Value Addition in the Wood Processing Sector

-Options for Production Waste Minimization along the Wood Value Chain-

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UNIDO’s approach:

To raise the level of value addition and to upgrade the wood value chain in developing countries by means of technology transfer and capacity building in strong cooperation with local wood industry associations / institutions and respective governmental departments with the main focus on the secondary wood processing industry

Proposed Solutions should contribute to:

✔ Creation of additional Employment through expanding labor-intensive secondary processing industries
✔ Raised performance and productivity of the secondary processing sector contribute to Economic growth
✔ Derive raw materials from Environmentally sound resources (certified forests, production forests under sustainable management / bamboo) and support programmes to minimize and utilize production waste
Employment Generation Furniture Industry: CANADA

• Value-added processing generates, on average, more than four times as many jobs as a primary sawmill.*

• Furniture manufacturing, as one example, generates more than 12 times as many jobs.**


Value added varies considerably from country to country
Goal for any forest industry is to derive maximum value out of its resource, but wide range:
> Indonesia and Canada produce large quantities of export commodities across the value chain in sawn wood, veneer and pulp, yet generate roughly five to six times less value than Germany and Japan at the top end.

> Countries focusing on higher value-addition and product design can generate more employment and revenue per cubic meter.

Source: Generating More Value from our Forests, BC MoF&R
EU household furniture market outlook

Consumption

• Total EU25 furniture consumption was estimated at € 74,199 million in 2004, the biggest in the world.

• Main market countries are Germany, France, United Kingdom, Spain, Italy, the Netherlands and Sweden which are among the largest furniture markets in Europe. (Together 80 percent, representing a value of € 59,349 million)

Imports

• The EU is the leading importer of furniture in the world and, in 2003, accounted for around 50 percent of total world imports, or 8,360 thousand tonnes valued at € 24,187 million.

• Germany imports more than one quarter (27%) of all EU imports and is followed by The United Kingdom (18%) and France (15%).

Wood Environmental Credentials

• Wood is a renewable resource unlike competing materials (steel, concrete, plastics, aluminium etc.)
• Requires much less energy for processing as compared to other materials
• As a construction material, wood has excellent thermal insulation properties, 15 times better than concrete, a 2.5 cm thick wooden board is better than a 11 cam brick wall
• Growing tree absorbs through photosynthesis around 0.9 tons of CO2 per cbm growth and producing 0.7 tons of oxygen
• Wood energy is carbon neutral, as it does not release more CO2 as it absorbed during growth
• Forests are an excellent carbon sink and wood products act as long-term carbon store, e.g. forests of Russian Federation store 37000 million tons of C!
• Decomposes naturally at the end of its lifecycle and/or can be recycled
• Most production waste and by-products can be utilized or used for energy production, in some countries up to 75 % of the energy required for wood processing comes from wood by-products

Promotion of wood over non-renewable resources should be a priority for countries seeking carbon neutral, sustainable initiatives across the globe.
UNIDO’s role in Value Chains

**Agro-Industrial Value Chain**

- **Production**
  - Purpose Plantation
  - Agricultural & Forestry Waste

- **Processing**
  - Industrial Production
  - Waste Minimization and Utilization

- **Marketing**

- **Recycling**
  - e.g. packaging
  - e.g. construction wood

**Bio energy value chain**

- **End use**
  - Electricity
  - Heat
  - Transport fuels

- **Conversion**
  - Direct combustion
  - Gasification
  - Fermentation

- **Supply systems**
  - Harvesting
  - Collection
  - Handling
  - Delivery
  - Storage

- **Biomass resource**
  - Agricultural crops & residues
  - Woody biomass
  - Oil bearing plants
  - Waste streams

**UNIDO/ECC**

Typical Scenario of unutilized wood waste

Using population growth as a driver for forest products consumption, Dykstra (2001) projected tropical industrial roundwood demand to increase roughly 130% by 2050, reaching 453 million m$^3$, up from roughly 195 million m$^3$ in 2000.

Improving product recovery rates throughout the wood value chain has the potential to contribute significantly to the sustainable consumption of wood resources.
**Wood Waste Volumes, potential Value**

- Despite improved utilization throughout the value chain significant wood residue volumes continue to be produced. (IEA (2007))

**Example:**
With 500,000 m³ the Ghanaian forest industry produces the theoretically sufficient waste for conversion into roughly one quarter of a million tonnes of wood pellets, with a market value of EUR~25 million in Europe (with wood pellet prices of EUR 100/oven dry tonne).

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume (million m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honduras</td>
<td>0.4</td>
</tr>
<tr>
<td>Croatia</td>
<td>0.4</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>0.5</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>0.6</td>
</tr>
<tr>
<td>Peru</td>
<td>0.5</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.6</td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.5</td>
</tr>
<tr>
<td>Ghana</td>
<td>0.6</td>
</tr>
<tr>
<td>Paraguay</td>
<td>0.6</td>
</tr>
<tr>
<td>Cameroon</td>
<td>0.7</td>
</tr>
<tr>
<td>Bosnia &amp; Herzegovina</td>
<td>1.8</td>
</tr>
<tr>
<td>South Africa</td>
<td>1.8</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1.8</td>
</tr>
<tr>
<td>Mexico</td>
<td>1.8</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3.3</td>
</tr>
<tr>
<td>China, Mainland</td>
<td>11.8</td>
</tr>
<tr>
<td>Canada</td>
<td>13.9</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>16.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>16.8</td>
</tr>
</tbody>
</table>

**Wood Waste Attributes for Utilization**

- **Volume available** will determine the nature of the possible end-uses.
- **Collection and transport** to an industrial user must support the business case.
- Consumers generally prefer waste with uniform characteristics, such as all bark or all wood. For example, forest residues would consist of bark, branches/limbs and roundwood, while sawmill residue would be more consistently segregated into sawdust or bark.
- Six main attributes in its appropriateness for further use and processing: species, segregation (species mixture), purity (clean or contaminated), moisture content, storage (in silos, bins or left on the ground), and size.
- Wood waste from secondary processing is well-suited to a number of end-uses due to a low moisture content. The majority of wood waste occurs as planer shavings, sawdust and small off-cuts all of which are kiln dried.
- In theory, this waste is ideal for bioenergy due to its high energy content, consistency in form/shape, reduced moisture content and consistent availability. But it might also be suitable for chipboard/MDF production, finally economic aspects will decide!
**Wood Waste Suitability for Bioenergy**

- Inverse relationship between volume of waste available and quality of the material for bioenergy end uses

*Based on Harker et al. (1982) gross calorific value (mean ± SD = 19.73 ± 0.98 MJ/kg) for hardwood species and the effect of moisture content on the heating value of fuelwood (*Forage Tree Legumes in Tropical Agriculture*).

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**Wood Waste Throughout the Wood Industry Value Chain**

[Diagram of the wood industry value chain showing flows from Forestry/Harvesting through Sawmills, Veneer/Plywood/Board Manufacturers, Drying & Preservation Facilities, and leading to Paper Industry, Bioenergy, Planes/Moulding Mills, Manufacturing of Furniture, Books, Windows, Household Articles, and Construction Companies, Prefab houses.]
Forestry and Harvesting Waste (Thinning and logging by-products)

Harvest recovery in natural hardwood forests is generally held to be 55% in developing countries, compared to 78% for softwood forests in the US (Dykstra, 2001).

Theoretically, harvesting residues make for a good and plentiful energy source, but a difficult one to utilize in practice:
• Logging By-Products are dispersed, dirty (soil, sand), high moisture content, heterogeneous and have limited end uses.
• Branches and tops are difficult because they are a mix of several different forms of biomass, are dispersed throughout a harvest block and are often awkward sizes and shapes.
• For these harvesting residues to be economically utilized for bioenergy, they must undergo collection, pre-processing (decentralized chipping) and transport to a facility within a reasonable distance. Unfortunately, the processes to accomplish this task will often cost more than the value of the energy extracted from biomass.

<table>
<thead>
<tr>
<th>Stumps</th>
<th>Top Logs</th>
<th>Branches</th>
<th>Off-cuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>14%</td>
<td>29%</td>
<td>40%</td>
<td>17%</td>
</tr>
</tbody>
</table>

*Adapted from Dykstra, 1992, cited in Pulkki 1997, cited in Trash or Treasure? Logging and the mill residues in Asia and the Pacific*
Recovery rates generally slightly below 50%. Differences between species, partly as a function of where species processed and how logs delivered:

- Veneer recovery in Brazil 60% in the north and lower (45%) in the south due to different veneering processes.
- In Ghana, recovery of Asafena veneers was particularly low at 23-35% due to inappropriately sized log diameters.

Veneer and plywood mills generate a significant volume of green waste (green waste is wood waste with green moisture content), which has a low combustion energy rate.

<table>
<thead>
<tr>
<th>Bark/debarker residue</th>
<th>Cores &amp; Lathe roundup</th>
<th>Spur knife trim</th>
<th>Veneer waste and clippings</th>
<th>Drying losses</th>
<th>Panel trimmings</th>
<th>Sander dust</th>
<th>Other conv. losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>33%</td>
<td>3%</td>
<td>38%</td>
<td>3%</td>
<td>6%</td>
<td>2%</td>
<td>5%</td>
</tr>
</tbody>
</table>

*Adapted from Dykstra, 1992, cited in Pulkki 1997, cited in Trash or Treasure? Logging and the mill residues in Asia and the Pacific*
Recovery rates are generally accepted to be 50% with ranges between 42-60%, very low recovery caused e.g. by:
- inappropriate equipment, maintenance or personnel training.
- Sawmills generate significant volumes of green waste in addition to sawn wood, which has a low combustion energy rate.

<table>
<thead>
<tr>
<th>Waste in Sawmill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bark/Debarker residue</td>
</tr>
<tr>
<td>3%</td>
</tr>
</tbody>
</table>

Production Waste in the Secondary Wood Processing

- The secondary wood processing industry adds value to commodity wood products.
- The products from this sector are diverse, from re-sawn or pressure-treated dimension sawn wood to mouldings to high-end furniture.
- In the process of adding value, manufacturing will consume sawn wood, veneer and/or panels (MDF, particleboard, plywood) produced by the primary industry, add chemicals, other materials such as foam, textiles, leather, metal, a design element and create finished or semi-finished products.

According to the International Standard Industrial Classification of All Economic Activities (4-digit ISIC codes), the SPWP would fall into the following classes:

- 3100 - Manufacture of furniture (This class includes the manufacture of furniture of any kind, any material (except stone, concrete or ceramic) for any place and various purposes)
- 1622 - Manufacture of builders’ carpentry and joinery
- 1623 - Manufacture of wooden containers
- 1629 - Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials.


Production Waste in the Secondary Wood Processing

The secondary wood processing industry is more diversified in terms of products and less standardized compared to primary processing:
- Equipment utilized and production flow product specific
- Few standard recovery rates available as benchmarks
- Analysis on the company level required
- Companies producing more waste than their peers will operate at a competitive disadvantage

- To systematically reduce waste, a waste reduction plan is required, it requires several phases, which should in the best case be undertaken as a continuous cycle:

- Conduct a waste self-assessment
- Analyze and evaluate the financial and product recovery/yield data
- Use the analysis to prioritize and set waste minimization targets.
- Implement waste reduction strategies
- Monitor financial and product recovery/yield data on an ongoing basis.
Wood Waste Self-Assessment

• A waste self-assessment is the first stage in developing a waste minimization plan.

• The information required for a company to undertake a waste reduction self-assessment shall go hand in hand with other aspects of production management like:
  • Product costing (cutting list)
  • Production flow (routing sheets)
  • Quality control
  • Cost Centers
  • Energy Audit
Lumber receiving/drying/storage – ensures an appropriate inventory of wood is available for further processing. Appropriate wood will be of a usable grade, within dimensional and moisture content specifications, and of a sufficient volume for the production schedule.

Rough end/gluing/machining/sanding – converts the dried rough lumber into finished pieces ready for assembly. Key processes would include cutting to length, edge gluing, planing to thickness, pre-drilling, moulding, tenoning etc. Sanding ensures a surface adequately smooth for the finishing stage.

Assembly – incorporates the pieces into its final structure whether furniture, cabinets etc. The end product takes shape in this stage with the use of fasteners, glues etc.

Finishing – applies a coating to the wood to improve appearance or protect the wood.

Building/equipment maintenance – maintains the effective utilization of the capital invested in the production facility.

Design – a cross cutting factor influencing success at all stages. Product design must fit both the manufacturing capabilities of the company and the market demands. It includes technical as well as aesthetical aspects, e.g. a flat pack design can reduce packaging materials and subsequent transport costs.
Analyze and Evaluate Waste

Identifying wasteful processes or areas of production and determining the cost of that waste. The goal in setting up a waste minimization plan is to discover the most wasteful processes and prioritize those processes for waste minimization.

>Where waste is generated?

Analyze the information collected in the self-assessment:
- Prepare a flow chart, accounting for inputs and outputs at each stage of production.
- Outline the processes through which products flow in their plant (plant layout), such as the various machine centres (equipment list) and the inputs and outputs at each stage (cutting list).
- Fine-tune this flow diagram to suit the processes it undertakes during the production of each product.

>How much waste is generated and what is it worth?

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Part Name</th>
<th>Cost per Unit</th>
<th>Unit</th>
<th>Material In</th>
<th>Rough Dim.</th>
<th>Final Dim.</th>
<th>Yield</th>
<th>Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Table Legs</td>
<td>420 m³</td>
<td>US-$</td>
<td>0.006</td>
<td>8.27</td>
<td>0.018</td>
<td>7.96</td>
<td>0.015</td>
</tr>
<tr>
<td>2</td>
<td>Rails Long</td>
<td>420 m³</td>
<td>US-$</td>
<td>0.009</td>
<td>3.68</td>
<td>0.006</td>
<td>3.38</td>
<td>0.004</td>
</tr>
<tr>
<td>3</td>
<td>Rails Short</td>
<td>420 m³</td>
<td>US-$</td>
<td>0.009</td>
<td>3.68</td>
<td>0.004</td>
<td>1.47</td>
<td>0.002</td>
</tr>
<tr>
<td>4</td>
<td>Table Top</td>
<td>420 m³</td>
<td>US-$</td>
<td>0.043</td>
<td>18.01</td>
<td>0.038</td>
<td>16.08</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-Total</td>
<td>US-$</td>
<td>0.060</td>
<td>33.83</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Part Name</th>
<th>Cost per Unit</th>
<th>Unit</th>
<th>Material In</th>
<th>Rough Dim.</th>
<th>Final Dim.</th>
<th>Yield</th>
<th>Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Dowels</td>
<td>0.04 piece</td>
<td>US-$</td>
<td>9.00</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Dots</td>
<td>0.31 fr</td>
<td>US-$</td>
<td>9.26</td>
<td>1.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Screws for Top</td>
<td>0.07 piece</td>
<td>US-$</td>
<td>11.00</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Sanding Sealer</td>
<td>0.51 fr</td>
<td>US-$</td>
<td>0.55</td>
<td>2.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Primer Layer</td>
<td>0.39 fr</td>
<td>US-$</td>
<td>0.55</td>
<td>2.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Sandpaper</td>
<td>0.26 piece</td>
<td>US-$</td>
<td>5.50</td>
<td>1.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-Total</td>
<td>US-$</td>
<td>8.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>US-$</td>
<td>42.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Acceptable Production Waste or Excess Waste?
**Prioritize**

Process of determining which wasteful processes to engage first, based on the magnitude of possible savings and the cost required to achieve those savings and/or based on law/regulation. Savings will be determined in reduced cost, improved working conditions for employees and gains in efficiency.

The waste minimization hierarchy presents a template for organizing the different waste streams generated in the production and indicates the waste minimization strategy to be pursued.

**Setting Waste Minimization Targets**

Based on the priorities and waste minimization hierarchy, a company will be setting waste minimization targets including all aspects of production.

Waste minimization activities need to be realistically costed, can be split into *no cost, low cost, high cost*.
Implement and Monitor

The implementation phase of waste minimization must be a total company effort. Management will be responsible for prioritizing waste minimization efforts, but employees will be doing the implementation. Therefore, it is important for everyone in the company to make waste minimization a priority.

The implementation of waste minimization strategies also requires monitoring. Just as the waste self-assessment was the first stage of entering the waste minimization planning, monitoring will ensure the continual process of self-assessment. Monitoring verifies that assumptions about potential waste minimization measures can be achieved. Monitoring also allows company personnel to determine the true benefits of each strategy and build momentum for further work on waste minimization.

<table>
<thead>
<tr>
<th>Implementation Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Have key personnel involved in waste minimization been identified?</td>
</tr>
<tr>
<td>2 Has company management stressed the importance of waste minimization?</td>
</tr>
<tr>
<td>3 Are employee roles well defined for waste minimization?</td>
</tr>
<tr>
<td>4 Implement company policy to maintain employee motivation and participation in waste minimization efforts?</td>
</tr>
<tr>
<td>5 Are systems in place to continually monitor waste minimization performance?</td>
</tr>
</tbody>
</table>

Some Thoughts:

How to involve the private sector as a driving force? (throughout the value chain)

Consider incentives for companies willing to participate in waste minimization and utilization schemes

Further analyze wood processing by-products by volume, location etc. to determine value and potential utilization

Consider technology for decentralized wood-based schemes by chips and/or briquettes

Analyze industrial clusters and industrial parks for energy surplus (e.g. Woodprocessing) and demand (foodprocessing, steam for sterilisation)

Setup pilot facilities in cooperation with associations, chambers, which undergo a constant waste assessment cycle and have installed briquetting presses / boilers to utilize by-products