Title of paper

Life Cycle Assessment of Wood Based Heating in Norway

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Content

Summary

Household heating by wood stoves is significant in Norway, providing approximately 20% of the heat requirements in the households.. In light of the growing concerns about global warming, emissions of CO_2 from energy production is getting increased attention. Biomass based energy can be one (of many) way(s) to mitigate global climate change.. As marginal electricity in Norway is shifting towards more fossil fuel based electricity production, biomass can play an important role in limiting the electricity demand for heating in households. A comparative life cycle assessment of a wood based heating system with old and modern stove technology is conducted. A novel hybrid approach is applied, limiting the data intensity usually associated with the method.

The assessment shows that new stove technology significantly reduces life cycle environmental impacts. It also shows that for all impact categories, the combustion of fire wood in the wood stove is the most important part of the life cycle.

Introduction

The Norwegian energy balance differs significantly from other European neighboring countries. The most striking difference is the strong dependency on electricity for heating buildings. The explanation for this dependency can be found merely by studying a map of Norway. The population density is very low and the population is scattered along the Norwegian valleys and fjords. The large mountainous regions in Norway combined with the moist North Atlantic air regularly coming in over the Norwegian west coast constitute a perfect place for hydro power production. Presently hydropower constitutes 99% of the electricity production in Norway. In post war Norway electricity was seemingly abundant, and a lock-in on use of electricity for heating purposes developed and still maintains. The climatic conditions in Norway with long and cold winters require considerable amounts of energy for heating. Today approximately half of the stationary energy consumption in Norway is related to space heating. The continuous increase in electricity consumption requires new production capacity or a shift towards other technologies. One of the strategies of the Norwegian government is to provide incentives to increase the share of heat produced by other means than electricity. At present, wood combustion is the most common alternative to electricity for heating purposes in the households, providing about 20% of the heat demand. However; about two thirds of Norwegian households have a fire place. This indicates a strong potential for increased use of wood for heating purposes.

Biomass utilization is in general getting increased attention due to efforts to reduce global warming, as wood is considered CO_2-neutral if outtake maximum equals regrowth. This is currently the case for Norway (Statistics Norway, 2005). On the other hand, wood combustion is one of the largest contributors to local air emissions. In 2000, 64% of all particulate matter (PM10) in Norway was generated by residential wood combustion. Apart from particulate matter, wood combustion is a significant source of several other compounds that may be harmful to health, such as PAHs, dioxines and CO (Statistics Norway, 2005).

There are, however, large differences in emissions from different stove designs. New clean burning stoves emit small amounts of local air pollutants compared to traditional stoves. Of the existing fire places in Norway 78% are traditional stoves, 4% are open fire places and 18% are new ”clean burning” wood stoves (As of 1998 wood stoves must be classified as ”clean burning” to enter the market). This means that there is a significant potential for environmental improvement with respect to local air pollution and energy efficiency in residential wood combustion.

To evaluate the environmental burdens of residential wood combustion, and to capture impacts from the production and transport of the stove and the wood, Life Cycle Assessment (LCA) is applied. Environmental hot spots are identified providing increased understanding of the system as well as areas of improvement. Two types of stove technology are evaluated; a modern clean burning stove, and a traditional stove design.

System description

The functional unit has been set to delivering 1 kWh of heat to a house. We have chosen birch wood as fuel. An overview of the system is included in Figure 1. We have assumed an overall efficiency (LHV_{wood} to heat delivered) of 70% for a modern stove and 50% for a traditional stove. The efficiencies are highly uncertain and the results will be very sensitive to this parameter, both in terms of efficiency as well as emission factors. Average regional transportation distances are used.

The main components are:

- Production of birch fire wood
    1. Forestry and logging
    2. Transportation to a production facility
    3. Cutting
    4. Transportation to the consumer or local dealer
- Production of wood stove
- Operation of stove

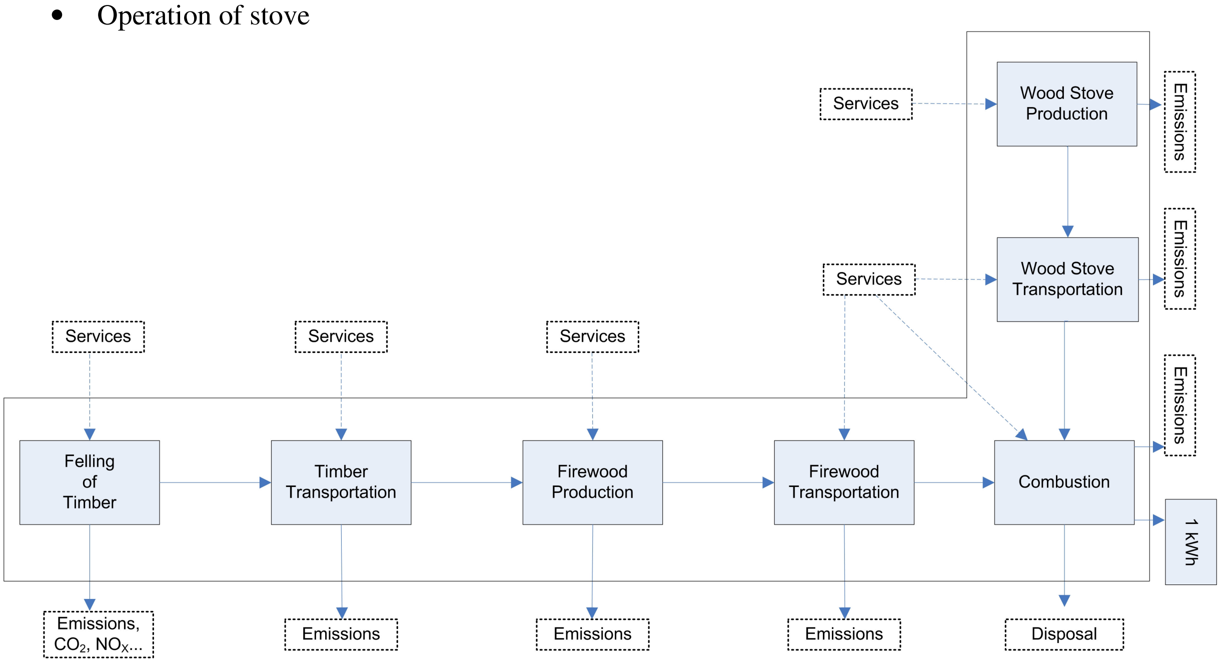

Figure 1: Overview of the fire wood production system

A novel method of LCI compilation has been used; a mix of specifically collected data together with data estimated from input-output tables, forms the basis for the assessment. For detailes see Strømman and Solli (2006). Data sources have been specifically collected data from companies in the fire wood value chain, and the Norwegian input-output tables and sectoral emission figures from 2000 (Statistics Norway, 2005). Emission factors for transportation and from wood combustion were taken from Ecoinvent (2004) and Statistics Norway (2005). A detailed inventory is not presented in this short paper; further details on inventory data are available from the authors.

Results and discussion

We have chosen to use a selected set of impact categories from the CML 2 baseline method (Centre for Environmental Studies, 2000) for the impact assessment in our study. For human toxicity, the human toxicity potential (HTP) of Hertwich et.al (2006) has been used.

Results from the analysis show that the new combustion technology introduced in wood stoves significantly reduces values for all the included types of environmental impact. Most pronounced is the improvement in cancer toxicity to humans; a reduction of 81% is achieved mostly due to reduced emissions of PAH. The differences between the technologies is generally explained by cleaner combustion, i.e. lower emission factors in the use phase, combined with higher efficiency and hence a reduced demand of upstream value chain activities. Another observation is that, of course, wood based heating will be cheaper with a more efficient stove, due to the lower demand of fire wood.

Table 1: Life cycle impacts from delivering 1 KWh heat.

Impact category	**Indicator**	**Old technology**	**New "clean burning" technology**	**Improvement**
GWP	kg CO2-eq.	0,103	0,0749	27 %
Photochemical oxidation	kg C2H2-eq.	0,00557	0,00311	44 %
Acidification	kg SO2-eq.	0,000486	0,000354	27 %
Eutrophication	kg PO4-eq.	8,99E-05	6,53E-05	27 %
HTP air, cancer	kg benzene eq.	0,00375	0,000694	81 %
HTP air, noncancer	kg toluene eq.	1,16	0,623	46 %
Value added	NOK	0,743	0,543	27 %

Digging deeper into the results of the “clean burning” technology, Figure 2 shows that the use phase contributes the most to all environmental impact categories. Despite considering CO_2 emissions from the combustion of biomass carbon neutral, the methane emissions dominate global warming impacts in the value chain; transportation of fire wood being the second largest contributor. This is, of course, highly sensitive to transportation distances.

For the other impacts combustion of diesel in mechanized logging and transportation of fire wood is dominant, even though supporting activities (purchases from the background economy) have some contribution. For photochemical oxidation almost all impact occurs in the use phase; this is due to emissions of NMVOC and CO.

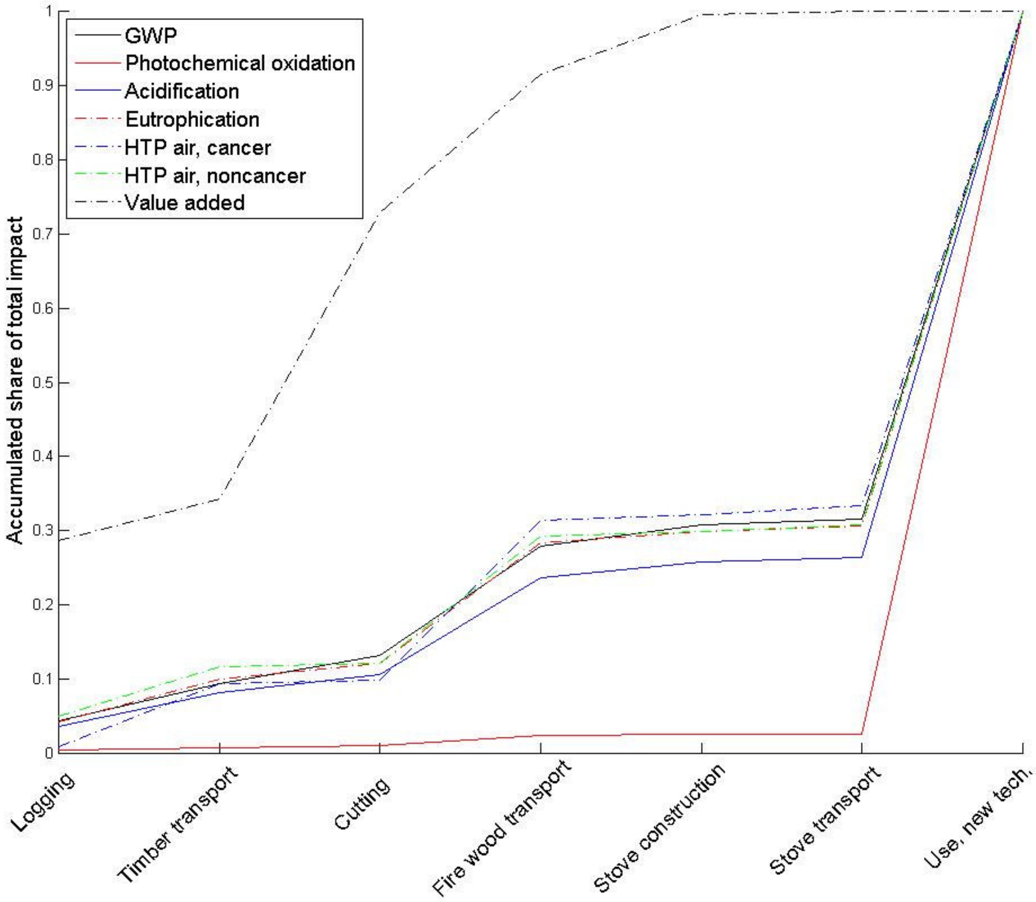

Figure 2: Cumulative representation of environmental impacts in the value chain

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