have always to be taken in account.

Moreover, as it has happened in Europe, the threat of delocalisation is a powerful vector that enables firms (manufacturers and park markers) to pressure labour unions into a making concessions (Lung, 2003).

The likelihood of economic systems of US and Canada played an important role in this change. The local and cultural proximity of Ontario region in Canada to the eastern part of US more precisely to Detroit ("Motor City") helped the automobile industry to create one of the biggest and most interesting supply chains in the world. Moreover, the economic stability of Canada comparing to Mexico have introduced stability for new investments.

The automobile sector has become the largest manufacturing sector in Canada with 12% of GDP in 2006 (Strategis, Canada). In 2005, 2.6 millions vehicles were produced in

Canada with 81% of production value being exported to the US (Strategis, Canada). The Ontario region was responsible for 99% of all automobile exports in Canada.

This huge supply chain mainly located close to the boarder, has three main crossing points: Ambassador Bridge and the Windsor Tunnel (Detroit – Windsor), Blue Water Bridge (Port Huron – Sarnia), and Peace Bridge (Buffalo – Fort Erie) (Fig.3.2). The average time for a shipment to cross the boarder is 20-30 min. Sometimes, due to congestion at the approach aprons and paperwork difficulties it takes 60 to 90 min.

During the past years Canada has increasingly become an assembler and exporter of vehicles, while the US increasingly has exported parts to Canadian assembly facilities (C.A.R.; 2002). The everyday need to reach economies of scale has brought first tier suppliers close to the boarder in the US side providing JIT deliveries for factories in Canada.

It is important to understand the huge role of these 3 specific points in the economy US – Canada. Considering that factories are related in a JIT basis, lateness on delivery of a single shipment could shut-down a whole plant creating unimaginable lost.

In the automobile industry, some auto parts, based on its shipments frequency and transport cost, are usually located just beside the automobile assembly factory (Fig. 3.2). However, all other parts are well managed coming from US

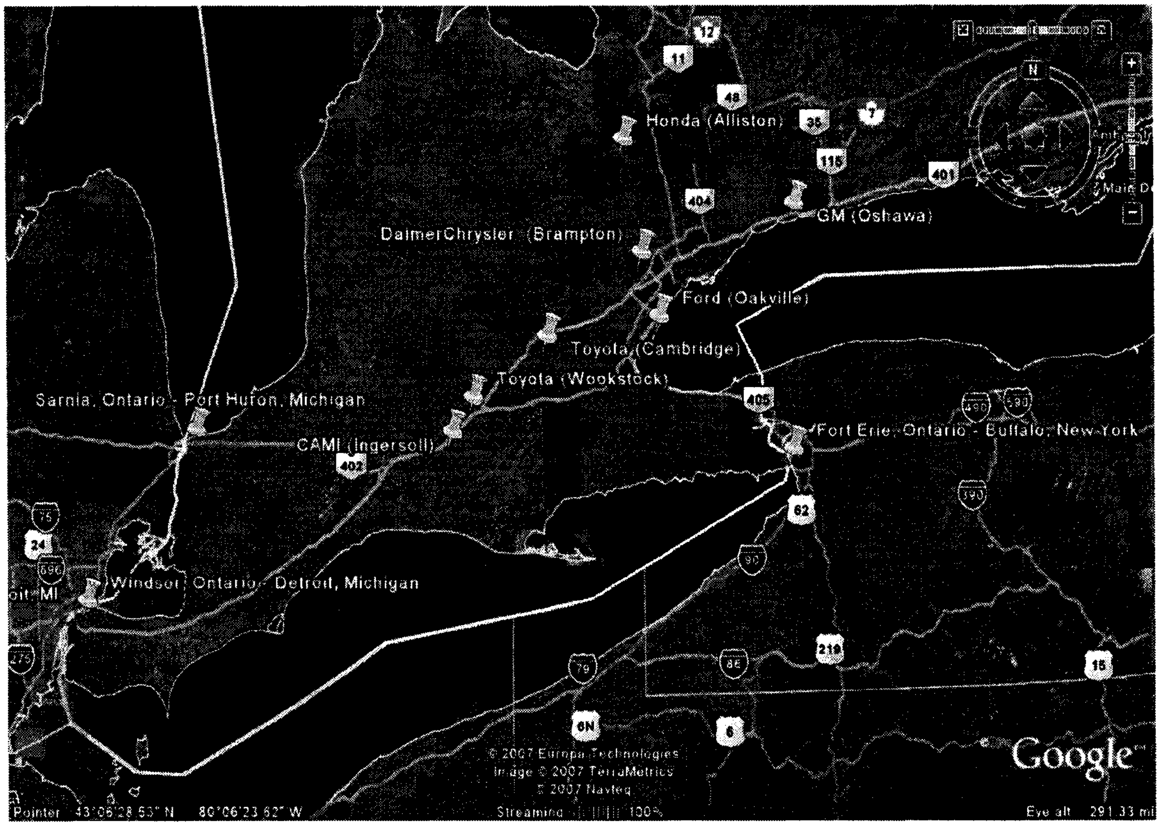

Figure 3.2 - Canada Automobile Factories

The need for proximity between automakers ad part makers is closed related to a reduction in transport and inventory costs, introduced my well-known Japanese JIT. Automotive suppliers are requested to make several deliveries in a single day, creating a system that is extremely reliable in deliveries.

The arrivals of Japanese automakers haven't changed the structure of the region. With companies such as Toyota and Honda some Japanese part makers have come, maintaining its well known partnerships. This particular trend of part makers following national automakers in a process of internationalization is called: *follow sourcing*. For example, even before Toyota officially announced its plans for a new plant in Woodstock (Ontario), its seat supplier Araco of Japan had opened a plant in Ontario.

Honda's supplier, such as Musashi Seimitsu and Ube, are currently also expanding (Canadian Economic Observer; 2007).

3.2. Laptop Industry

The laptop industry has been in particular changes for years. During the past 15 years, major changes were implemented creating a remarkable and unique industry organization. Those years have changed China from a minor player to the largest laptop producer in the world. However, differently from most part of the industries that have outsourced and off-shored production to Asia, laptop industry have switched its production to third part owned Taiwan firms, located in China. For the surprise of consumers, for years the major laptop producers in the world are not the well known brands that can be seen in electronic stores around the world, but companies that produce all those brands that are in the costumer's mind in the same factory. Those third part companies are specialized in produce any laptop design presented selling services to large and worldwide firms such as: HP, Sony, Accer, Toshiba, Apple, etc.

The market's change, increasing the share of laptops compared to desktops has been of the main change factors. The industry that was used to a small laptop market had to change fast and adequate its production. In 2006 after an increase of 24.7 % the laptop industry reached 72.6 million units produced.

In 2006, 85.5% of the laptop world production was controlled by only five laptop companies located in China. The five major laptop producers, its market share and clients can be seen bellow:

1. Quanta (~33%)
   (Clients in 2004: Gateway, Dell, HP, IBM, Apple, Sharp, Sony, Fujitsu-Siemens)
2. Compal (~20.6%)

(Clients in 2004: Dell, HP, Fujitsu-Siemens, Acer)

3. Wistron (~15%)

   (Clients in 2004: IBM, Dell, Acer, Hitachi, Fujitsu-Siemens)

4. Inventec (~10%)

   (Clients in 2004: HP, Toshiba)

5. Asus (~7%)

   (Clients in 2004: Sony, Apple, Trigem)

However, as the market is still in transition, and the concept is relatively new, those companies are still having some difficulties. Struggled in between well structured suppliers and customers willing to have cheap products, Taiwanese laptop producers have seen very low net profit margins compared to those of its suppliers. With exception by Asus that has a considerable separated market for mother-boards; laptop companies have seen profits somewhere around 3%. Moreover, the development in production could not yet impede a large number of laptops being returned on the first year of warranty (25% in 2005). Probably, because of its huge variety of products, Taiwanese laptop producers couldn't yet have reached the desired level of economies of scale.

Most part of laptop producer and suppliers are located in the area of Shanghai (Quanta and Inventec), Suzhou (Asus; 85Km east of Shanghai), Kunshan (Compal and Wistron; 52Km east of Shanghai), having Shanghai as its main connection with the world.

In 2004, 90% of laptop manufacturer's suppliers were located in Suzhou, operating in build-to-stock and build to order depending from the component and having very flexible delivery.

The main destiny markets for the industry are US (35.5%) and Western Europe (34.5%) and are mainly transported by air.

The product development concept, following the unique characteristic of the industry has its particularities. The in house development where a laptop brand designs its product and sends to an ODM to manufacture is slightly applied. The most part of product's development is made in join design and development by brand owner and ODMs showing integration introduced by concurrent engineering in the market. Moreover, another small part of the design is made in a particular way. The concept is totally designed and manufactured by an ODM and sold to a famous brand on what is called *off the shelf acquisitions*. This totally different way of managing introduces the change in the relationship designer producer from a notion of product to a notion of service.

3.3. Major Household appliance

Major household appliance industry can be defined as a mix of the diversification of automobile industry and some uniqueness of laptop industry. In Canada, as in automobile industry, the proximity to the huge US market is a reason for its development. Moreover, as quoted before, the economic stability and technological capacity are also taken in account. However, the lower Mexican wages are the biggest enemies for the industry in Canada. Also, the relatively low transport cost and the NAFTA agreements make this industry not as centralized as automobile industry.

As a consequence of the size of the market, some industry changes toward different modes of production can be observed. The Canadian market starts to see the implementation of third part multi-brand companies as the laptop industry has seen for a long time.

In 2003, Canada produced 1.6 billion dollars in manufacturing shipments (value of goods produced) with a manufacturing value-added ((goods produced + inventories) –

(cost of materials + fuel + electricity)) of 0.6 billions. Moreover the electricity and fuel cost was 16.6 million dollars for the same year, giving an idea about the industry's size.

Household appliances industry is forced to deal with an unstable decision on whether outsource production of not. The size and weight of its product creates a strange equality on cost of producing close to consumers cutting transport cost or in low-wages countries.

3.4. The Rise of "Contract manufacturers (CM)" and "Original design manufacturer (ODM)"

On the late 90s, electronic industry in US shift toward a new orientation after poor results from big well-known companies. Many facilities in US started to be sold for companies which sole business were manufacturing. Nonetheless, some electronics were being manufactured in the same facilities, under the same brand, but by a new company that had a contract with the previous facility owner. An example is Apple that sold its Fountain, Colorado facility in 1996 to SCI systems that received a 3 years contract to produce Apple products in the same factory (Sturgeon, 2002).

The trend was followed by many other companies (Ericson, Nokia, NEC, etc.) vertical decentralising, being able to concentrate in design activities and exchange production to "contract manufacturers" that were ready to reach economies of scale.

As a result of using CM, brand-name firms could gain the ability of changing production volume on short notice without having to increase the number of facilities or equipments. Moreover, use of contract manufacturers develops a market competition by having the same company producing different brand-name firm's product.

In some industries this market change goes even further. The "Contract manufacturer (CM)" not only manufactures but also designs, changing its reference to "Original design manufacturers (ODM)". ODM can be largely seen in laptop industry and are mainly from Taiwan such as Quanta, Compal and Wistron. The design of a laptop is usually made by an ODM or in partnership with the brand-name company, as will be explained later in this work.

However, with the increase of outsource of production to regional contract manufacturers, some difficulties of managing the relationship with suppliers in different locations in the world arrived. Key costumers start to demand, from contract manufacturers, global manufacturing and engineering support that had to respond opening several facilities in the world (Sturgeon, 2002). In some cases to make this change possible, CMs had to vertical integrate the company as a result of poor local supply base.

According to Sturgeon (2002), by the time, the main CMs in North America were: Solectron, California; Flextronics International, California; Sanmina, California; Celestica, Ontario; and Jabil Circuits, Florida.

3.5. Modularity

In an attempt to lower costs and develop a more flexible type of organization, modularity has been developed in different ways. Manufacturers have changed to module design and have passed some of their production costs to their suppliers in systems frequently called ***modular consortium***.

In the automobile sector, modular consortium creates a unique relationship between automaker and first tier supplier. In this new industry organization the automobile is divided in a certain number of modules and all assembly operations are controlled by the first tier supplier.

This new way of manufacturing has been largely used in Volkswagen's (VW) plant at Resende, Brazil, and Smart in Hambach, Germany. In VW's plant in Brazil, where 19 models of trucks and 5 models of buses are assembled, first tier suppliers are responsible for the assembly operations. VW is responsible only for quality control and product development. Moreover, the first tier suppliers' production is located just beside to the main assembly line. Modules are managed in just-in-sequence[1] with the main assembly line reducing inventory and production time (Volkswagen Brazil) Organizational proximity made it possible to create a shared language between the various groups of employees (Lung and Frigant, 2002).

Despite the fact that first tier suppliers are located in VW's property, they have contributed to 1/3 of the total investment. The automaker remains owner of the land to avoid its module makers from supplying another automaker.

The irony intrinsic in this new industrial organization is the fact that Henry Ford had opened a complex called Rouge in Detroit (1927) with a close idea. The Rouge complex was able to input raw materials from one gate and output finished cars from the other. However, by this time, Ford Motor Corporation was totally vertical integrated.

Modular consortium has permitted the risk to be shared between automakers and module makers and a degree of partnership to be introduced; however some constrains has been observed such as: The coherency between technological and organizational competencies and management of the employment relationship. To avoid some problems, VW had to minimize the disparities in the wage package that each supplier would offer to its staff (Lung and Frigant, 2002).

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[1] Parts being supplied in the exactly sequence in the main assembly line.

Shared goals and expectations, built through social and spatial proximity and long term contracts, can never be replaced by an authority structure of the integrated firm explaining ongoing thick linkages are more commonly observed in economic life than in neoclassic theory suggests (Granovetter's, 1985). Moreover, trust can lower transaction costs to a point where externalization is a more efficient outcome than internalization (Jarillo, 1988).

The actual trend of automobile industry of releasing an incredible amount of new cars with the same platform (chassis and structure) and modules have brought a new reality. First tier suppliers have also been hit by this trend: The use of complex components (something that specifically requires major R&D investments) on different models (coming from different manufacturers or else from the same one) makes it possible to spread out costs and benefits from economies and of scope (Lung, 2003).

New strategic production areas such as Eastern Europe become loci for experimenting with new forms of productive organisation and/or with technical innovation (Lung, 2003).

As a base for modular consortium, is the modular product architecture. In contrast with integral product architecture where components are adjusted to each other to create a whole system, components in modular product architecture, interact trough interfaces allowing the same module to be used in many different models. A modular component has it own function in the system. In automobile industry a great improvement towards modularity was the *drive-by-wire* that allowed car's design to surpass some technical constrains.

Moreover, modularity created a great possibility to implement outsourcing to multi-brand factories as can be already seen in notebook and household appliance industries.

Modularity is considered to be one of the main structures for Dell Computer's growth. Combined with mass customization, modular components gave the chance to reduce costs and improve delivery.

In 2006, Assche designed a model to link offshoring and outsourcing in the industry to the rise of modular production. Comparing US with Japanese industry, this model explains that as a result of a previous focus on the production of goods that need more dense interactions in the design and manufacturing, Japanese industry encountered a higher cost to adopt modular production. As a result offshoring and outsourcing have not come into play in Japan's electronics industry.

The introduction of modularity gives to suppliers, financial strength, technical and operational competence and geographic reach. Also, brand-name firms become more reliant on them, creating a sort of partnership.

Modularity has driven the industry to many changes. In the automotive sector, modularity has been used to reduce costs and share risks with suppliers. However, it is important that the industry starts to understand the way how modularity will change the organization and more precisely its supply chain.

3.6. Other trends

Some other trends have to be considered in order to complete understand changes in industrial organizations.

3.6.1. Same platform

Mainly guided by developments in automotive industry, there is a new trend to design many products in a same platform basis. For years, automobiles have been manufactured under just a few main platform improving economies of scale while retaining the ability to adapt for costumers desire. An example is Volkswagen (Owner of Audi) that produces the VW Golf and the Audi A3 using the same platform.

3.6.2. CKD plants

Also started with automobile industry there is the development of a CKD ("complete knock down") assembly plants. CKD assembly plants consist in a low investment facility able to assemble vehicle kits manufactured by main factories. CKD plants have been used in order to enter in emerging market without having considerable risk (Wikipedia, 2008c).

3.6.3. Sharing capacity

Another important trend is sharing capacity of large capital expenditure operations with other manufacturers to minimize the risk of implement a totally owned new facility. In Germany, some small and medium firms integrate in a ways where design, production and sales can be shared whenever a spare capacity exists (Sturgeon, 2002). Sharing capacity can be easily seen in automobile industry where investment costs are usually very high.

3.7. Global Wood Furniture Industry

Something has changed in the wood furniture business. Even though solid wood furnitures have kept their high-end consumers, the advent of a new design for wood furnitures made the IKEA business concept possible ("We shall offer a wide range of well-designed, functional home furnishing products at prices so low that as many people as possible will be able to afford them." IKEA).

Mass producing furniture became a viable manufacturing strategy with the advent of flat-pack or ready-to-assemble designed furniture. These changes increased the possibility to ship products in large quantities. Between 1995 and 2000 global furniture trade grew 36% faster than world merchandise trade as a whole (26%). The wood furniture industry is becoming increasingly competitive, with more producers entering the market and prices falling (UNIDO, 2003).

Furniture industry is divided into different product groups, each of which has distinct market segments. Product classification distinguishes four product groups, namely office furniture, kitchen furniture, bedroom furniture, and dinning/living and shop furniture. In 2000, 74% of furniture imports in EU was dining/living and shop furniture. Furniture industry is in the throes of intense global competition and therefore moving towards a common and falling global price.

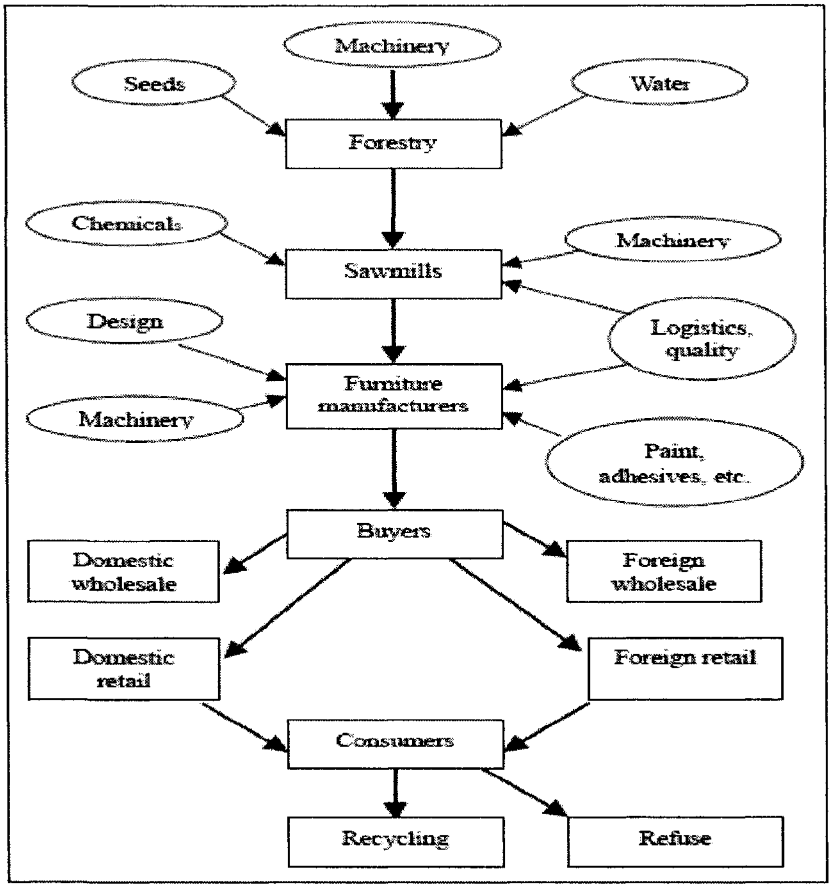

Figure 3.3 - Value Chain in Wood Furniture Industry (UNIDO, 2003)

Figure 3.3 shows the wood furniture value chain, which for the forestry sector involves the provision of seeds, chemicals, equipments and water. Then cut logs go to the sawmill, which obtains its primary inputs from the machinery sector. From there, sawn timber moves to furniture manufacturers who, in turn, obtain inputs from the machinery, adhesives and paint industries and also draw on design and branding skills from the service sector. Depending on which market is served, the furniture then passes through various intermediary stages until it reaches the final costumer, who after use consigns the furniture for recycling or refuse.

There are different categories of buyers in the value chain, from large multi-store retailers till small-scale retailers. IKEA for example, sources from 2000 suppliers in 52 countries and has more than 300 outlets in three continents. Small-scale retailers, which buy directly from a limited number of suppliers in a limited number of countries. Specialized medium-sized buyers, which source from many countries and sell on to retail outlets, usually in a single country or region. These buyers may have over 1500 suppliers, located in many countries (United Nations Industrial Development Organization [UNIDO], 2003).

In the case of the largest multi-store retailers, the overwhelming proportion of furniture, more than 85% comes from middle- and upper-income countries, although imports from China, Indonesia and Vietnam are projected to grow rapidly during the early of the second millennium.

Not only suppliers have to develop the ability to upgrade existing processes and products, firms are expected to have capacity to provide upgrading assistance to their own suppliers and provide value for their customers. Suppliers may also be required to develop new capacities and to assume new functions such as product design and outward logistics, both within their own link of the chain and in different links. In addition, they may need to move into new but related sectors if they are to survive (UNIDO, 2003).

During the last decade, multinational companies in the industry have outsourced more and more its manufacturing activities to concentrate on areas such as design, technology, branding, logistics, marketing and after-sales service. This increasing tendency has grown the capabilities of independent producers, that take a role as contract manufacturers (CM).

Upgrading design processes has been one of the goals of this industry. IKEA, for example, has designers living in the homes of final consumers in new markets. They may employ specialized design houses, and may work with suppliers in design for manufacture activities, but for these firms direct control of design is critical.

Moreover, specialized buyers and small retailers saw products being more and more designed by suppliers while the large multi-store retailers saw an outsourcing trend in their suppliers.

In 2002, Schuler & Buehlmann reinforced the need for improvements in managerial abilities, entrepreneurial spirit and a more appropriate business model, to improve the US wood furniture industry. The existence of centers of excellence – a group of interrelated industries, government and private organizations/institutions, research institutes and universities, equipment manufacturers, and consultants that reinforce/support the core industry – is now being recognized as a key competitive factor in establishing and maintaining global competitive position in a number of industries.

The US furniture industry needs strategic renewal in the form of a new and more appropriate business model – a paradigm shift –that will include: (1) a new business model – mass customization (moving away from the commodity business is central to this); (2) new manufacturing strategies - such as strategic supply chain alliances, global outsourcing, just in time (JIT), and lean manufacturing; (3) "reinventing furniture" – using design and construction to make furniture manufacturing a more modular product; (4) new sales channels – including internet sales; and (5) innovation.

Another interesting strategy for the future would be to export to our main competitor, China. Although China currently imports only about 1 percent of its domestic furniture demand (about $100 million in 2000) (Badanelli 2002), the country's increasing wealth and the large number of potential customers should lead manufacturers to find ways to sell their product overseas. Exports to Europe, too, should be seriously considered, since in Europe, solid wood furniture is in high demand.

Adoptable solutions currently exist in Europe, where the problems faced by the US industry have existed for a longer time. Among several European producers that use the concept of mass customization, Huelsta, a German producer of living room furniture, offers customers the opportunity to design their own modular furniture using free design software available online (www.huelsta.de). The design is electronically forwarded to the company to receive a quote and a delivery date. After acceptance of the quote, the furniture is delivered to the customer's home in a few weeks.

This system is very similar to Dell Computer Corporation's system where customers select system components and obtain pricing, delivery, and other information from the Internet. To our knowledge, the closest implementation of this concept by an American residential furniture company is Stanley Furniture's design page (www.stanley.com). However, this design page only allows the customer to select predefined pieces of furniture and to arrange them in a floor plan, very much like obtaining the information from a catalog. Customization and fast, reliable delivery in the United States is not outside the industry's possibilities, as proven by the office furniture industry.

Herman Miller Inc. delivers its customizable Simple, Quick, Affordable (SQA) product line in fewer than 10 days. SQA performance metrics are more than 99 percent on-time deliveries and average time from order to shipment is less than 5 days.

Highly successful companies, such as Dell Computer Corporation or Honda Automotive, are involved in all steps of manufacturing their products, yet they do little manufacturing on their own. In fact, Honda purchases 80 percent of the total costs of its car from outside suppliers (Monczka et al. 2002) and Dell outsources all of its manufacturing activities except assembly (and for notebooks, not even assembly is done at Dell) to original equipment manufacturers that specialize in certain activities (e.g., core competencies).

The manufacturer becomes a "system integrator", ensuring that all parts of the value supply chain are available in the quality required, and on time. Such supply chains are possible for furniture, yet still are not very common. Probably, the wood products industry, with some notable exceptions such as the office furniture or the kitchen cabinet industries, is still in the beginning or early stage of supply chain development.

CHAPTER 4 - METHODOLOGY

The process of studying a supply chain is time consuming and usually requires the use of a method. Supply chains are by definition systems or networks of organizations, people, technology, activities, information and resources involved in moving a product or service from suppliers to costumers.

For every system that is studied, limits have to be set. The limits are usually determined according to the precision of the answer required and the length of time to complete the analysis. As an energy crisis approaches and environmental concerns rise, simplifying a whole supply chain analysis into an energy and transport use, accelerates the process. Analysis thus requires less time.

Data is by all means the most important part of a project. Without it, research studies are not possible. Data acquisition and generation is extremely time consuming. However, readily available databases exist in almost all study fields.. Databases are the primary source of information for a project. Usually, they contain abundant data but in certain cases the cost of accessing them could be exceptionally expensive.

In the case where data has never been published, it has to be collected. Data assessed in the field represents the second source of information for a project. Most of the data need measurements of all sorts to be made. However, it represents the most trustable data. All proxies are under your control and decision.

The goal of this project is to create a tool (Method) that allows different industries to conveniently define their next business plan based on the increasing importance of environmental impact concerns and oil prices.

During the literature review, no similar method was discovered. In general, our method is created based on data collection, observation and brainstorming. The method originates from the need of a simplified tool to prepare companies for future changes.

The first hypothesis is that we are exclusively studying the isolated impact of logistics decisions. Certain analysis regarding changes on product or production processes are derived from global logistic analysis, but these, are not the main concern of this methodology. Therefore, an important decision is the definition of limits for the system. In this study every aspect of logistics decisions is considered in isolation from the rest of variables.

Our method doesn't claim to assess neither a complete environmental impact nor the exact amount of energy use through the supply chain. It only covers the required information that could have an impact on logistics decisions.

The main steps of our methodology are:

1. **Choice of a product**
2. **Construction of the supply chain network**
3. **Limit's definition**
4. **Analysis of each node**
5. **Analysis of each edge**
6. **Synthesis of the analysis**
7. **Definition and analysis of different scenarios**

Every step has to be followed by the corresponding procedure and methods. All tools used are considered below.

4.1. Choice of a product

The choice of a product determines how significant results can be for a company. Product choice is usually based on weight / volume rate and volume of sales. Generally speaking, products should be chosen as many as necessary to cover all existing weight / volume rates.

Moreover, matching volume of sales is important to generate results significative enough to be economically representative. Product choice should be a comprehensive process that takes into account the company's main processes, economical strength and the environmental impact of a company as a whole. In most cases, products that have been commercialized for many years give a good clue.

Despite of the fact that previous life cycle assessment studies (LCA) (Annex B) tend to show that generalizations of one product through the whole product family are not good proxies for impact assessment, a limit on the number of products considered has to be defined.

On this first phase, visiting a show case and going through catalog books certainly helps to make the choice. Usually, sales departments have product knowledge, useful in conducting this phase.

4.2. Construction of the supply chain network

In this phase, an understanding of the origin of the product is absolutely indispensable. The product's path can be easily analyzed in a top-down approach. The product's materials, parts and transportation should be assessed to the raw material level. Knowledge of every company related to the case study should be listed.

Information on the supply chain network can be assessed through the purchase department. It is valuable to build a list containing complete contact information of each company represented in the supply chain. As a sub-part of the network, locations can be added in a mapping software (e.g. Google maps) to convey a geographical comprehension of the supply chain

Furthermore, research is complemented by assessing the environmental impact and energy use by the companies related to the specific product. As presented before, the main impacts under consideration will be a consequence of transport and energy use.

Finally, a measurable unit is defined. This unit will further be linked with a functional unit on the LCA study. A measurable unit can be one product or a group of products that can be easily analyzed. Even though a single unit usually helps on defining manufacturing processes, in some cases they are transported in batches becoming hard to define the impact of a single unit in a truck load (Full truck load is defined by the number of batches and not number of units that can fit).

One should be looking for: energy bills for the period studied (Kwh and cost information), other sources of energy not regularly billed such as oil and wood, energy mix of the region, product flow from raw material to final product, location and energy use of every single player on the supply chain, transport flows (Cross docking? Direct transport?), truck loads used, truck sizes and capacity, location of each employee's residence.

4.3. Limits definition

The limits definition phase is usually integrated with the previous step. A detailed definition of the limits is responsible for a project's follow-up. However, certain industries survive in a no-information-share basis, making information assessment particularly challenging.

It is essential to define a geographic limit for the system. The cutting line is defined based on time constrains and information interaction in the supply chain. For a most general analysis, the limits can be set so that they comprise the main manufacturer (product's owner), its transport links and cost interactions between members.

Limits must enclose the main parameters responsible for a strategic change on the supply chain. The Pareto's principle is considered as a tool in this phase of the methodology. Usually, 20 percent of parameters will be responsible for 80 percent of effects.

The larger the limits are, the more time-consuming and challenging the ensuing project will be. Therefore, limits are set to make a project possible within a certain time frame and use as much information as is needed for representative conclusions to be reached.

An important aspect that is usually neglected for not being directly related to the product itself is employees' daily commute to work. Depending on number of employees, the impact can be considerable.

4.4. Analysis of each node

Each company, organization and client in the supply chain is represented as a node. For each node covered by the system, the energy cost and labor cost have to be analyzed. Often, an understanding of operations on each node may be required for further analysis.

Every node can be considered as a small system with its respective inputs and outputs. Moreover, for every node, a transformation process (economical, physical or geographical) occurs. Transformation should be assessed on every aspect. For this reason, it is important to use the unit previously defined.

In general, one "unit" can be decomposed in several parts that put together become the final piece.

During the analysis stage of each node, each supplier in the supply chain has to be contacted for information assessment. Contact has to be established by means of a personal interview or by email. Phone interviews are discarded for a lack of interest on the subject matters by the supplier. Usually, only a first contact is made by phone as an introduction. A questionnaire (Example in annex) is sent by email. It is important to understand that every company has its own privacy rules and production secrets and won't be willing to share specific information. Questions have to be general and summarize the need. However, a contract of secrecy on every aspect should be provided to every player assessed.

4.5. Analysis of each edge

Edges are every link's end connecting nodes created on the network. In studies like ours, edges are generally transport edges.

One should examine the nature (frequency, truck type, contract type) and the volume and weight transported. It is necessary to comprehend the limitations of each transport edge. Transport is usually limited either by weight or volume.

During analysis of each edge, transporters in the supply chain have to be contacted for information assessment. As with nodes analysis, every aspect of the contact has to be applied. Sometimes, transport information can be found in the reception and expedition departments of every company being part of the supply chain.

4.6. Synthesize the analysis

At this stage a considerable amount of information should have been gathered. At this step data should be scrutinized and only truly useful information be kept for further analysis.. Completing all missing information in the network flow diagram is a good way of defining wherever is useful or not.

Environmental impact assessment is the following step. Life-cycle Assessments (LCA) try to determine the most significative actions to increase the environmental efficiency of a system, considering the impact through the economical plan (Annex B). LCA can evaluate the environmental impacts of a product or service based on a particular function, considering all stages of a life-cycle. Covering all stages is of relative importance to avoid improving a local system by simply relocating pollution and causing the same overall impact on the system as a whole.

Once all information is organized and in a concise format, different scenarios have to be benchmarked. Scenarios emerge from the understanding of strengths and weaknesses of actual scenarios. Comparison of environmental impact can be analyzed through a LCA software (Simapro, Gabi4, etc). Comparison on cost and strategic options come from full understanding of the industry considered.

4.7. Define and analyze different scenarios

One should be looking for a change in reducing transport use, energy use attitude, a location change, decreasing local impact, change in the manufacturer-supplier relationship, car pooling between employees, etc.

After a brainstorming session about possible changes in the industry, the scenarios have to be identified and analyzed.

4.8. Important aspects of the methodology

Throughout the analysis, the understanding of the unit to be measured is particularly important. In every aspect, node and edge, the unit has to be respected. Only the amount of components, materials, transport use and energy use, related to the production of one "unit" have to be considered.

There are several elements to be considered in the analysis. The most important are:

- The network is analyzed by a flow diagram respecting the limits previously defined.
- Underlying manufacturing processes, have to be considered in order to gain a complete understanding of any possible environmental impact.
- Clients are considered as a knot, with the exception of a few cases. They can be either retailers or final clients. Their energy use and environmental impact are usually not important. Moreover, every transport has to be considered.
- Main components usually have its own supply chain that can be studied if defined within the system's limits.
- Raw materials define the lower limit of the system. Only main raw materials used on final product are considered.

The role of transportation in this analysis is mainly related to oil use (cost and environmental impacts). Its limitations allow the division per unit studied of every main transport cost and environmental impact. Every transport where energy use has been previously assessed (e.g. electric conveyors and electric carts) should be neglected. Only transport related to business strategy has to be analyzed, to avoid erroneously including the same energy use twice.

CHAPTER 5 – CASE STUDY

Our study was developed based in a company located in the south-eastern of Quebec in Canada. The name and location of the company will be kept confidential and for the sake of simplicity, the company will be called C1 in this report. Two products made of birch wood, one chair and one table, were chosen to be studied in detail. These two products were selected for its representative volume of sales.

5.1. Quebec Wood Industry: An overview

Wood furniture industry in Quebec is important for the region. The enormous area of land covered by forests gives the region and its inhabitants the opportunity to engage in wood production and exploitation while insuring its sustainable development (Annex C).

C1 is a leading manufacturer of wood furniture in Quebec. Its clients are located all over North America, mainly in the US. Products are manufactured in 4 to 6 weeks and transported to the client (retailer) by truck.

It is clear that during a short time frame, C1 Inc. has always grown in the industry. Its business plan has proven to work at a sustainable pace. From a small family business, it became a respectable and well administrated company with working procedures similar to those of huge conglomerates. However, the wood furniture industry in Quebec would certainly experience considerable advantages if some of its processes were improved. Bigger economies of scale and a more reliable supply base have to be created. The industry's size does not seem to present suppliers with the same economic strength as the main manufacturers (e.g. Automobile industry). Also, high quality standards created by main players such as C1 are hardly achieved throughout the supply chain.

Unfortunately, the relationship in the wood supply chain is a buyer / seller relationship and not a partnership. It is explicit that a closer relationship would generate either a better quality control or lower inventory level. Despite of the fact that closer relationships such as Keiretsu are only based on mutual trust, it could certainly reduce the inventory and the work-in-process (Number of Kanban).

As a consequence of this fact, for years, an increasing verticalization was brought into the company. C2 Inc. (Part of C1's group) was created to negotiate wood boards with the saw mill, to treat and classify them according to high quality standards, to create different wood blocks and either sell them to part suppliers or manufacture some parts. Furthermore, a supplier's folding factory was bought and relocated just beside C1. The acquisition will certainly achieve cost reductions for the company, and result in increased flexibility.

The product development for hardwood furniture is far less developed than the softwood one. Softwood furniture industry had to develop a product with less volume in box and less weight to reduce the large transportation cost of manufacturing products in China and sending them to be consumed in North America. It forced products to be finally assembled by the client. The process was well accepted by the market (e.g. IKEA).

As most parts of the industry's business is intended for a medium-high end consumer, apparently the industry does not have enough production volume to grow towards a stronger and more reliable supply base.

Nevertheless, the medium-high end business safeguards the industry from highly inexpensive imports from developing countries. Business plans such as IKEA (low-medium end) are highly dependent from products and economies of scale created abroad. Low end businesses easily develop wide and diverse supply bases.

5.2. Towards the methodology

The methodology created for this analysis and previously explained, is followed in our case study.

5.2.1. Choice of a product

C1 manufactures thousands of products in several types of finishes and fabrics. Moreover, over 170 finishes and 55 types of fabric can be applied to products, creating a practically infinite choice of combinations. Among all products' families there are:

- Over **390 bench, chair and barstool** models
- Over **2,000 table** models
- Over **90 buffet and hutch** models

All products' family sales were analysed in order to choose the most profitable table and chair, which are by far the most sold products. Two products were studied: chair 1 and table 1.

The chair has a considerable volume (17ft3) and a low weight (36 lbs). The table (11.1ft3; 98lbs) is heavier than the chair but packaging is extremely concise. Therefore, these two products cover a large range of volume / weight ratios, in the product's family.

5.2.2. Construction of the supply chain network

Most part of information gathered was taken from a software application that stores the company's database. The use of the software to compile all information was essential to the project. All information needed was taken on site during a 3 months period on a full time basis. For each specific input and output needed, hours of compilation and analysis were necessary as the information had never been assessed before. MS Excel was used to organize and analyze the data.

An important question to be asked in the beginning of energy and transport analysis is what the necessary information to accomplish the project is. The first analysis cut time waste and guided us to focus on realistic goals. In an energy and transport study, the data needed is:

- Energy bills for the period studied (Kwh and cost information),
- Other source of energy not regularly billed such as oil and wood,
- Energy mix of the region,
- Product flow from raw material till final product,
- Location and energy use of every single player on the supply chain,
- Transport flows (Cross docking? Direct transport?),
- Truck loads (LTL? TL?),
- Truck sizes and capacity,
- Location of every employee's residence.

The analysis of the energy data gathered at C1 and C2 gave the following results:

- Electricity at C1: 10.15 kwh / chair and 46.95 kwh / table
- Electricity at C2: 5,18 kwh / chair and 26.89 kwh / table
- Gas at C1: 5.05 m3 / chair and 16.81 m3 / table
- Gas at C2: 0.036 m3 / chair and 0.18 m3 / table
- Wood (as energy) at C2: 6.48 kg / chair and 33.61 kg / table

A question form was send to most important suppliers in order to gather information needed (Annex D). Due to an extreme lack of partnership in the industry, only very limited and incomplete information was shared by part suppliers. Despite of the fact that the most important suppliers were contacted, only a single and incomplete response was received. Even though, C1 is an important client for some of the suppliers, supplier's scale seems to be the main reason for the lack of cooperation.

A flow diagram and a geographical diagram were created. The measurable unit analyzed was one unit of each product. Both analysis (chair and table) were conducted in parallel.

Specific information in this project can not be disclosed in this paper due to confidentiality agreements.

5.2.3. Limit's definition

For every product at C1, there are over 20 part manufacturers supplying over 170 different pieces. Each of these pieces has its own supply chain which, by consequence, has its own energy and transport impact. Over 20 sawmills supply wood to C2, creating an enormous variety of node and edges to be controlled. Moreover, as many of those supply chain's players are small organizations with just little resources, information probably has never been assessed before, creating a huge difficulty for the project. Limiting the system to its main components is a crucial part of the study.

System limits were set over all wood parts suppliers, paint supplier and packaging suppliers. The only supply chain followed was the wood one. The source of every other material has not been analyzed. Moreover, final clients are not considered due to lack of information. Only retailers are covered by the study.

5.2.4. Analysis of each node

Nodes represent companies in the supply chain. Each node was analyzed giving special attention for wood loss during every transformation. Inputs and outputs were wood volume and cost. Transformations usually needed energy and human labor.

Both the chair and table analysis covered the 7 major sawmills used, which account for 90% of all wood supplied. For the chair, 5 major part manufacturers (including C2), 2 packaging manufacturers and 1 paint / glue manufacturer were considered. For the table, 4 major part manufacturers (including C2), 2 packaging manufacturers and 1 paint / glue manufacturer were considered.

All nodes considered were located in the province of Quebec with the single exception of a sawmill located in New Brunswick.

5.2.5. Analysis of each edge

Edges represent transport activities. Most transportation information was assessed by analysis of contracts. Type of transportation, rotation, cost, and capacity were the most important information.

All transport from node to node was considered. Transport from employees to C1 was also analyzed in order to better understand its impact. Most of the times, transport activities had one single destination. However, multiple destinations are part of some edges. Transport in C1 and C2 is made by a contract transporter which charges predefined rates and fuel surcharges for a list of routes. Most of the trucks used were 53 ft ones. Fuel surcharges vary according to the North America transportation council.

5.2.6. Synthesis of the analysis

In order to synthesize the project, a meticulous analysis was made on the flow diagram, having every blank filled-up. Moreover a life-cycle assessment was made using the software Simapro. Simapro is a tool created by product ecology consultants (PRÉ) to collect, analyze and monitor the environmental performance of products and services. The software allows modeling and analysis of complex life cycles following the ISO 14040 series recommendations. IMPACT 2002+ (Annex B) has been used as method of impact assessment. The functional unit is a unit of the product studied.

Every node studied has to be created in the software model. Some information from a data base called ecoinvent, was used. During the study, only the transport and energy use have been analyzed. Therefore, the software was used to understand the impacts of only those two factors in the product's life-cycle.

5.2.7. Definitions and analysis of different scenarios

There were several scenarios that could have been studied. After a brainstorming session, only a few considerable important scenarios were analysed in order to develop an effective solution. Only scenarios that would be useful to compare with the current one were analysed in depth. All other scenarios were quoted and briefly explained.

5.3. General Analysis

The use of our methodology generated interesting results. As a consequence many possible changes should be considered by C1's management. C1 has a very bright future and should be prepared for a challenging economic environment.

It is important to understand that all costs related to transport were analysed based on the period from July 2007 and December 2007. In this period, a barrel of oil averaged 60 USD and was quoted by 69 USD in November 2008. Consequently, the oil surcharge charged on the transport was much less today.

Table 1 attracted closer scrutiny and analysis as long as few changes to the *status quo* are feasible and realistic. The interaction between product's cost and volume encourage organization to maintain its actual practice. Transport cost for a table is less than 3% of total product's cost, in the case of the most important client. Moreover, the LCA shows that the transport from part manufacturers until C1 represents the greater environmental impact with almost 70%, having to be considered for change.

However, the chair's case is a little bit different. Chairs are assembled and usually placed in boxes by two. Transport cost averages 7% of product's cost, for the case of the most important client. Moreover, it is the second highest environmental impact of the product. For the case of the most distant client, transport cost comes up to 15%.

Supply chain and environmental impact networks for both products studied are presented bellow. All Excel, Visio and image files have been included in this report.

Figure 5.1 represents the flow of material from the saw-mill to the final client for the chair 1. Each box represents a node where a company or client is defined. The arrows that link the boxes are edges and represent transport between two nodes. The volume of wood materials and their cost are presented over each node. All information relates to the transformation and production of one single product.

On the far left side of the figure 5.1, seven nodes represent the most important sawmills that supply standard wood boards to C2. The total transport cost of 10 FBM of wood (Volume needed to have one chair at the end) from sawmills to C2 is 0.8% of the total product's cost. The arrows going from each sawmill to C2 represent that transport contracts are not interrelated.

The wood processed by C2 suffers considerable loss, averaging 40%. This means that, 1 FBM of wood bought by C2 becomes 0.6 FBM of wood sold to parts manufacturers. The total transportation cost of 5.9 FBM of wood (Volume needed to have one chair at the end) from C2 to parts manufacturer is 0.09% of the total product's cost. The arrows represent that one single transport contract is used and products are delivered in the order presented.

Five parts manufacturers (Including C2 that produces some of the parts) and three nodes in blue represent the paint and packaging suppliers. Each part manufacturer has its own material loss and production cost that can be verified in the figure 5.1. The total transportation cost of 5.74 FBM of wood from parts manufacturers to C1 is 0.15% of the total product's cost.

C1 assembles the parts having almost no wood material loss on its processes. The final transport cost from C1 to the client (Usually a retailer) is 6.7% of the total product's cost in the case of the company's most important client and 16.4% of the total product's cost in the case of the most distant client.

Figure 5.1 gives a clear view of what should be changed in terms of cost. In the case of the chair, the final transport should be modified and reduced. Cost savings could average 10% of products total cost and represents one of the most important change factors in the supply chain.

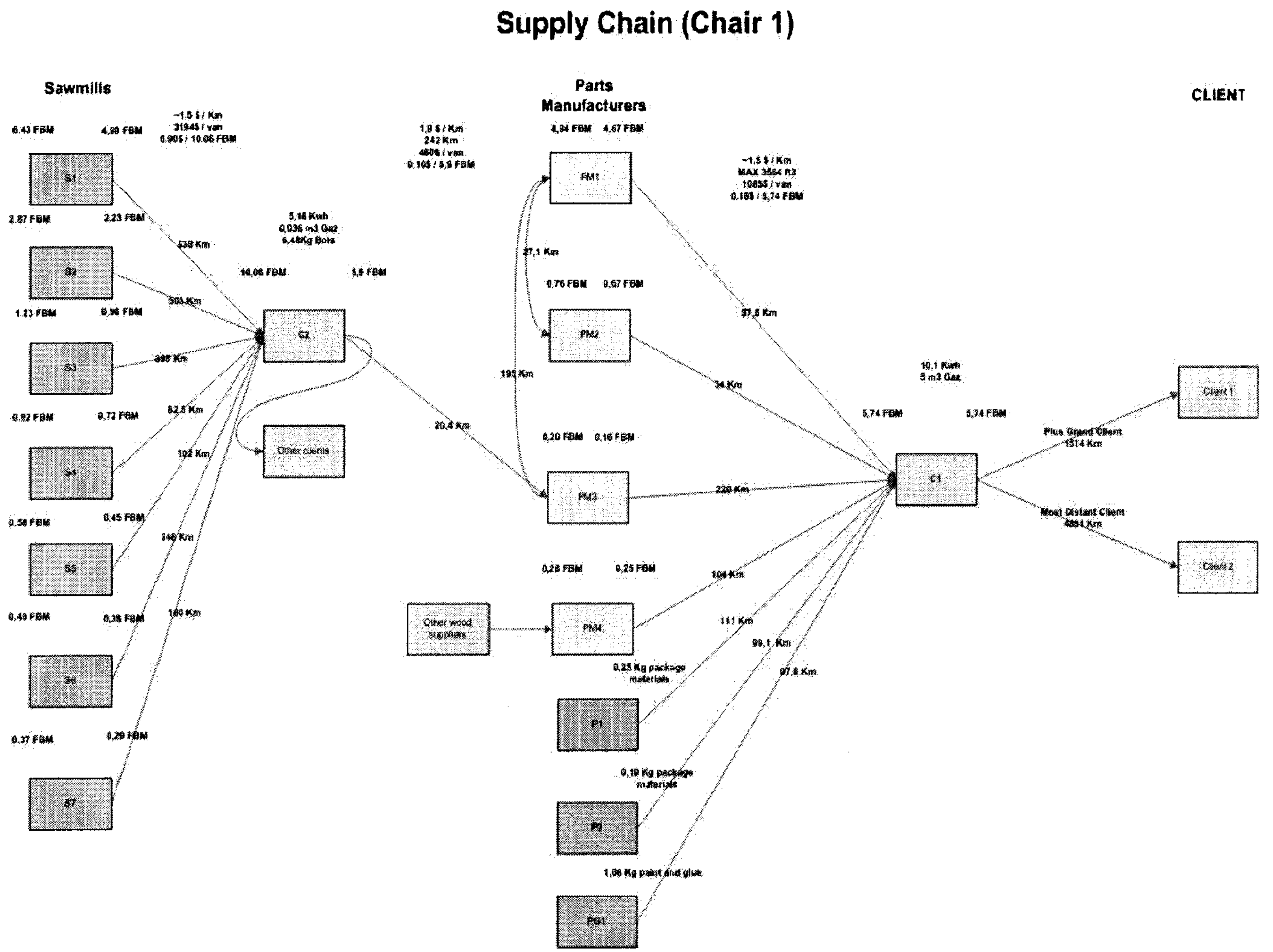

Figure 5.1 - Supply chain (Chair 1)

Figure 5.2 represents the supply chain analysis for table 1. On the far left side of the figure, seven nodes represent the most important sawmills that supply standard wood boards to C2. The total transportation cost of 50.1 FBM of wood (Volume needed to have one table at the end) from sawmills to C2 is 0.9% of the total product's cost. The arrows going from each sawmill to C2 represent that transport contracts have no relationship whatsoever.

The wood processed by C2 suffers considerable loss that averages 40%. It means that, 1 FBM of wood bought by C2 become 0.6 FBM of wood sold to parts manufacturers. The total transport cost of 29.36 FBM of wood (Volume needed to have one chair at the end) from C2 to parts manufacturer is 0.13% of the total product's cost. The arrows represent that one single transport contract is used and products are delivered in the order presented.

Five parts manufacturers (Including C2 that produces some of parts) and three nodes in blue represent the paint and packaging suppliers. Each part manufacturer has its own material loss and production cost that can be verified in the figure 5.2. The total transport cost of 23.58 FBM of wood from parts manufacturers to C1 is 0.16% of the total product's cost.

C1 assembles the parts having almost no wood material loss on its processes. The final transport cost from C1 to the client (Usually a retailer) is 1.8% of the total product's cost in the case of the company's most important client and 5.3% of the total product's cost in the case of the most distant client.

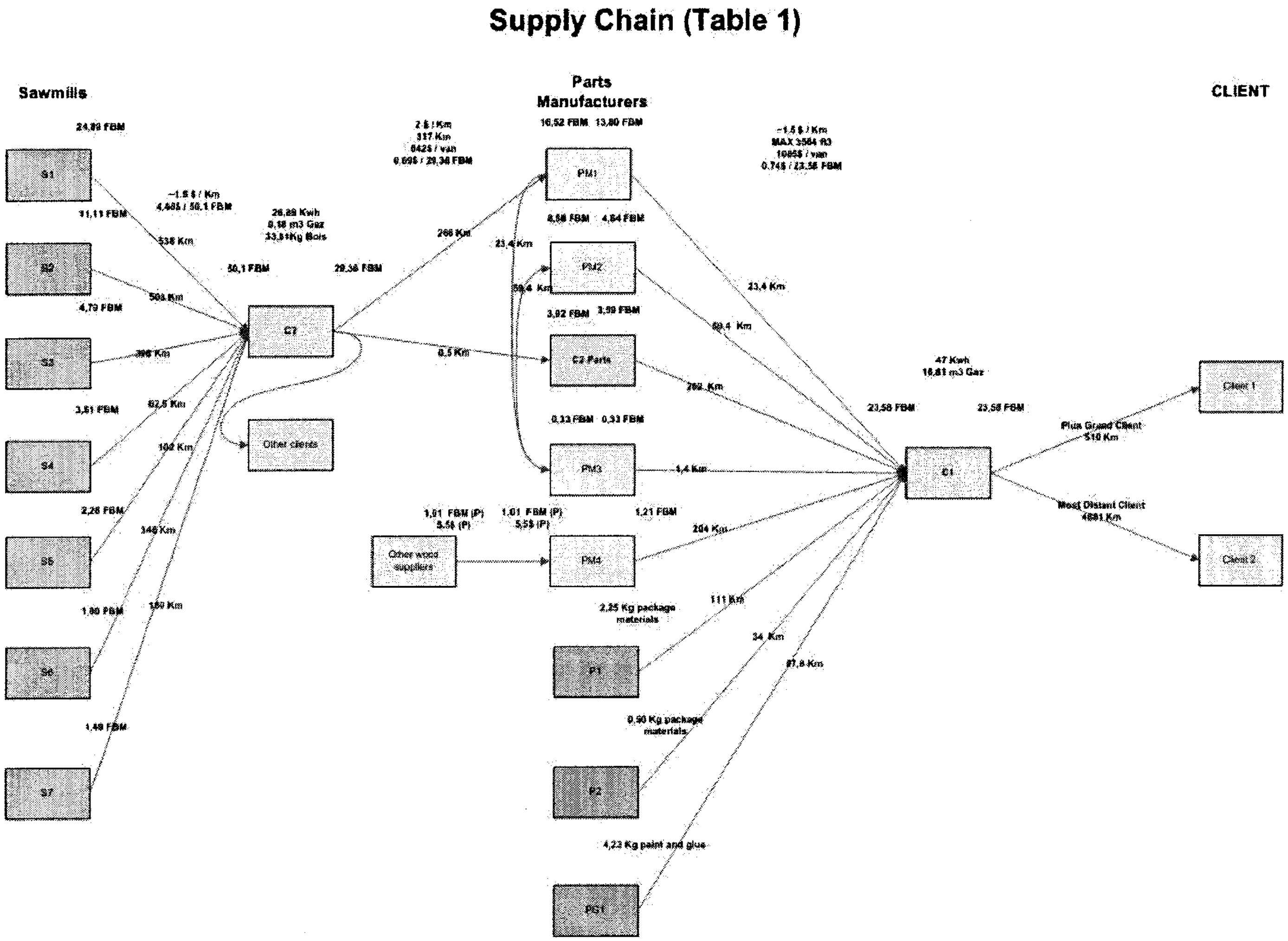

Figure 5.2 - Supply chain (Table 1)

Figure 5.3 presents the environmental impact for chair 1. Only the processes with considerable impact are shown. Each box represents a process. Processes summon other lower processes which add-up to be become the cause of the process' impacts.

Line thickness of the links between boxes is proportional to their impact. Processes are quantified in their representative units and by the percentage contribution to the total impact. Unit "p" represents the number of times an assembly of activities was counted.

Figure 5.3 shows that energy use at C1, accounts for the most representative environmental impact in manufacturing a chair 1 with 37.7% of the total impact. Most of its impact is caused by the use of natural gas in the factory of chairs at C1.

Transport from C1 to clients is the second most destructive accounting for 30.2% of the total impact. Its impact comes from the use of diesel as a fuel.

Figure 5.4 represents the environmental impact of a table 1. Transport from part's manufacturer to C1 accounts for 69.8% of the total impact. Energy use in the factory of tables at C1 accounts for 13.3% of this total

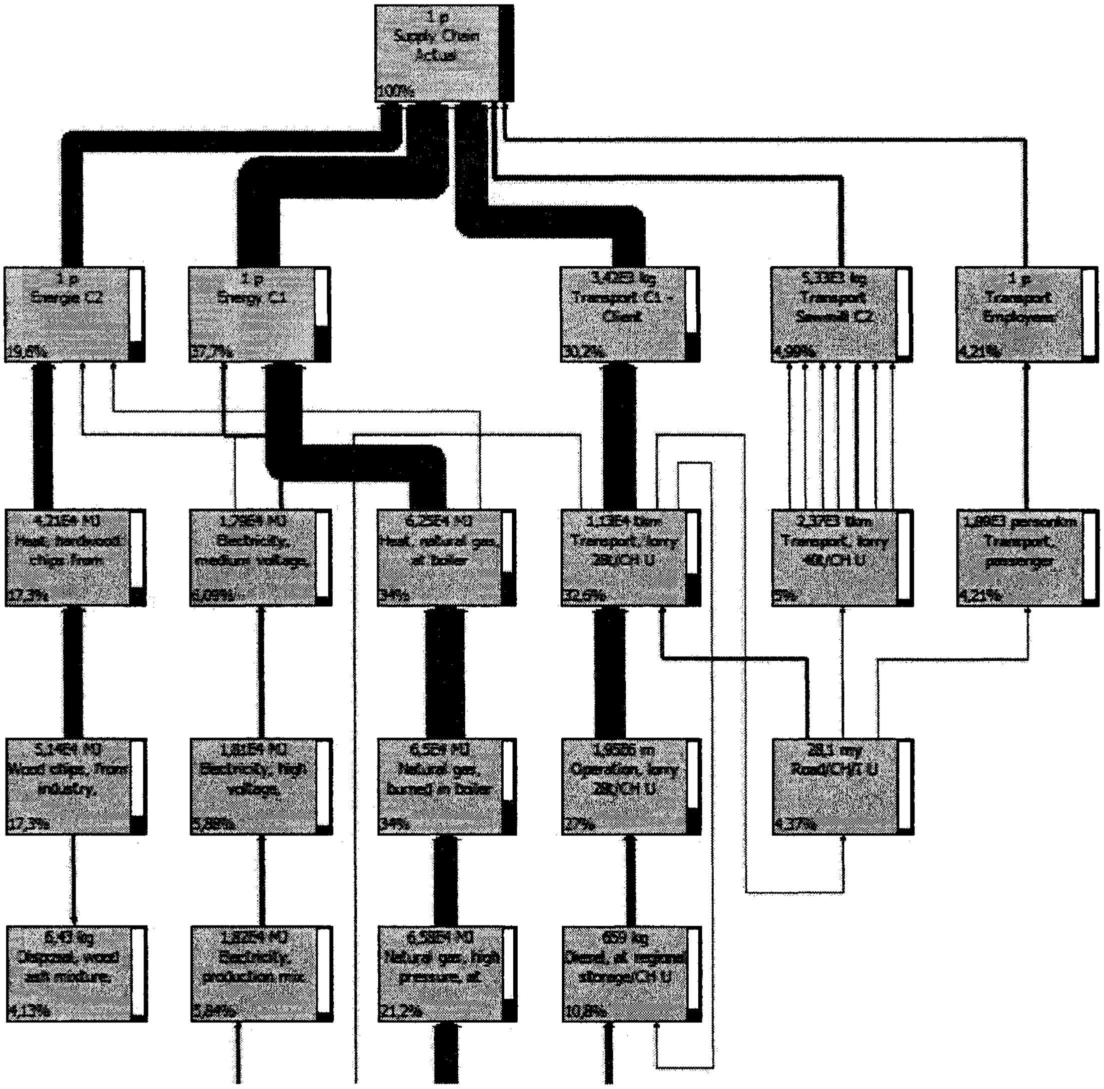

Figure 5.3 - Environmental Impact - Chair 1

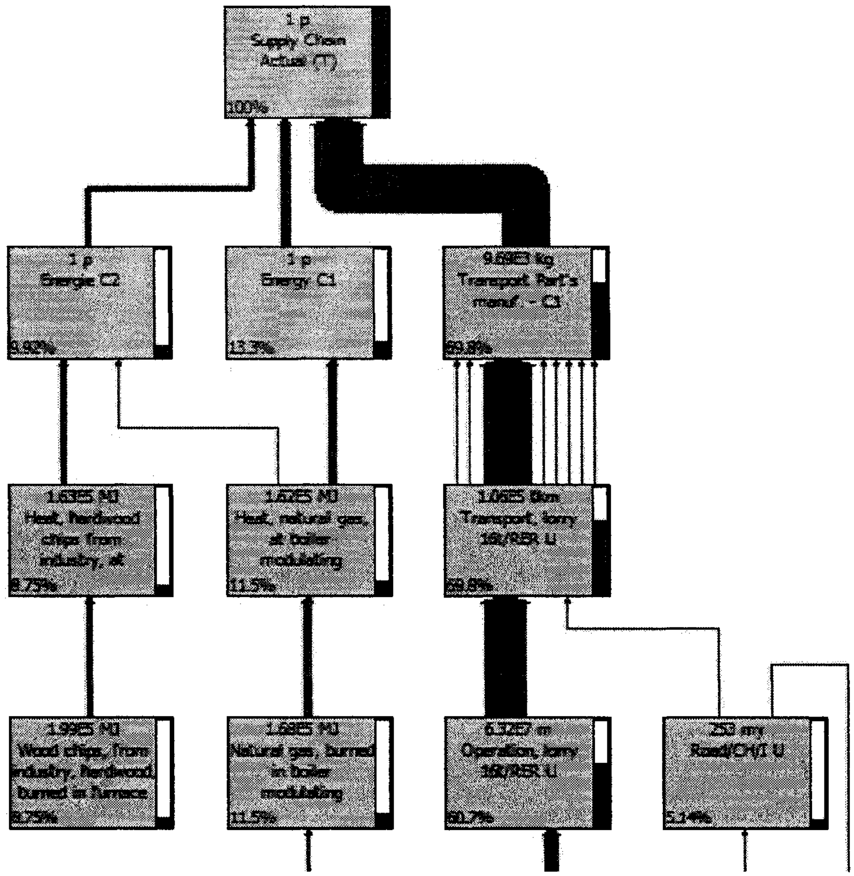

Figure 5.4 - Environmental Impact - Table 1

Table 5.1 represents an analysis of the cost of a chair 1. Wood parts account for 66.1% of the total cost. Labor can be seen as the second largest cost with 15.7% of the total. Finally, transport from C1 to biggest client, account for 6.3% of products cost. The cost of wood boards is traced back to its origins. It is important to understand that wood as a raw material for C2, represents 10% of total cost. Different processes are responsible to transform the raw material (10%) to what will become 66.1% of the total cost. A better representation of cost can be seen on picture 2.

Table 5.1 - Cost analysis for a unit of Chair 1

CHAIR 1	%	**% (tot price)**
Product's COST price	100.0%	100.0%
Wood parts	66.1%	**66.1%**
Labor	15.7%	**15.7%**
Transport C1 - Biggest client	6.3%	6.3%
Paint and Glue	5.5%	5.5%
Packaging	2.3%	2.3%
Gas	1.8%	1.8%
Hardware pieces	1.5%	1.5%
Electricity	0.8%	0.8%

WOOD PARTS	%	**% (tot price)**
Product's SALES price	100.0%	66.1%
Others (Profit, Energy, Labor…)	65.5%	**43.3%**
Wood Boards	34.2%	**22.6%**
Transport Part's Manuf. To C1	0.2%	0.1%

WOOD BOARDS	%	**% (tot price)**
Product's SALES price	100.0%	22.6%
Wood Raw Material	44.2%	**10.0%**
Wood (Burned for Heat)	16.6%	3.8%
Transport C2 to Part's Manuf.	3.3%	0.7%
Electricity	2.2%	0.5%
Gas	0.1%	0.0%

Table 5.2 represents an analysis of the cost of a table 1. Wood parts account for 59.7% of the total cost. Labor can be seen as the second largest cost with 15.8%. Finally, paint and glue account for 4.7% of products cost. The cost of wood boards is traced back to its origins. It is important to note that wood as a raw material for C2, represents 22.4% of total cost. Different processes are responsible to transform the raw material (22.4%) to what will become 59.7% of the total cost, having proportionally less aggregate value than a chair. A better representation of cost can be seen on picture 3.

Table 5.2 - Cost analysis for a unit of Table 1

TABLE 1	%	**% (tot price)**
Product's COST price	100.0%	100.0%
Wood parts (C2 included)	59.7%	**59.7%**
Labor	15.8%	**15.8%**
Paint and Glue	4.7%	4.7%
Transport C1 - Biggest client	1.9%	1.9%
Packaging	1.7%	1.7%
Gas	1.6%	1.6%
Hardware pieces	1.3%	1.3%
Electricity	1.0%	1.0%

WOOD PARTS (C2 incl)	%	**% (tot price)**
Product's SALES price	100.0%	59.7%
Others (Profit, Energy, Labor…)	52.8%	**31.5%**
Wood Boards	47.0%	**28.0%**
Transport Part's Manuf. To C1	0.3%	0.2%

Table 5.2 - Cost analysis for a unit of Table 1 (Continued and end)

WOOD BOARDS (C2 incl)	**%**	**% (tot price)**
Product's SALES price	100.0%	28.0%
Wood Raw Material	79.9%	**22.4%**
Electricity	20.6%	5.8%
Wood (Burned for Heat)	18.2%	5.1%
Transport C2 to Part's Manuf.	0.5%	0.1%
Gas	0.1%	0.0%

WOOD RAW MATERIAL	**%**	**% (tot price)**
Product's SALES price	100.0%	22.4%
Others (Profit, Energy, Labor…)	100.0%	**21.4%**
Transport	100.0%	1.0%

As previously said, life-cycle assessments are extremely time consuming and specific, abundant data is required. For the purpose of this project only transport and energy data were considered.

Figure 5.5 represents the impact of a chair 1 divided by impact category and normalized. Normalization is a procedure needed to show to what extent an impact category has a significant contribution to the overall environmental problem. This is done by dividing the impact category indicators by a "Normal" value. There are different ways to determine the "Normal" value. The most common procedure is to determine the impact category indicators for a region during a year and, if desired, divide this result by the number of inhabitants in that area (Pré, 2007).

Figure 5.5 shows that the biggest impact of a chair 1 is on natural resources, mostly caused by the use of natural gas on factory 4 and use of transport fuel from C1 to clients.

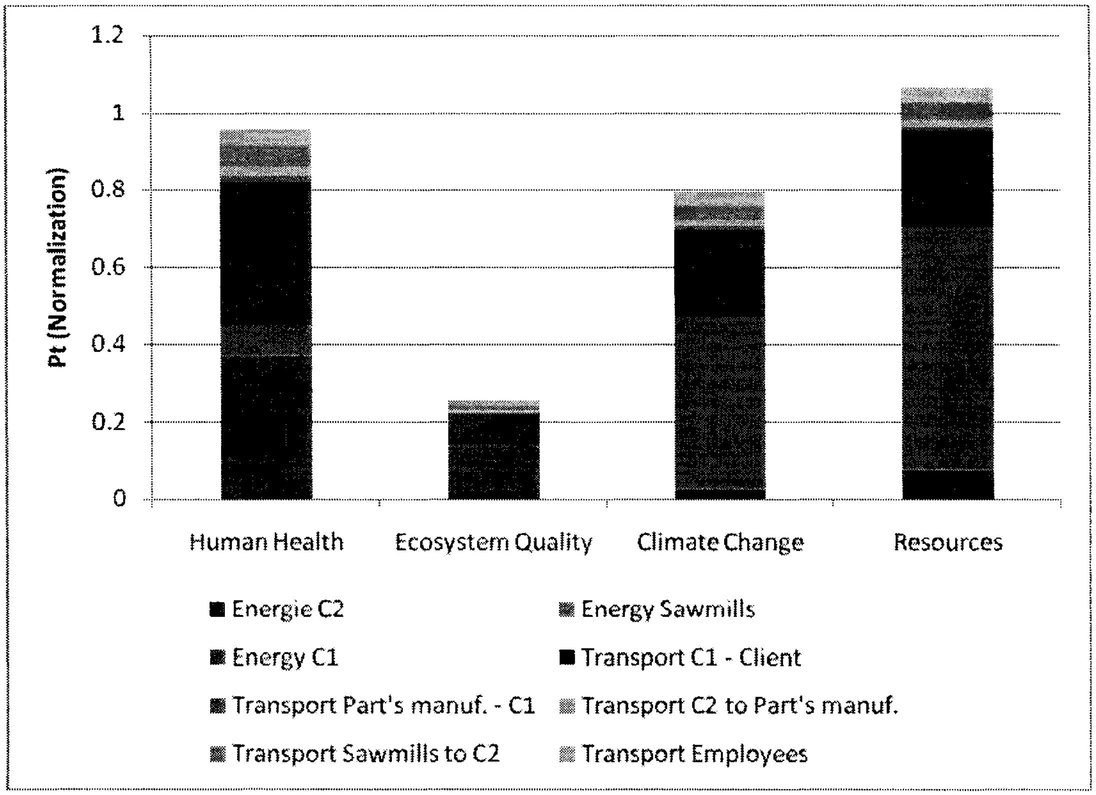

Figure 5.5- Actual Supply Chain; Impact 2002+; Normalization (Chair 1)

Figure 5.6 shows the impact of a chair 1 in a more detailed way for different types of impacts. It is important to see that the use of natural gas on factory 4 has the most representative impact on global warming. The comprehension on where a product stands on global warming impact represents a capacity to change in the case of new regulations.

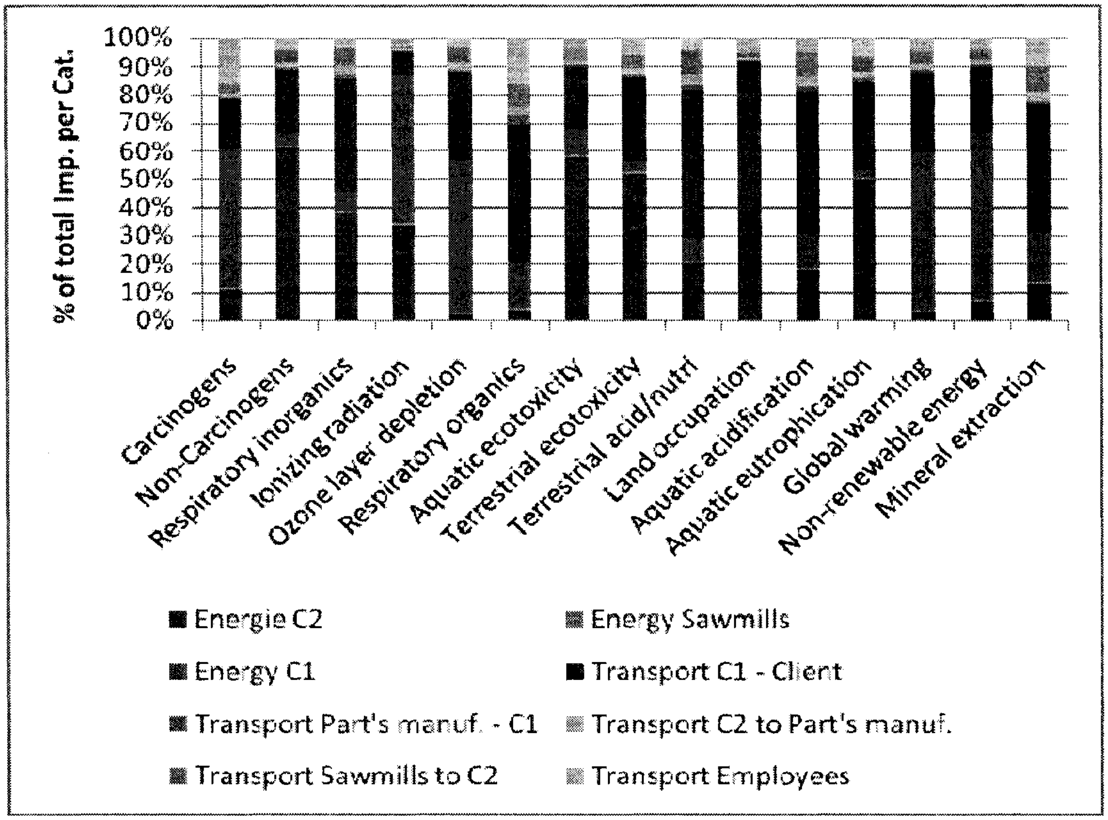

Figure 5.6 - Actual Supply Chain; Impact 2002+; Characterization (Chair 1)

5.4. Possible strategy planning options

There are several changes that could be considered in the case of C1. After a brainstorming on C1's operations some possible strategy planning options were analysed. The fact that there are no major changes to be deduced of the manufacturing process of the table 1, limits the action range. The chair 1 and suppliers deserve most of our attention. Despite of the fact that some solutions have no direct relationship with energy use or environmental impact, they are considered as a growth possibility for the group.

The most suitable strategy planning options are:

1. **Reduce transport of assembled chairs**
    a. **Strategy towards a new facility**
    b. **Use of contract manufacturers (CM)**
    c. **Create chairs easily assembled by retailers**
2. **Reduce energy use in the chair's factory**
3. **Reduce distance from sawmills to C2**
4. **Approach players in the supply chain**
5. **Create a new market in China**
6. **Create partnerships with key competitors**

5.4.1. Reduce transport of assembled chairs

Transport, as it is done today, is always limited either by volume or by weight. Through out the supply chain, the limitation can change according to the type of product being transported. The product being analysed is a unit of chair 1. Despite of the fact that they are made of hardwood, today, chairs from C1 are transported in packs of two assembled chairs. The fact of transporting an already assembled chair certainly results in limitations to the volume. The final result is an excessive increase in transport costs. A truck that could transport around 50000 lbs transports, for the same freight rate, transports 10000 lbs. There are some options to be taken into account when considering possible transport cost savings:

- Creation of new facility, closer to main market and capable assembling chairs,
- Use contract manufacturers to assemble chairs in the US,
- Create chairs easily assembled by retailers.

Figure 5.7 shows the overall possible reduction in volume for a chair 1. In the figure, two boxes are shown: the actual and the future one. The reduction is of approximately 50 percent of the size of the box that is currently used.

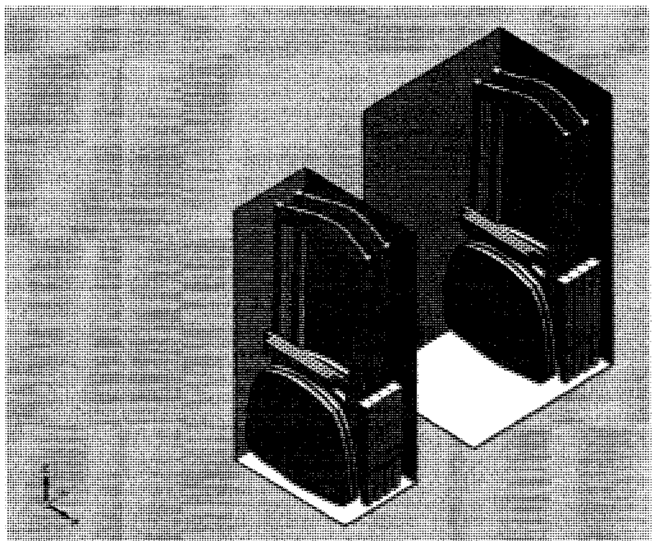

Figure 5.7 - Possible volume reduction for boxes (Chair 1)

Strategy towards a new facility

Main clients are 1500 km away from Cl in the large US market. Today, chairs travel, assembled, all the way to the client. A new facility could result in significative cost savings in short to mid term for C1. Moreover, it could create a cost advantage of approximately 7% (Reduction in average transport cost) over all other competitors in the Quebec region.

Environmental impact's comparison

A basic LCA comparing the actual supply chain and a new supply chain with an assembly facility closer to the client was made. The fact that a new facility would have to be built, the resulting impact, was considered along with the transportation cost reduction. The results are presented bellow.

A comparison by mid-point categories was created. Figure 5.8 presents that by far; the new supply chain would reduce the overall environmental footprint in every type of impact including global warming.

Mid-point categories were added into greater and more complex damage categories. Impacts are presented in percentage (Figure 5.9) showing that on average 16% of reduction is possible. In the figure, the actual supply chain is set to 100% while the new one goes lower presenting the amount of reduction.

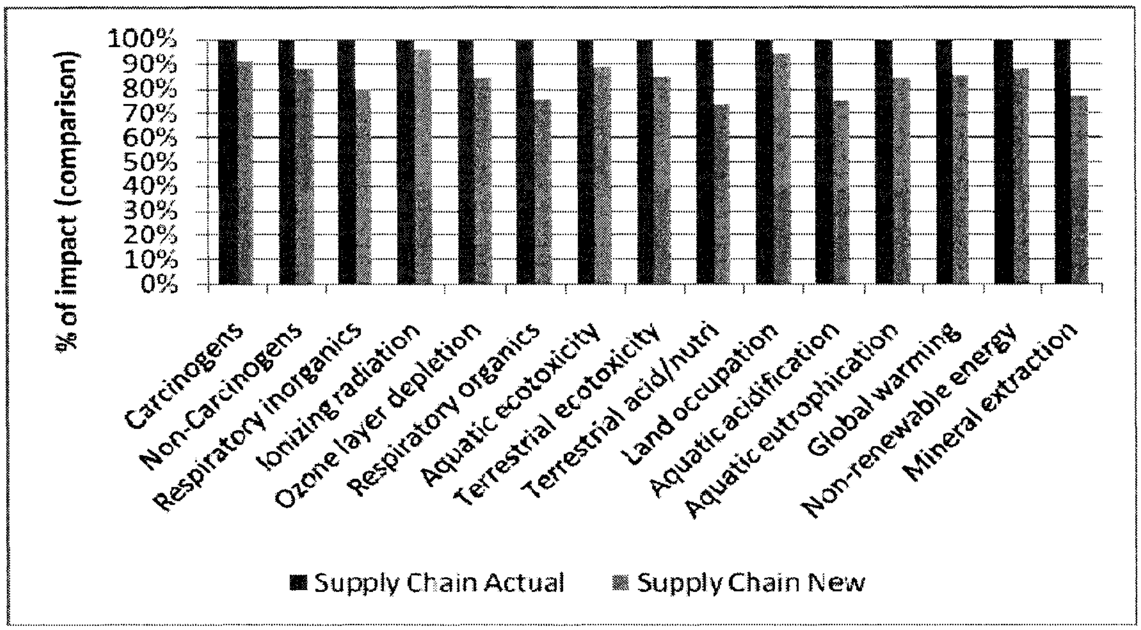

Figure 5.8 - Comparison Current situation x SC -New facility; Mid-point Categories

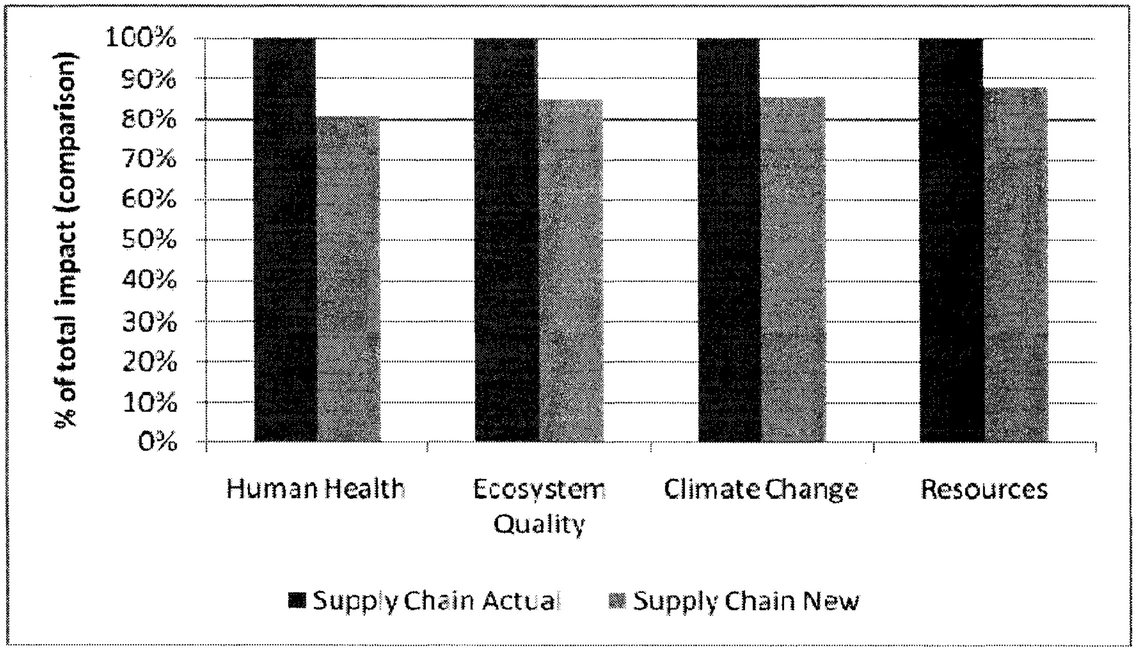

Figure 5.9 : Comparison Current situation x SC -New facility; Damage Categories

Figure 5.10 presents the results by normalized points. Results are in the same scale for the purpose of comparison. The unit (Pt) was explained earlier in this document.

Finally, the creation of a new facility to assemble chairs closer to clients could represent not only a great reduction in transport cost (Around 7%) but also a reduction close to 16% in the overall environmental impact.

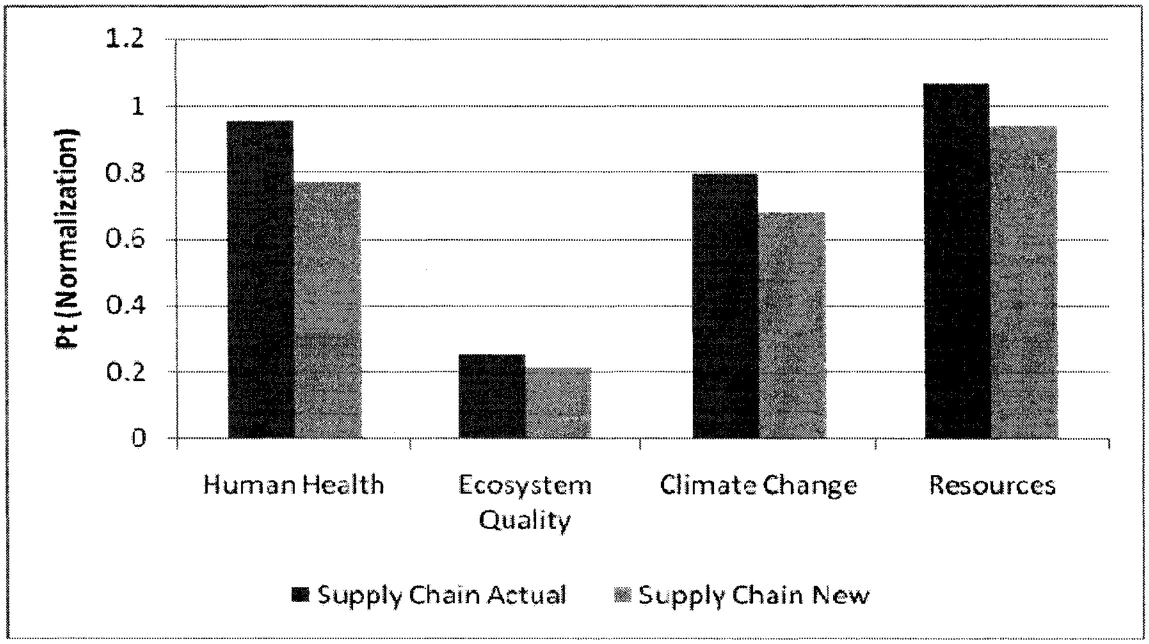

Figure 5.10 : Comparison Current situation x SC -New facility; Damage Categories; Normalized

Cost Analysis

Cost analyses are always needed to ensure profitability. Despite of the fact that environmental impact reductions always generate some profitability through marketing strategies, profit has to be secured by probable cash revenue. Financial information used in the calculations below, was taken by a logic consideration on the issue. The percentage of chairs considered to be assembled by the new facility was taken by the current amount of chairs exported by the company to the US. Return on investment and internal rate of return were defined based on average annual interest rates in Canada.

Actual transport cost (Most important client) = 7,64 CAD

Likely volume reduction = 50%

Average chairs assembled in 1 year = 166000 Chairs

Percentage of chairs assembled in the new facility = 70%Basic cost analysis:

- Cost reduction per chair = 7,64 / 2 = 3,82 CAD / Chair
- Cost red. per year = 3,82 x 166702 x 0,7 = 445761 CAD
- Time period to return full investment = 5 Years
- Internal rate of return (IRR) = 10%

Investment ≤ 445761 x 3,79[2] = 1,6 Million CAD

- Other profits and costs not considered:
  - Cost reduction due to operation reductions at factory 4
  - Operating cost of new facility

It is important to understand that the amount of 1.6 million CAD is directly proportional to oil cost. Every increase in oil price would increase transportation cost increasing the maximum amount to be considered for a new facility. Trends of future oil increases should be considered as a solid base for a strategic decision.

Use of contract manufacturers (CM)

As part of an opening process, C1 could profit from CM's as a goal of transportation cost reduction and strong market introduction. Chairs could be sent in kits to CM's and assembled where needed. CM's are responsible for all manufacturing processes of a specific product. The use of CM's, reduces costs and provides a possibility for fast change of volume of production.

The increase in production capacity and proximity to markets, by using CM's in other regions, would give C1 the possibility of an extremely competitive price and speed of delivery.

[2] Present Value of an Annuity (5 Years; 10%)

Create chairs easily assembled by retailers

Products made for class-A customers are required to be delivered in perfect conditions and ready to use. Creating a product to be assembled by retailers or final clients is not an easy mission. The best known way of ensuring quality is controlled by the manufacturer. However, in certain cases, such as C1, where transport cost of assembled products are extremely high, changes need to be made. The main restriction of passing out final assembly activities to retailers is ensuring that products will be delivered with the quality required by clients.

5.4.2. Reduce energy use in the chair's factory

Accounting for one of the biggest environmental impacts of C1, natural gas is still less expensive than electricity. Today, natural gas is used for heating and paint drying. Exchange natural gas for electricity would probably generate less environmental impact, especially in Quebec where most of the energy is generated by renewable sources. However, the cost of this change is still high.

Replacing the use of natural gas for electricity was analysed and results are presented below. Figure 5.11 shows the environmental impact divided by category. Only one damage category (Ecosystem quality) sees an increase in impact by the change. Normalized comparison (Figure 5.12) shows that the overall result is a reduction in the environmental impact.

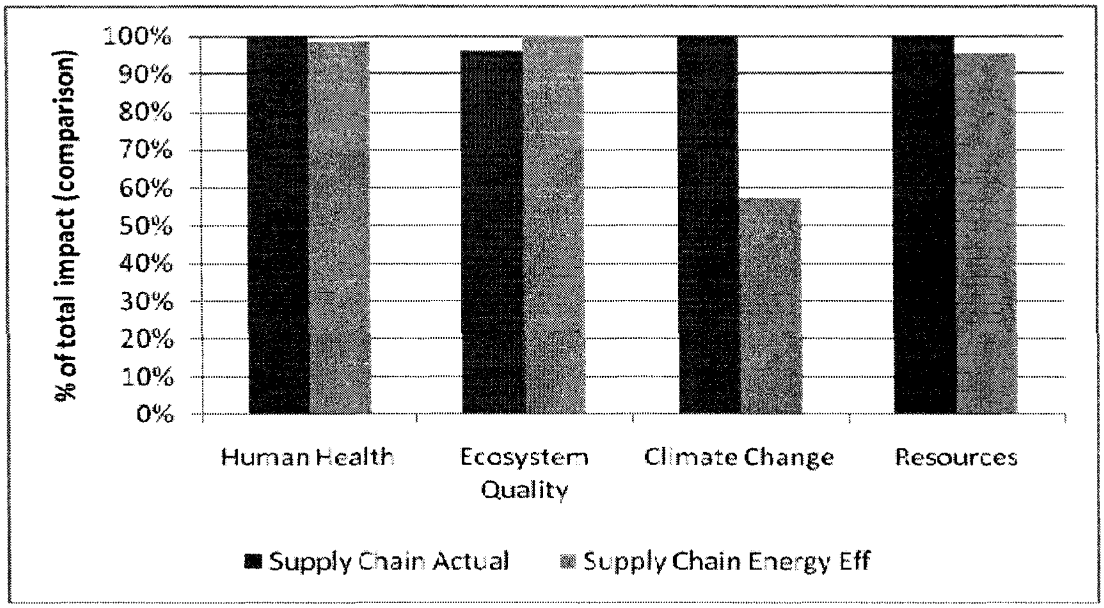

Figure 5.11 - Comparison of SC impact; Gas X Electricity; Damage Assessment

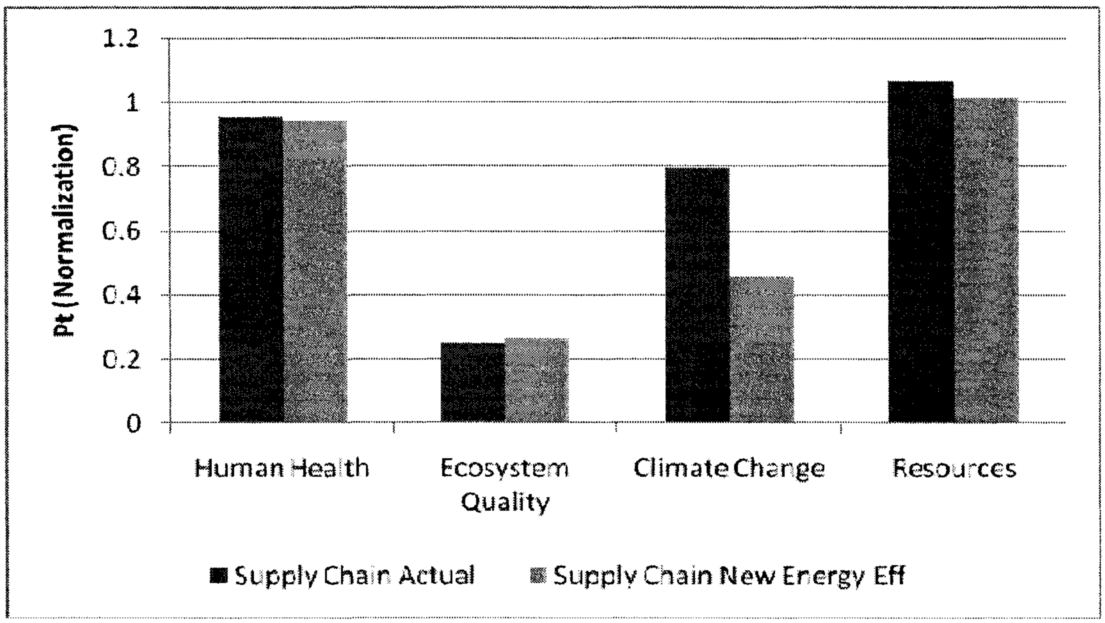

Figure 5.12 - Comparison of SC impact; Gas X Electricity; Normalization

5.4.3. Reduce distance from sawmills to C2

Currently, up to 50 percent of all wood used by the group comes from a single sawmill in Saint-John, New Brunswick. Unfortunately, it also represents the most distant sawmill to C2. If the wood could start to be supplied by closer sawmills, the dependency of C1 and C2 to transport cost could be reduced. A further analysis on quality of wood supplied would be needed before any decision is made

According to our cost analysis, if the distance of transporting wood from sawmill to C2 could be reduced by 80%, the total cost would be reduced by approximately1% and the environmental impact would be reduced by approximately 5%.

5.4.4. Approach players in the supply chain

Despite the size of the supply base, interactions between C1 and its suppliers are not as clear as it is in huge industries such as in automobiles and laptop computers. In the future, suppliers may need a greater assistance to develop strong businesses and give strength to the whole industry. Nowadays, part's design is made entirely by C1 and without interaction with the supply base and will probably sees a need for review in the future.

Moreover, part's suppliers have their own independent transportation. Cooperation between all of them could certainly reduce impact and cost. A single transportation company could be responsible of transporting all wood parts. Further analysis would have to be done in order to understand in depth the impacts and costs.

5.4.5. Create a new market in China

According to our assessments, a possibility of opening a new market front in China should be considered. Despite of the fact of its intrinsic environmental impact, China's economy is soaring. Moreover, transportation costs are very low when transporting goods to China where containers are usually transported empty (UNCTAD, 2006). Moreover, CKD plants' concept is highly used in the automobile sector as explained earlier in this research paper. Industrial organizations around the world have kept the wrong idea that China's potential is limited as a source of cheap labour and finished products. Why not to try to capitalize on the opportunities arising with China's prosperity by introducing high-end products, rather than only seeing the country as a source of inexpensive products?

5.4.6. Create some partnership with key competitors

Due to a lack of capacity, partnerships in the industry will have to be established in order to achieve economies of scale and compete globally. A tight relationship between C1 and geographically close competitors could be a solution to increase strength in the wood supply chain. Suppliers could be forced to move closer and cut transportation costs.

Moreover, modularity could be part of product's development enabling part's manufacturers to achieve high economies of scale (Sturgeon, 2002). At the end, all players would be profiting from cost savings and the whole supply chain would get more competitive from an international point of view.

However, this concept has some limitations. For the sake of secrecy, rival companies could fear the future of this partnership and instead create a major obstacle.

CHAPTER 6 - CONCLUSION

There are several types of industrial organizations around the world. From industry to industry, transportation use, energy choices and certainly environmental impacts change. Business plans are based on strategic planning and on economic cycles. The interaction between company and the whole economy is in an unstable state that can be altered as fast as the economy moves.

Today, environmental concerns as well as the approach of the materialization of the oil peak theory threatens the structure of all world economy (Hirsch, Bezdek, and Wendling 2005). While industrialized countries oppose setting a short term target for carbon emissions, companies are beginning to grasp customer's desire for an environmentally friendly product. Oil consumption has risen to unsustainable levels lead by the ever-growing demand of China coupled with production declines with a probable encounter of world's oil peak extraction and production (IEA, 2007).

As the market moves towards a greener way of thinking, advertisements emphasise how environmentally friendly products are. Projects are held to decrease the environmental footprint of product manufacturing everywhere (Zhu, Sarkis and Lai, 2007).

The impact of transportation cost is directly related to the product's volume and price (Baptiste and Pires, 2008). There are two industries that represent the extremes of the analysis: Laptop computers, and vehicles.

In the Laptop computers industry, volume and product's price create the possibility of manufacturing in low wages countries such as China and selling anywhere in the world. A laptop computer averages 1000 USD. Average transport cost for a 20 feet long shipping container from China to US is 1800 USD (UNCTAD, 2006). Considering the number of computers that can be fit in a single container, transport cost becomes so low relative to the product's price that this cost doesn't need to be considered as a factor to optimize. On the other end, volume and price of vehicles force factories to be placed locally to cut transportation costs. The production cost of a simple car averages 18000 USD. Transportation cost in this case could represent up to 10% of product's total cost (Armstrong, 2002).

Lean production (Just-in-time system), which has been the base for the major industries, will have to be reviewed and probably modified. Its increase in transportation results in serious environmental impacts and its dependence on cheap transportation (cheap oil) will have to be taken into account.

Around the world, new trends for changes in industrial organizations are presented. The rise of contract manufacturer (CM) is a possibility to adapt to a less transport dependant organization. The use of contract manufacturers gives flexibility to the brand's owner by changing productions volume without the need of direct investment. Moreover, modularity, which has already proven its value on the automotive industry, rises as a possibility of enhancement for other industries (Sturgeon, 2002).

The acceptance of CM and MP by industries would lead the world to local production thus decreasing transportation costs and its impacts. However, the fact that at the same time transport decreases, more material and electrical energy is used to build and run factories around the world, creating a need for future life-cycle assessments comparing different industrial organizations (Baptiste and Pires, 2008).

The methodology created during the study and validated by the case study allows different industries to define their future business plan based on the increase of environmental impact concerns and oil prices. Information is managed and synthesized using different tools (i.e. Life-cycle assessment) to achieve the main goal. Despite the fact that the method doesn't claim to assess neither a complete environmental impact nor the exact amount of energy use through the supply chain, the results are extensive. The method covers all major energy use in a supply chain, including oil and gas.

The context of the case study involving production at C1 is as follows: Two products were studied (Chair 1 and table 1). Transportation cost was considered throughout the supply chain and mainly from the assembly factory in location Quebec to the biggest client.

In the case of the table, the interaction between product's cost and volume encourages the organization to maintain its current practice. Transportation cost for a table is less than 3% of product's cost, in the case of the largest client. This is a reasonable transportation cost / total cost of production ratio considering the table is a product manufactured for a high-end consumer. Moreover, the LCA shows that the transportation from part manufacturers to C1 represents the greatest environmental impact with almost 70% of the total impact. A closer interaction between players in the supply chain could reduce the impact. Transportation could be made to be of a lesser burden through partnerships among part manufacturers, having only one truck doing one single route instead of each supplier sending one individual truck.

However, the chair's case is a little bit different. Chairs are assembled and usually placed in boxes containing two units. Transportation cost averages 7% of product's cost, in the case of the largest client. Moreover, it is the second highest environmental impact of the product. In the case of the most distant client, transportation cost comes up to 15% of the total cost.

Solutions for reducing transportation cost in C1 have been presented. Moving final assembly process of chairs to the US, and thus closer to clients, seems to be the best alternative in today's oil prices prospects. Weather they opt for building a factory, buying one, or contracting a CM, the strategy would take C1 one step ahead of other competitors. Delivery time would be reduced, transportation cost would be cut and consequently customer satisfaction would increase.

Despite of the fact of the recent (November 2008) decrease in oil prices caused by a deceleration in the world economy, this study remains valuable. It is important to mention that oil prices are still higher that the average of its historical price.

The US financial crisis of 2008 created a huge devaluation on company's market capitalization across North America. Instead of preventing from not investing in times of crisis, wouldn't be the time of acquiring a company to assemble chairs in US?

Moreover, other improvements such as reduced gas use, reduced paint loss and decreasing distance between C2 and sawmills should be considered.

Furthermore, the wood furniture industry in Québec certainly needs to consider improvements. The relationship between players in the supply chain is a weak commercial client-supplier relationship. The supply chain should integrate creating the strength needed in today's global competition. Despite of the fact of certain limitations, interaction between C1 and other local competitors could increase economies of scale in suppliers and reduce transportation costs throughout the supply chain from forest to final clients.

Among all supply chain studies published, very few describe the way in which information should be analysed. This project created a methodology for supply chain analysis based in energy cost and environmental impact. This set of procedures use different engineering tools in order to create a powerful way of analysing without that is neither resource intensive nor excessively time consuming. The need for financial investments has also proved to be low when compared with possible gains.

Our case study presents an example on how the method can be applied. In general the study can need little adjustment to fit, resource or budget constraints. Our case study results proved the efficiency of the method. We consider that other industries should study the use of the methodology as a base for future improvements.

All renewable energy sources and probably most if not all the fossil fuels can be traced back to the sun. Renewable energy conversion systems make direct use of solar irradiation or extract heat or kinetic energy from the natural transformation of sunlight of biomass, cycling of water or wind. The energy in biomass takes the form of chemical bindings mediated by photosynthetic plants and microorganisms. Human use of natural resources or actually the mere existence of human beings relies on the past and present energy from the sun (IEA, 2002).

With shrinking oil supply and an increasing demand, trends show that fuel cost will continue increasing for the next years (Hirsch, Bezdek, and Wendling 2005). Preparation for a crisis gives a huge competitive advantage to any company (Baptiste and Pires, 2008). In a possible high fuel cost scenario, the use of the methodology created here and validated in the industry leads to advantages in environmental impact and cost reductions.

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ANNEX A - WORLD ENERGY SUPPLY AND DEMAND

Table A.1 - World oil supply and demand (Million barrels per day) (IEA, 2007)

	1Q07	2Q07	3Q07	4Q07	2007	1Q08	2Q08	3Q08	4Q08	2008	1Q09	2Q09	3Q09	4Q09	2009	2010	2011	2012
OECD DEMAND																		
North America	25.7	25.4	25.9	26.0	25.8	26.1	25.8	26.2	26.3	26.1	26.3	26.2	26.5	26.7	26.4	26.8	27.1	27.5
Europe	15.1	15.0	15.6	15.8	15.4	15.7	15.2	15.7	15.9	15.6	15.6	15.4	15.8	15.9	15.7	15.8	15.9	15.9
Pacific	8.9	7.9	8.0	8.9	8.4	9.3	8.0	8.1	8.9	8.6	9.3	8.0	8.1	8.9	8.6	8.6	8.6	8.7
Total OECD	49.7	48.2	49.6	50.8	49.6	51.1	48.9	50.0	51.1	50.3	51.2	49.6	50.5	51.6	50.7	51.2	51.6	52.1
NON-OECD DEMAND																		
FSU	3.8	3.6	4.1	4.4	4.0	4.0	3.9	4.2	4.5	4.1	4.4	4.1	4.0	4.3	4.2	4.3	4.4	4.5
Europe	0.8	0.8	0.7	0.8	0.8	0.9	0.8	0.7	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.9	0.9	0.9
China	7.3	7.7	7.6	7.7	7.6	7.8	8.2	8.0	8.2	8.1	8.2	8.4	8.5	8.9	8.5	9.0	9.5	10.0
Other Asia	9.1	9.2	9.0	9.2	9.1	9.4	9.4	9.2	9.5	9.4	9.5	9.6	9.6	9.8	9.6	9.9	10.1	10.4
Latin America	5.3	5.5	5.6	5.5	5.5	5.5	5.6	5.7	5.7	5.6	5.6	5.8	5.9	5.8	5.8	5.9	6.0	6.2
Middle East	6.4	6.5	6.8	6.5	6.6	6.7	6.8	7.1	6.8	6.9	7.0	7.1	7.4	7.1	7.2	7.5	7.9	8.2
Africa	3.1	3.1	3.0	3.1	3.1	3.2	3.1	3.1	3.2	3.1	3.3	3.3	3.2	3.3	3.2	3.3	3.5	3.6
Total Non-OECD	35.8	36.3	36.7	37.3	36.6	37.4	37.8	38.0	38.7	38.0	38.9	39.1	39.3	40.0	39.3	40.7	42.2	43.7
Total Demand[1]	85.6	84.6	86.3	88.0	86.1	88.5	86.7	88.0	89.8	88.3	90.1	88.7	89.8	91.5	90.0	91.9	93.8	95.8
OECD SUPPLY																		
North America	14.4	14.0	14.0	14.1	14.1	14.4	14.0	13.9	14.2	14.1	14.5	14.1	13.9	14.1	14.2	14.2	14.3	14.4
Europe	5.2	4.7	4.7	4.9	4.9	4.9	4.6	4.4	4.6	4.6	4.7	4.3	4.2	4.4	4.4	4.1	4.0	3.7
Pacific	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.7	0.7
Total OECD	20.2	19.4	19.4	19.7	19.7	20.0	19.3	19.2	19.6	19.5	20.0	19.2	19.0	19.4	19.4	19.2	19.0	18.7
NON-OECD SUPPLY																		
FSU	12.5	12.6	12.6	12.8	12.6	12.8	13.0	13.0	13.3	13.0	13.3	13.5	13.6	13.7	13.5	13.8	14.1	14.4
Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
China	3.7	3.8	3.9	3.8	3.8	3.9	3.8	3.8	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Other Asia	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.8	2.8	2.8	2.8
Latin America	4.4	4.4	4.5	4.6	4.5	4.8	4.8	4.8	4.7	4.8	4.9	4.9	4.9	4.9	4.9	5.0	5.2	5.5
Middle East	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Africa[8]	2.6	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	2.8	2.8
Total Non-OECD[8]	27.8	27.9	28.0	28.3	28.0	28.6	28.8	28.9	29.1	28.8	29.3	29.5	29.6	29.7	29.5	30.0	30.4	31.0
Processing Gains[2]	1.9	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1
Other Biofuels[3]	0.4	0.4	0.4	0.4	0.4	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Total Non-OPEC[4,8]	50.3	49.6	49.6	50.3	50.0	51.2	50.7	50.7	51.4	51.0	52.0	51.4	51.3	51.8	51.6	51.9	52.2	52.6
OPEC																		
Crude[5]	30.2																	
OPEC NGLs[5]	4.8	4.8	4.8	5.0	4.9	5.2	5.4	5.6	5.8	5.5	6.0	6.2	6.4	6.5	6.3	6.7	6.9	7.1
Total OPEC[8]	35.0																	
Total Supply[5]	85.3																	
Memo items:																		
Call on OPEC crude + Stock ch.[7]	30.5	30.2	31.8	32.7	31.3	32.1	30.6	31.8	32.6	31.8	32.0	31.0	32.1	33.2	32.1	33.2	34.7	36.2

1 Measured as deliveries from refineries and primary stocks, comprises inland deliveries, international marine bunkers, refinery fuel, crude for direct burning, oil from non-conventional sources and other sources of supply.

2 Net volumetric gains and losses in the refining process (excludes net gain/loss in former USSR, China and non-OECD Europe) and marine transportation losses.

3 Biofuels from sources outside Brazil and US.

4 Non-OPEC supplies include crude oil, condensates, NGL and non-conventional sources of supply such as synthetic crude, ethanol and MTBE.

5 As of the March 2006 OMR, Venezuelan Orinoco heavy crude production is included within Venezuelan crude estimates. Orimulsion fuel remains within the OPEC NGL & non-conventional category, but Orimulsion production reportedly ceased from January 2007.

6 Comprises crude oil, condensates, NGLs, oil from non-conventional sources and other sources of supply.

7 Equals the arithmetic difference between total demand minus total non-OPEC supply minus OPEC NGLs.

8 From 1 January 2007, Angola is included in OPEC data.

ANNEX B - LIFE-CYCLE ASSESSMENT

Life-cycle assessment is a tool allowing one to reach sustainable development in a system. The UN defines sustainable development as follow: "Development that meets the needs of the present without compromising the ability of the future generation to meet their own needs"

According to ISO there are four phases of a LCA: Goal and scope, inventory, impact assessments and interpretation.

B.1. Goal and scope

In the first phase, the LCA-practitioner formulates and specifies the goal and scope of study in relation to the intended application. The object of study is described in terms of a functional unit. Apart from describing the functional unit, the goal and scope, should address the overall approach used to establish the system boundaries. The system boundary determines which unit processes that are included in the LCA, and must reflect the goal of the study. In recent years, two approaches to system delimitation have emerged. These are often referred to as 'consequential' modeling and 'attributional' modeling. Finally the goal and scope phase includes a description of the method applied for assessing potential environmental impacts and which impact categories that are included (Wikipedia, 2007d).

In the majority of studies, systems are multifunctional requiring a certain time to specifically define the main function and the secondary ones.

The functional unit quantifies the function of the system in order to compare two scenarios. Ex: Product – Sandals; Functional Unit – 1 pair of sandals in regular use during 1 year.

Based on the functional unit, a reference flux is defined, where the amount of products needed of each compared product. Ex: Product – Sandals; Functional Unit – 1 pair of sandals in regular use during 1 year. Reference Flux: 0,5 pair of sandals high quality (2 years) or 2 pairs of sandals low quality (0,5 year); Key parameter: Life time of a sandal.

A LCA can have many different use according to the public related. Information regarding a product, product's legislation, development of new products and development strategies are some of the use of a LCA. The public related can be the costumer, the manufacturer or the government. Following the standard LCA, sometimes a cost analysis can be found. It is usually considered a complementary study and can help to define an action.

B.2. Inventory

The inventory is by definition the quantitative description of flux of materials, energy and emissions that cross the limits of the system. This stage quantifies the emissions on air, water and soil as well as extraction of renewables or non-renewables raw materials during the life-cycle of a product.

Usually an aggregation is made to simplify the work. Emissions are considered by its global impacts on the environment and not by its source of emission. However, emissions in different locations can have different impacts on the environment.

Today, most part of the inventory is made out of existing data bases such as Ecoinvent. However, primary sources of energy from field information are important to refine the study. The inventory stage presents the amount of materials, energy and emissions that cross the system. The impact assessment stage is indispensable for an analysis and comparison of different scenarios.

B.3. Impact Assessments

This stage of the study evaluates the impacts of emissions and extractions on the environment. The impact assessment starts by linking the aggregated emissions from the inventory with midpoint categories such as human toxicity, climate change and ozone depletion. Further, midpoint categories are connected with damage categories such as human health, natural environment and natural resources.

Today, there are many methods to impact assessment such as Ecoindicateur 99, EPS 2000 and IMPACT 2002+. Each of them identifies the impact in a different manner. Some methods present the result in terms of midpoint categories and some in terms of damage categories. IMPACT 2002+ presents in both ways being largely used nowadays.

Moreover a normalisation can be done to provide a basis for comparing different types of environmental impact categories (all impacts get the same unit).

B.4. Interpretation

The phase stage 'interpretation' is the most important one. An analysis of major contributions, sensitivity analysis and uncertainty analysis leads to the conclusion whether the ambitions from the goal and scope can be met. More important; what can be learned from the LCA? All conclusions are drafted during this phase. Sometimes an independent critical review is necessary, especially when comparisons are used in the public domain.

ANNEX C - FOREST CONSERVATION AND MANAGEMENT

C.1. Forests – New Brunswick

The total area of the province is 7.2 million há (17.7 million acres), of which 49% is Crown (including 2% federal) and 51% is privately owned. The total annual allowable cut (AAC) for the province is approximately 11 million m3, of which 5.4 million m3 are from Crown land.

All of the foregoing discussion has focused exclusively on Crown land wood supply. Crown land comprises about half of the total provincial landbase, with the remainder about evenly split between small freehold and large industrial freehold. Small freehold properties (i.e., private woodlots) are organized under seven marketing board areas within the province and each is currently undergoing a revised wood supply analysis. Other than a requirement to maintain buffers around watercourses, there are no government regulations controlling the rate of harvest on private woodlots. However, there is general agreement that private woodlots are currently over-harvested. Large industrial freehold owners independently determine their sustainable AACs using silvicultural inputs and they include management for some nontimber objectives (Canadian Council of Forest Ministers, 2005).

C.2. Forests – Québec

The first sustainable allowable cut was calculated in 1989; it was estimated at 42.4 million m3. It was recalculated in 1994 and the result was 40.7 million m3. Because of an increase in forested area, Quebec's allowable cut reached 43.7 million m3 in 1999. Sustainable allowable cut in Quebec's Crown forests will be reassessed in 2008 (Canadian Council of Forest Ministers, 2005). The forest accounts for nearly 750300 km2 (185.4 million acres) of Québec's total area of 1.7 million km2 – in other words, they cover nearly half its territory (Ressource Naturelles et Faune, 2008).

C.3. Forests – Maine (US)

Forests cover 17.7 million acres (71.6 thousand km2) or 90 percent of the land area of Maine. Maine has the highest proportion of forest land of any state in the US. The wood invertory of the state is 685.8 million m3 in 2003 (USDA Forest Service, 2003).

ANNEX D - QUESTIONS FORM

Date

C1's project

Project: ***title***

All questions are related to a period from XXX and XXX.

Questions:

1. How much wood did you sell (Weight or Volume) from XXX and XXX? OR What is the lost in volume on average from your input products and output ones?
2. How much electricity did you consume from XXX and XXX? How much did you pay for it?
3. How much natural gas did you consume from XXX and XXX? How much did you pay for it?
4. Do you burn wood waste for heating or other operations? If yes, how much from XXX and XXX?
5. Do you use any other energy sources? How much?
6. How much do you pay to transport the wood panels from your factory to Bois C2?
7. What is the average weight or volume that your transport from your factory to Bois C2?
8. Who are your wood suppliers?
9. How much wood have you bought from XXX and XXX