A Life Cycle Assessment Framework for Assessing the Greenhouse Gas Balance in Short Rotation Forestry

Mike Clancy*[1], Thomas Cummins[2], Kenneth A. Byrne[1]

1: Department of Life Sciences, University of Limerick, Limerick, Ireland
2: School of Agriculture and Food Science, University College Dublin, Dublin, Ireland
* corresponding author: michael.clancy@ul.ie

Introduction

Short Rotation Forestry (SRF) has the potential to increase biomass production and contribute to the EU Renewable Energy Directive target for Ireland of 16% renewable energy by 2020. SRF can also offset Ireland's greenhouse gas (GHG) emissions from the combustion of decreasing reserves of peat and fossil fuels through their displacement in industrial and domestic heat and power plants.
This study aims to investigate the GHG balance of SRF silviculture systems through the use of both Attributional Life Cycle Assessment (ALCA) and Consequential Life Cycle Assessment (CLCA) methods. These tools will enable the assessment of SRF plantations from initial establishment and operation, through to biomass harvesting and bioenergy products end-use.

Material and methods

LCA is a method of comparing products and services via the four steps outlined below. Using the LCA framework and associated tools we can identify opportunities for reducing the environmental impacts attributable to associated process wastes, emissions and resource consumption (Pennington et al, 2004).

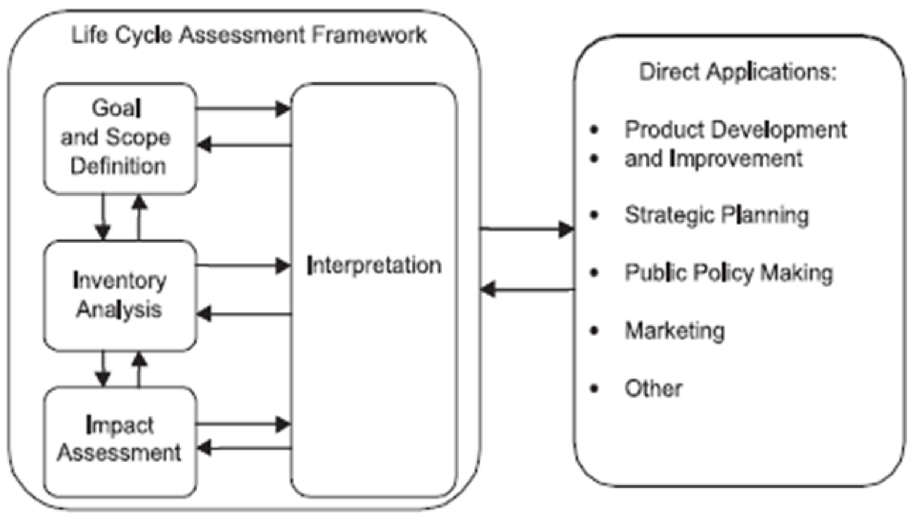

Fig 1. LCA framework phases and applications (ISO 14040, 1997)

1. Goal and scope definition: Includes the reasons for undertaking the study, the selected application, and the intended audience. It is also where the system boundaries and the functional unit of the study are described. The functional unit is a quantitative measure of the functions that the product or service provide.
2. Life Cycle Inventory (LCI) analysis: This is a compilation of the inputs (resources) and the outputs (emissions) from the product or service over its life-cycle, each defined in relation to the functional unit.
3. Life Cycle Impact Assessment (LCIA): The LCIA is aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of the studied system.
4. Interpretation: Results from the previous phases are evaluated in relation to the goal and scope in order to reach conclusions and recommendations.

Fig 2. Integrated harvesting operations for SRF stems, residue, and stumps

Table 1. Upstream and downstream SRF LCA system activities:

1. Fertilizer (N,P,K), lime, herbicide, and pesticide production
2. Seed propagation and cutting production.
3. Land use change/site establishment (natural & machine emissions - from roads, sub-soiling/ripping, rotation, ploughing/mounding, fencing).
4. Herbicide, pesticide, and lime application.
5. Plantation establishment, equipment use or manual.
6. Post plantation maintenance: Fertilizer, herbicide, pesticide application.

---

1. Harvest operations: Mechanical and chemical thinning, clearfell, forwarding, chipping, Residue windrowing/removal.
2. Product or machine transport, drying, storage and handling, on or off-site.
3. Product mixing for co-fired power stations.
4. Emissions from biomass conversion factories/power plants, product combustion, disturbed soil, harvest residue decomposition.

Fig 3. Eucalyptus (*E. nitens*) beside Sitka spruce, Cappoquin, Co Waterford, planted in 1992 (photo by Kevin Hutchinson)

Results

The GHG life cycle inventory data in Table 2 is drawn from published European database values for input and output flows associated with electricity cogeneration (demand value 1kWh) from a high efficiency gasifier (of 20-25 MW biomass input) in using wood energy from poplar SRF.

Table 2. Typical LCI contributions

Inputs Flow	Category	Sub-category	Unit	Result
Heat, waste	air	low population density	MJ	1.43711
Energy, gross calorific value, in biomass	resource	biotic	MJ	0.00658994
Peat, in ground	resource	biotic	kg	6.59051E-08
Wood, hard, standing	resource	biotic	m3	9.13607E-08
Wood, soft, standing	resource	biotic	m3	5.87892E-07
Wood, unspecified, standing	resource	biotic	m3	6.66874E-12
Carbon dioxide, in air	resource	in air	kg	0.000588241

Outputs Flow	Category	Sub-category	Unit	Result
Carbon dioxide, fossil	air	lower stratosphere	kg	3.70314E-11
Carbon monoxide, fossil	air	lower stratosphere	kg	4.34972E-14
Chromium	air	lower stratosphere	kg	5.87807E-19
Copper	air	lower stratosphere	kg	1.99846E-17
Dinitrogen monoxide	air	lower stratosphere	kg	3.52682E-16

References

ISO 14040. Environmental management - Life Cycle Assessment - principles and framework. Geneva, Switzerland: International Standards Organisation (ISO); 1997.

Pennington DW, Potting J, Finnveden G, Lindeijer E, Jolliet O, Rydberg T,. Life cycle assessment-Part 2: current impact assessment practice. Environ Int. 2004.

Acknowledgments

The ShortFor project is funded by the Department of Agriculture, Forestry and the Marine, and supported by UCD, WIT, UL, TCD, Coillte and Teagasc