LCA Modelling

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LCA Studies were conducted in Year 4 to expand the range of impacts being looked at. The processes concentrated on were the Benchmark BF, TGRBF and Smelting Reduction. The models have been developed to ensure a full set of inventories and LCIA's are available. These results will be used to check that the new technologies do not cause other environmental impacts while reducing global warming potential.

Further work was conducted in checking the validity of the electricity process model developed in ULCOS for modelling future electricity scenarios. It was found that while the individual processes showed differences in CO2 emissions compared to the listed figures, the grid mixes analysed gave acceptable results.

Sensitivity analysis for bulk transport has also been conducted. Even with the maximum amount of material being moved the maximum distance the transport emissions for CO_2 are not significant to the overall impact of the steel making process. More detailed transport modelling has now been incorporated into the LCA models to ensure that other environmental impacts are also incorporated into the assessments.

The scenario modelling of environmental impacts was also extended in Year 4 to move away from traditional static modelling into a dynamic system. This was to assess the impacts in the future scenarios and recognising that the steel industry would not be the only industry looking to reduce it's environmental impact with continuing tightening environmental legislation and lowering of emissions limits. This was modelled by applying reduction factor to all air and water emissions from the system.

Introduction

LCA Studies were conducted to expand the range of impacts being looked at. This involved building LCA models of the breakthrough technologies and extending their boundaries from iron making to factory gate back to earth's resource.

The quality of the LCA models would be improved over Phase 2 of the project as the other subprojects gained a greater understanding of their technologies and the material and energy requirements of the processes more clearly understood.

Further work was conducted in adapting the upstream data sets to the future scenarios generated in WP1 to give a fair comparison of the breakthrough technologies in the future scenarios.

Work has been conducted to extend the results to generate all LCA Impact Assessments including those used in the KPI's of SP9.4 Sustainability Assessments.

In undertaking its LCA work, it was ensured that the methodology used was ISO compliant, i.e. that it had clear goals, scope, functionality, systems boundaries, allocation rules and plans for data quality analysis and sensitivity analysis.

Further work was conducted in checking the validity of the electricity process model and sensitivity analysis for bulk transport has also been conducted. Dynamic Scenario modelling of environmental impacts was also extended in Year 4. This was to assess the impacts in the new future scenarios.

Electricity Modelling

Modelling was conducted to check the sensitivity of the electricity generation model built for the ULCOS project. The original model was construction in GaBi using the Team data set. The flexibility of the model allowed any ratio of power generation scenarios to be entered and the average grid electricity impact be calculated. These impacts also included the CO2 emissions. Utilising data the ULCOS models were checked for various scenarios and for the two extremes of external generation use. The benchmark BF utilises the least external electricity, while the breakthrough technology of electrolysis utilised the most.

The results of the LCA models were compared by taking the minimum and maximum CO2 emissions found and comparing them to the ULCOS figures taken directly from the process units. The data was entered into the ULCOS models to look at the Phase 2 scenario electricity grid mixes and compare with the min and max CO2 figures. The figure shows the ULCOS data with the min and max CO2 for each of the scenario grid mixes. The ULCOS model results generated slightly higher results in most cases but within acceptable levels.

Electricity Type	External LCA Studies (g CO_2/kWh)		ULCOS
	Min CO_2	Max CO_2	
Hydro	10	33	0
Geothermal	15	23	0
Solar	39	217	0
Wind	9.7	109	0
Nuclear	6	24.2	11.1
Coal	957	957	866
NG	405	405	663
Oil	661	661	821
Renewables	18.4	95.5	0

Figure 1. Comparison of ULCOS v other LCA Studies for electricity sensitivity

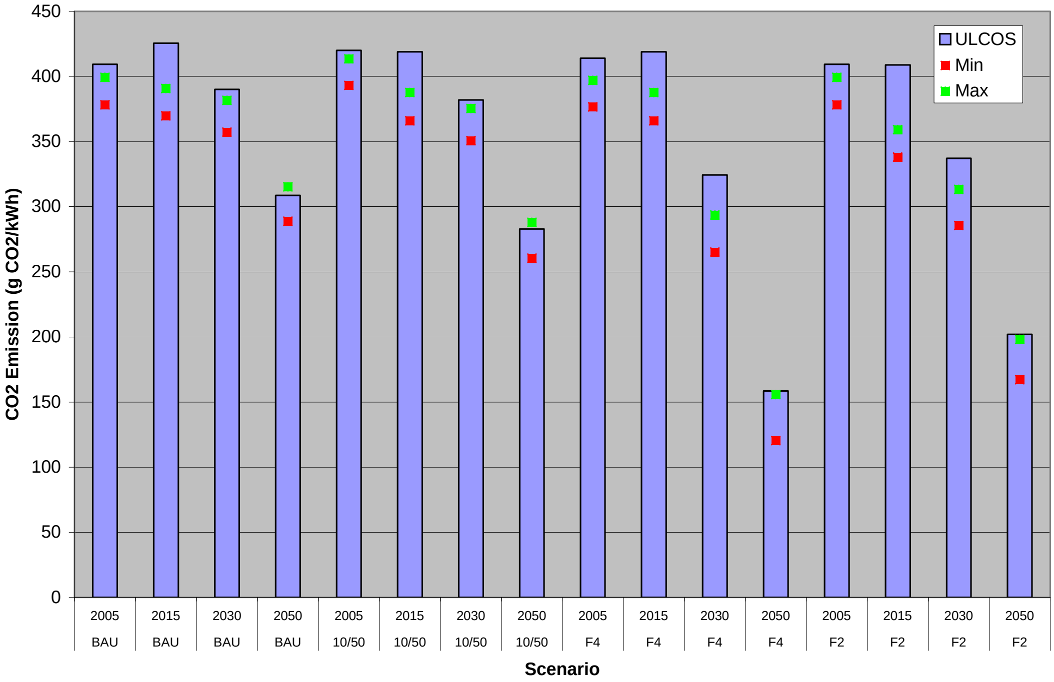

Figure 2. Sensitivity of ULCOS Electricity models compared with other LCA studies

Transport Modelling

Bulk transport is used to move the main raw materials from the mines and process units to the steel processing site. Two extremes of processing, with ores travelling a short distance, i.e. from Sweden to the Netherlands and a maximum distance from China to the Netherlands were studied. The initial assessment used the benchmark as it had the most material input to be transported and Electrolysis as this had the least material input. The mode of transport looked at was using a 200,000dwt transport ship.

The results show that even with the maximum amount of material being moved the maximum distance the transport emissions for CO2 are not significant to the overall impact. However it was recognised that the impacts of transport needs to be looked at in more detail to ensure no other impacts are more sensitive to the different quantity of materials that need to be transported.

In order to conduct this analysis in further detail, the LCA models for the benchmark and break-through technologies of smelting reduction and TGRBF were modified. The major materials had transport models added to them as shown in Fig. 4 and an initial assessment of transporting coal and ore from Australia to the Netherlands assessed. The transport models included rail transport from mine to shipping port and a bulk transporter from Australia to the Netherlands. Distances for shipping were calculated using data from a website(ref 2) assuming that ships could use the Suez canal, Panama Canal or Bosprus Strait, whichever was relevant. Connected to these transport models are also the upstream impacts of manufacturing the transport fuel.

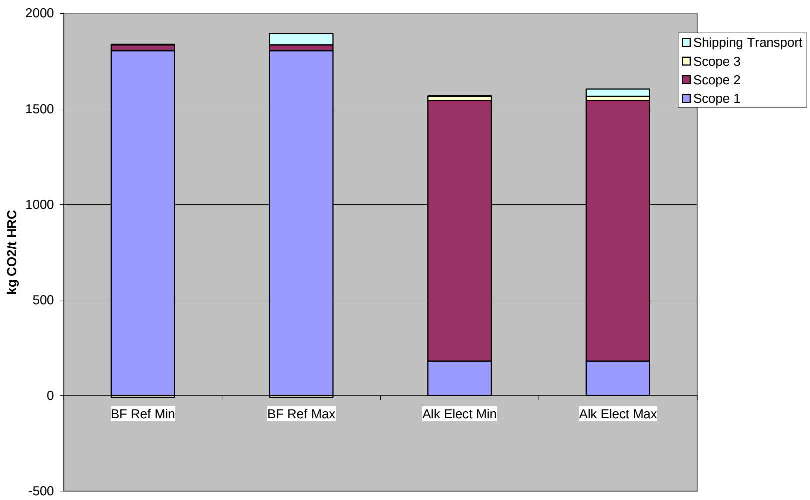

Figure 3. CO_2 impacts of bulk transport compared to Process and Upstream Emissions

Within the basic model the fossil fuels are shown, while grid electricity requirements are fed from the main grid electricity model and the connections made to the individual models as shown in Figs 4 and 5.

Also to expand the range of information being looked at, the new scenarios generated in WP1 for Phase 2 have been applied, including the various electricity grid configurations.

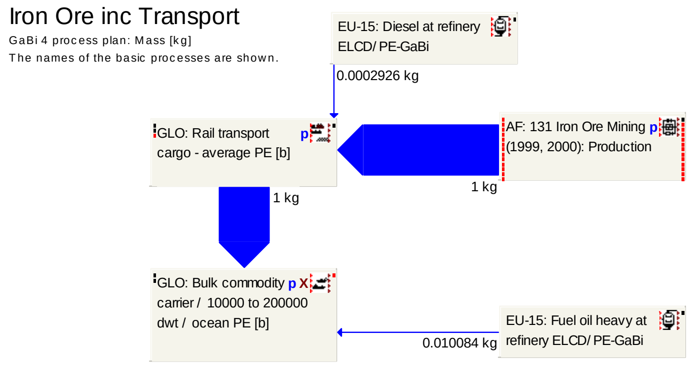

Figure 4. LCA Model with Transport Processes included to system

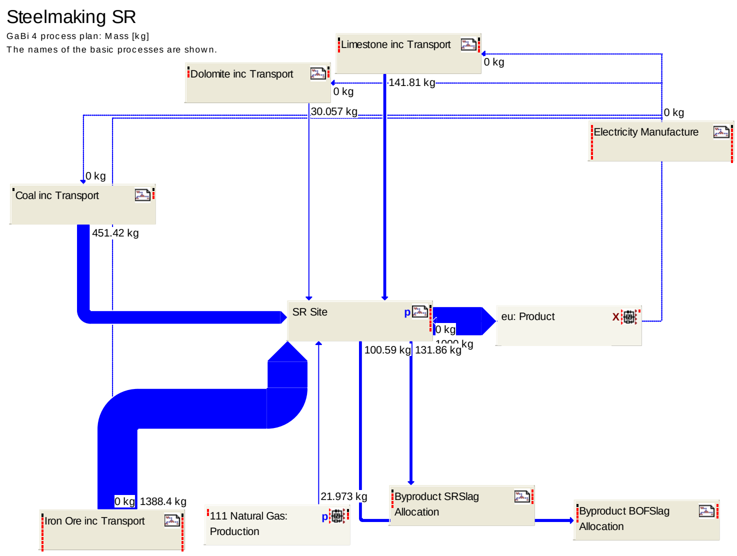

Figure 5. Overall System Plan including Transport Model for main process raw materials

Upstream Scenario reduction targets

The role of the WP2 was to investigate further the environmental impacts of the new processes beyond CO2 reductions. In Phase 1 the modelling of the other impacts was static. It was recognised that this would not be the case and this would need to be investigated further.

Also it was recognized that the steel industry would not be the only industry looking to reduce it's environmental impact. With the continuing tightening of environmental legislation and emissions limits being revised at a European level, there is a general trend to reduce all emissions. An ex-ample of the future targets being set is the 'UK Climate Change Bill' ref (3) which is passing through the parliamentary process at the current time and aims to set reduction targets for the UK into legislation during 2008.

Within Europe also there are future targets for CO2 reduction being set, often these targets follow the year of implementation, i.e. 20% reduction in 2020 and a 50% reduction in 2050.

To model these reductions a simple system has been implemented. This applies to all processes within the steel making site (excluding CO2 emissions as these have already been considered and modelled) and all upstream processes (including CO2 emissions from other industry). A reduction factor has been applied to all air and water emissions from the process. However resource use and waste emissions have remained unchanged.

Shown below is the modelling, implemented within the GaBi LCA system where the parameter is calculated based on the year factor reduction (See Table 3). This factor is then applied to all relevant rows and is multiplied against the amount within the process. More complex algorithms could be developed to calculate reductions for the future, but this method should help give an indication of the future impacts based on the legislative targets being developed.

The processes were then reconnected to form the systems shown below for Smelting Reduction, Top Gas Recycled Blast Furnace and Reference Blast Furnace.

The model scenarios were then entered into the system to look at three scenarios developed by WP9.1 (Fig. 9). The models had the various electrical grid mixes entered and the year the scenario was entered to be able to generate the reduction target emissions.

Shown below are the scenarios entered for the 3 systems studies in year 4.

This allowed a large number of simulations to be conducted simultaneously and any changes made to the models and be able to be modified instantly.

The software then allowed the generation of the following results table. In order to give a broad understanding of environmental impacts, the suite of CML Life Cycle Impact Assessments(ref 4) were utilised. These assessments are built into the GaBi software along with around 100 other assessments. The impact assessment phase of LCA is part of the ISO Standard 14044:2006(ref 5).

The CML Life Cycle Assessments are well known in the LCA community and contain impacts of varying nature. Including Global Warming Potential, Human Toxicity and impacts to Freshwater Ecotoxicity. They take the inventory flows from the system being studied, such as CO2 and Methane and characterise them. E.g. Carbon Dioxide and methane are grouped as part of Global Warming Potential. The inventory flows are then weighted by characterisation factors, i.e. CO2 equals 1 and methane equals 23 and the overall score given as indicator unit eg. Global Warming Potential as an equivalent amount of kg CO2.

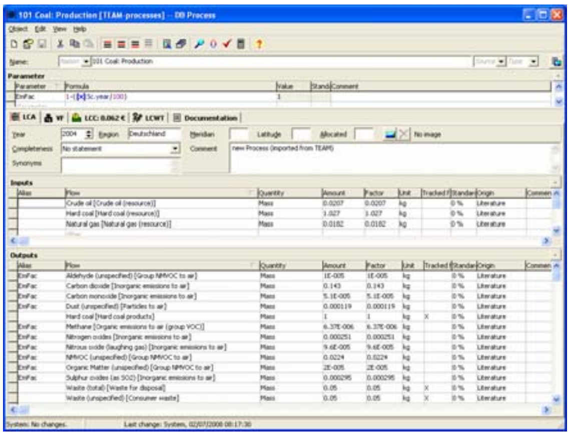

Figure 6. Emission Reduction Factor Modelling applied to Process.

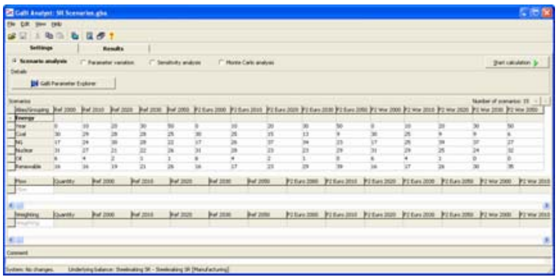

Figure 7. Modelling Scenario inputs to reflect different grid mixes and reduction targets

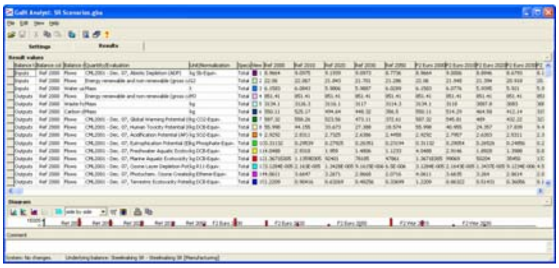

Figure 8. Results table generated by LCA software

Conclusion

The LCA Studies conducted have expanded the range of impacts being looked at beyond just CO_2 and Global Warming. This involved building LCA models of the breakthrough technologies and extending their boundaries from iron making to factory gate back to earth's resource.

The quality of the LCA models were improved with the development of changing the static LCA models with dynamic scenario modelling. Further work was conducted in adapting the upstream data sets to the future scenarios generated in WP1 to give a fair comparison of the breakthrough technologies in the future scenarios.

Further work was conducted in checking the validity of the electricity process model and sensitivity analysis for bulk transport. This modelling showed that the current datasets employed were valid and that the impact of bulk shipping in terms of Global Warming Potential had no great impact on the systems modelled as predicted in the Phase 1 work. Further analysis of other environmental impacts was required to ensure the transport systems did not contribute to other sustainability issues.

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[1] Priority 3 of the 6th Framework Programme in the area of "Very low CO_2 Steel Processes", in co-ordination with the 2003 and 2004 calls of the Research Fund for Coal and Steel

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