Monier (UK) Limited

PAS 2050 Assessment of Concrete and Clay Roof Tiles (Plain and Interlocking)

Summary Report

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July 2009

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Job number 208204-00

ARUP

Document Verification

Job title	PAS 2050 Assessment of Concrete and Clay Roof Tiles (Plain and Interlocking)	Job number	208204-00
Document title	Summary Report	File reference	

Document ref

Revision	Date				
Draft 1	17/07/09	Filename	Monier - Carbon Footprint of Roof Tiles - Summary Report v1.doc		
		Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Helen Jackson / David Dowdell	David Dowdell	Keith Evans
		Signature			
Issue	27/07/09	Filename	Monier - Carbon Footprint of Roof Tiles - Summary Report - Issue.doc		
		Description	Minor edits		
			Prepared by	Checked by	Approved by
		Name	Helen Jackson / David Dowdell	David Dowdell	Keith Evans
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

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1 Introduction

Following the introduction of the Climate Change Act on 26th November 2008 the UK Government has introduced carbon budgets that set a legally binding target for the UK to cut greenhouse gas emissions by 34% below 1990 levels by 2020. Following these budgets will put the UK on track to meet a requirement to reduce carbon dioxide emissions by 80% by 2050.

The introduction of the Act now focuses attention on greenhouse gas emissions arising from the private and public sector and encourages activities to implement reduction strategies.

In response to this Monier (UK) Limited commissioned Arup to undertake a product carbon footprint assessment to PAS 2050[1] for a range of tile specifications produced in the UK. The study also calculates embodied energy. The study, which is intended for Monier management and Monier customers, has been critically reviewed by The Carbon Trust and Professor Geoff Hammond of the University of Bath, in accordance with ISO 14040[2] requirements. The scope of the critical reviews and statements provided by the reviewers is provided in Section 5.

2 Goal and Scope

The goal of the study is to calculate and compare the embodied carbon footprint and embodied energy using cradle-to-gate system boundaries[3] for four different Monier tiles and their associated fittings, these being:

- Mini Stonewold (concrete interlocking tile);
- Plain concrete tile;
- Noreva (clay interlocking tile);
- Rosemary (plain clay tile).

Embodied carbon calculations have used the PAS 2050 methodology, using primary data representing 2007 production. Calculations for Mini-Stonewold, Plain Concrete and Rosemary have been completed using the PAS 2050 methodology, and additionally comply with the ISO 14040 standards.

Monier do not currently manufacture Noreva tiles in the UK but are interested to understand the potential carbon footprint if these clay interlocking tiles were produced locally. Since this scenario is only hypothetical rather than actual, these calculations do not meet PAS 2050 requirements (which only consider actual activities), although the same boundaries and methodology has been used in this study for the Noreva tile as is applied to the other three tile types. The study uses Monier's "state of the art" plant at Karstädt, Germany as the basis for the Noreva tile manufacture, but assumes the plant to be located in Bedworth, UK (a central UK location where the Rosemary plain clay tile is already produced), close to a source of clay.

The functional unit of the study is the tiles and fittings (with a 60 year design life[4]) required to cover a square metre of domestic roof on a new build 2 bedroom terraced house in the UK (which serves as the baseline case in terms of the ratio of tiles to fittings). Results are expressed per $kgCO_2e/m^2$ roof area and MJ/m^2 roof area for embodied carbon and

[1] BSi, Carbon Trust & Defra; PAS 2050: Specification for the assessment of the life cycle greenhouse gas emissions of goods and services; 2008.
[2] International Organisation for Standardisation; ISO 14040: Environmental management – Life cycle assessment – Principles and framework; 2006.
[3] For the purposes of this study, the "cradle" is defined as raw materials extraction from the ground and the "gate" is the factory gate of Monier's manufacturing sites.
[4] Tiles are likely to last longer than 60 years so this should be considered as a minimum.

embodied energy respectively. Embodied energy is based on the net calorific value (lower heating value). More detailed analysis and sensitivity/scenario testing shows results in terms of $kgCO_2e$/tonne and MJ/tonne of tiles and fittings.

Results "per m^2" include a provision for wastage on the construction site, taken as 3% for tiles and 10% for fittings. Results "per tonne" are taken up to the factory gate of the Monier manufacturing plants in the baseline calculations, i.e. they do not include onward transport to customers.

3 Summary Results and Conclusions

Summary baseline results are provided in Table 1.

Table 1: Summary Results of the Study

Tile	Type	$kgCO_2e/m^2$ roof area	$kgCO_2e$/tonne tiles	MJ/m² roof area	MJ/tonne tiles
Mini Stonewold	Interlocking (concrete)	12	206	91	1594
Plain Concrete	Plain (concrete)	15	174	146	1734
Noreva	Interlocking (clay)	14	265	240	4590
Rosemary	Plain (clay)	27	291	478	5252

- **Mini-Stonewold concrete interlocking tiles have the lowest embodied carbon footprint** of the assessed tile types on a square metre basis, when applied to a 2 bedroom terraced new build house in the UK. They also exhibit the **lowest embodied energy**. When applied to a 4 bedroom detached house with hips and valleys, Mini-Stonewold and Noreva exhibit similar embodied carbon footprints, as the greater proportion of fittings (which are lighter than the tile for Noreva) leads to a reduced overall weight to cover a square metre of roof (Table 2).

Table 2: Comparison of Results by House Type

$kgCO_2e/m^2$ roof area	Mini Stonewold	Plain Concrete	Noreva	Rosemary
2 Bed Terraced	12	15	14	27
4 Bed Detached (with hips and valleys)	13	16	14	34

- **Interlocking tiles (concrete and clay) have lower embodied carbon footprints compared to plain tile alternatives (in concrete and clay)**. This is because significantly fewer tiles are required to cover the roof area as interlocking tiles do not need to be double lapped.

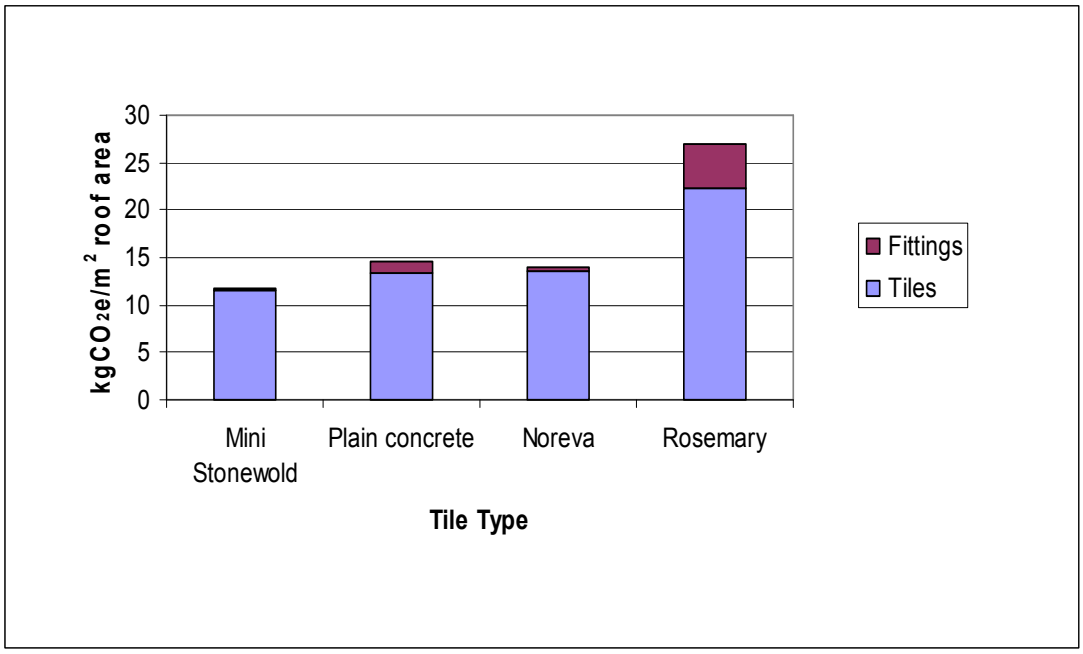

Figure 1: Embodied Carbon Emissions per m² Roof Area for a 2 Bedroom Terraced New Build House

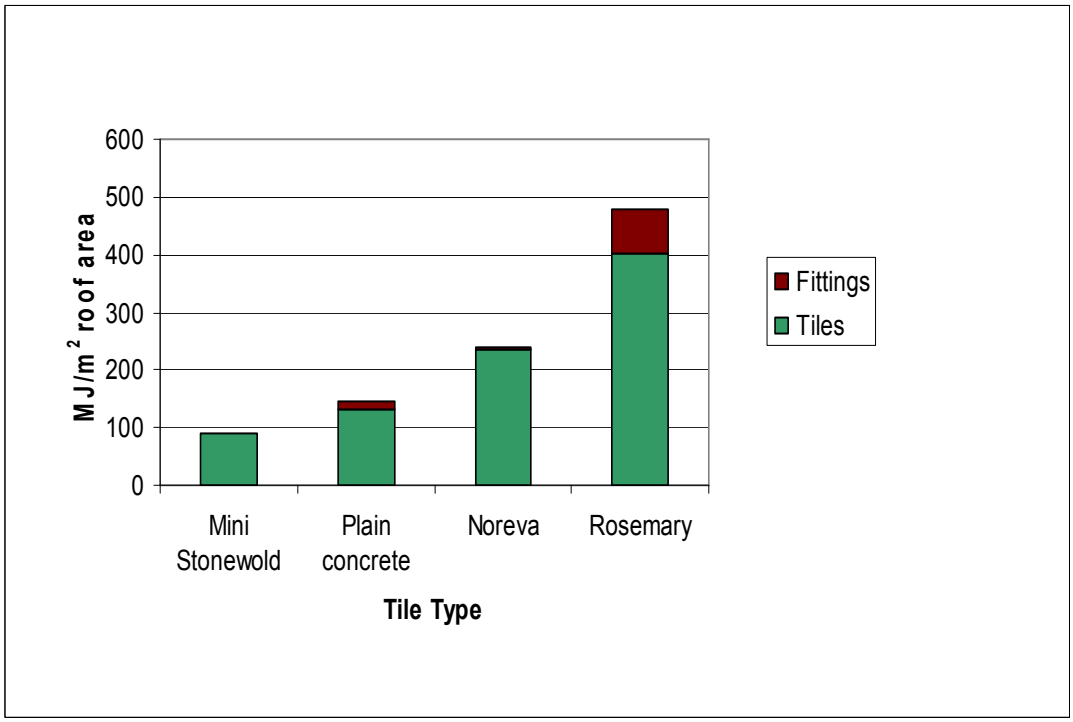

Figure 2: Embodied Energy per m^2 Roof Area for a 2 Bedroom Terraced New Build House

- **Noreva interlocking clay tiles have a lower carbon footprint compared to plain concrete tiles on a square metre basis but a higher embodied energy**. This reflects the more energy intensive nature of clay tile (and fittings) production at clay tile plants relative to concrete tile production. The carbon emissions for the concrete tiles include process emissions from calcination during cement production.
- **Rosemary fittings** (plain clay) are the **most carbon intensive** and have the **highest embodied energy** due primarily to the chamber kiln technology used at the Bedworth plant that manufactures them.
- A tonne of fittings production generates more greenhouse gases than a tonne of tiles for a range of reasons including curing and firing technology and methods used, sources of energy, variation in size and shape of fittings and volume of production. However, **fittings only make a small contribution to the overall embodied carbon and energy** results because they make up no more than 6% of the assessed roof composition.

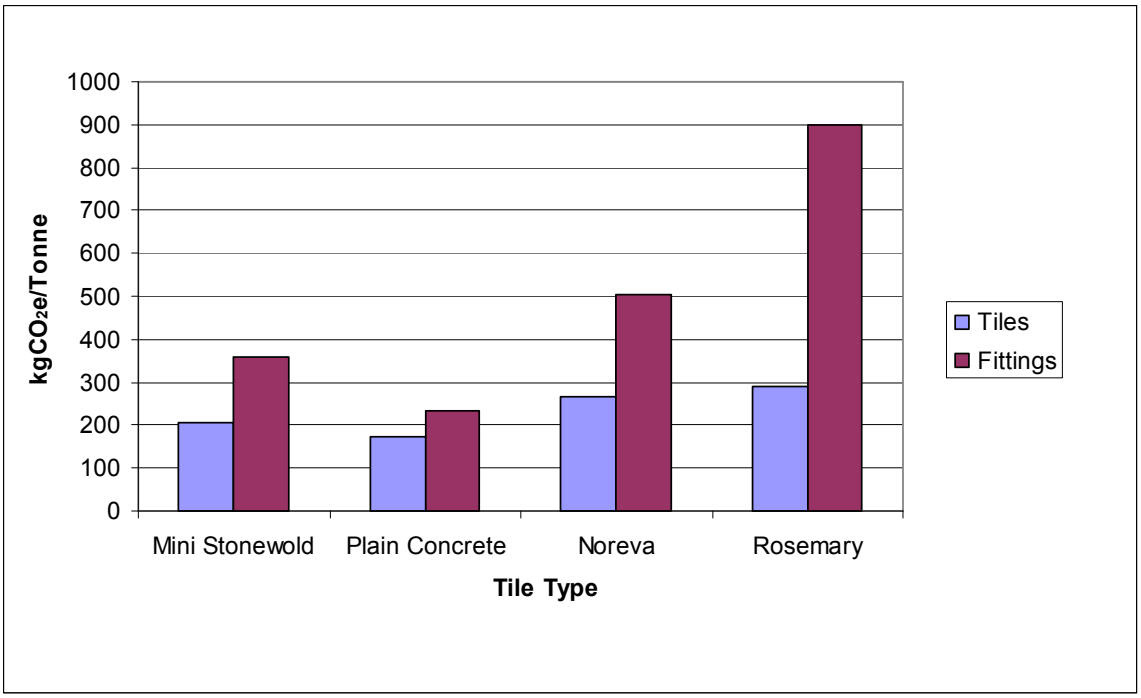

Figure 3: Embodied Carbon Emissions comparison between Tiles and Fittings

- If complementary products (nails, clips, wood screws and mortar) used to fix the tiles and fittings in place are considered, they increase the carbon footprint by no more than 4% for the 2 bedroom terraced house (5% for the 4 bedroom detached house with hips and valleys).
- Greenhouse gas emissions arising from extraction and synthesis of raw materials are the most significant contributor to the carbon footprint of concrete tiles (74-83%) as illustrated in Figure 4. Plain concrete tiles show the greatest sensitivity (5%) to an increase in the return transport distance required to deliver the raw materials. This is due to the greater distances travelled to supply raw materials to Monier sites producing concrete products e.g. 98 km one way for sand compared to a maximum of 55 km one way for transport of clay to clay tile plants.
- Use of heat and electricity at the clay tile plant is the most significant contributor to the embodied carbon and energy figures for clay tile production (84%). However, the Karstädt plant which produces the Noreva tile is considered to be very energy efficient

and therefore "state of the art" for clay interlocking tiles due to the installation of a tunnel hydrokiln and the practice of firing fittings on the main production line rather than in a separate chamber kiln.

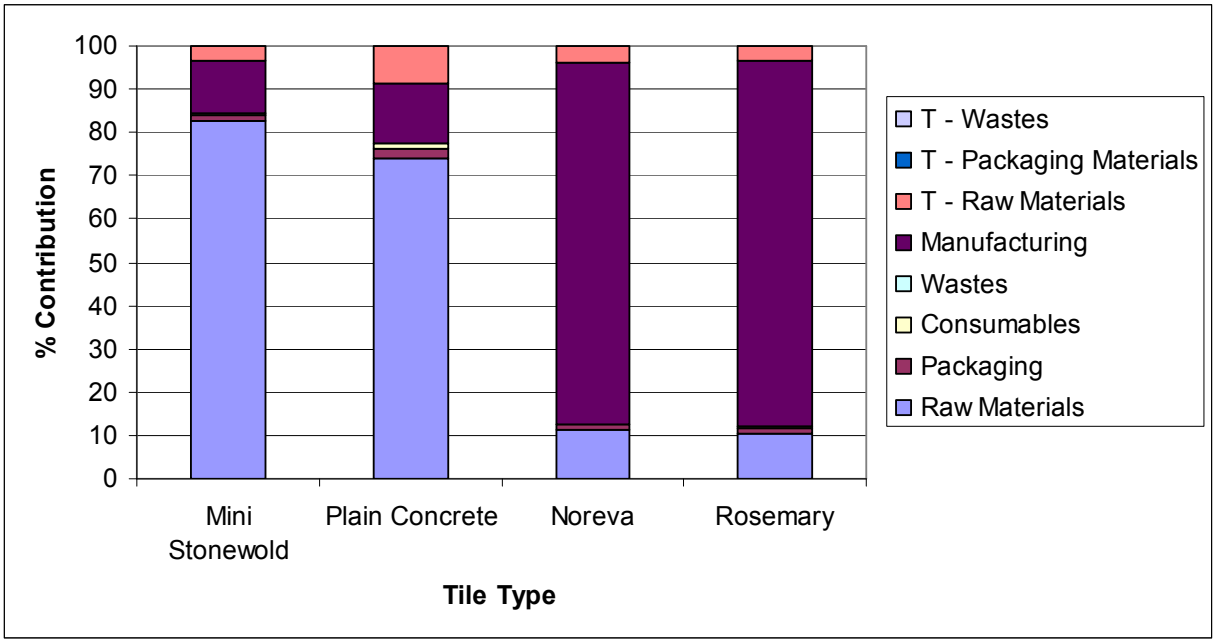

Figure 4: Breakdown of Contributions to the Embodied Carbon Footprint[5]

- Wastes, packaging and consumables do not significantly contribute to the embodied carbon footprint results (total of up to 3% per tile) in most cases. The embodied energy of these products contributes a similar amount except for plain concrete tiles where they are 13% of the total embodied energy. This is due to the pallet oil, which has a high embodied energy on production, being more significant in a lower mass tile.
- Study findings do not appear to be sensitive to onward transport to customers. If all produced tiles are delivered to customers, the increase in the product carbon footprint is no more than 5% on baseline values.
- Typical one way delivery distances are in the range 93 – 131 km and apply to 55% of Monier's production. If typical transport return journey distances to customers were to increase by 50%, this would result in no more than an additional 1-2% on the baseline carbon footprint. Delivery of all tiles to customers, travelling 50% further per delivery, typically increases the product carbon footprint by 3% with increases in embodied energy up to 5%.
- Use of 100% biodiesel (assumed to be supplied from sustainable sources) in trucks delivering tiles to customers would have a minor reduction (1%) on the product carbon footprint of delivered tiles. Use of 100% biodiesel in trucks supplying raw materials to Monier's sites would typically yield a 2% reduction in the product carbon footprint (4% reduction in the case of plain concrete tiles).
- Results presented in this study are compared with other reported results in Table 3, and were also compared with data in the EcoInvent 2.0 and GaBi 4 databases. The difference between concrete and clay roof tiles calculated in this study is less than reported by other sources but still demonstrates the lower embodied carbon footprint of Monier's concrete roof tiles in comparison with Monier's clay roof tiles. The main reason

[5] A "T" prefix in the legend refers to return transport of the stated materials and wastes

for the smaller differences in this study particularly in regard to interlocking tiles can be attributed to the choice of a "state of the art" (in terms of energy efficiency) manufacturing plant for clay interlocking tiles with existing "average" manufacturing sites for concrete interlocking tiles.

Table 3: Comparison of Results from this Study with Other Results

Tile Type	This Study*	Oko-Institut[6]	ICE[7]
CO_2e Emissions (kg CO_2e/ tonne)			
Concrete Tile	206	211	224
Clay Tile	265	479	460
Embodied Energy (MJ/tonne)			
Concrete Tile	1594	2204	1650
Clay Tile	4590	7871	6500

4 Recommendations

- A detailed analysis of Mini Stonewold tiles by plant showed that Stirling production is the most carbon intensive. This is due to the heat energy being predominantly sourced from diesel. Similarly, Shawell, the second most carbon intensive plant, uses 100% diesel on the production lines. A shift to natural gas at Stirling would reduce the carbon footprint of Mini-Stonewold tiles by 1%. A similar exercise at Shawell as well as Stirling, would reduce the carbon footprint of tiles and fittings by 2.4% and 21% respectively.
- Monitoring of energy use between fittings and tile production lines will facilitate future carbon footprint updates. This would be particularly beneficial at Shawell. Real time monitoring and recording of energy use by line by each tile type being manufactured would provide the best data for future carbon footprint updates.
- Where possible, Monier should seek to procure significant raw materials for concrete production (cement, sand) from sources as close as possible to Monier sites in order to help to reduce the carbon footprint. In addition, Monier should seek to use cements with a lower carbon emissions factor where possible. In future, Monier should request embodied carbon figures are provided by suppliers for materials that Monier is considering procuring, when renewing supply contracts. In this way, the carbon impact of suppliers' activities on Monier's own product carbon footprints, can be assessed and factored into decision making.
- Monier should get the carbon footprints for Mini-stonewold, plain concrete and Rosemary tiles certified by The Carbon Trust, as this demonstrates that the product carbon footprints not only meet the requirements of PAS 2050, but the more stringent Footprint Expert™ Rules. This is a necessary pre-requisite for use of the Carbon Reduction Label and will provide a more robust basis for marketing and demonstration of Monier's management of the carbon issue.
- Monier should obtain maximum marketing benefit by considering the use of the Carbon Trust's Carbon Reduction Label on its product portfolio. This is becoming the benchmark for credible marketing claims about carbon emissions associated with

[6] Gensch, C.-O.; Liu, Ran: Ökobilanzieller Vergleich von Dachziegel und Dachstein. Endbericht im Auftrag der Monier Group Gmbh. Freiburg 2008

[7] Concrete tile figures provided by Prof. Geoff Hammond, Director of the Institute of Sustainable Energy and the Environment, University of Bath, assuming that a tile is 50 Mpa precast concrete with no slag content. These figures are new (provisional) ICE data. ICE figures are based on carbon dioxide only emissions and higher heating value (gross calorific value)

products. Recent market research[8] found that "almost two thirds of consumers (63%) are more likely to buy a product if they know action is being taken to reduce its carbon footprint. At the same time, 70% of consumers want businesses to do more to help them make more informed environmental choices about the products they buy". In particular, the research found:

- ***Green credentials carry consumer weight*** – Committing to reduce a product's carbon footprint has a positive impact on the brand's reputation, as 58% of consumers say they value companies that are taking action to reduce their carbon emissions.
- ***Environmentally responsible brands must shout louder*** – Only 12% of consumers think that companies are doing enough to cut carbon emissions and tackle climate change.
- ***Consumer understanding of sustainability grows*** – 60% of consumers understood that a product has a carbon footprint. More than two thirds of the UK's carbon footprint comes from products and services, so acknowledging that we need to reduce these, as well as a company's or individual's carbon footprint, is vital.

Furthermore, the developing European CEN/TC 350 programme on Sustainability of Construction Works includes a provision for Environmental Product Declarations (EPDs) for construction products meaning that accurate, certified declarations of environmental performance of construction products will become more common in the coming years. Monier can build on the work carried out in this report in order to be ready to meet these requirements.

5 Critical Review

5.1 Scope of the Carbon Trust Review

The Carbon Trust assessed compliance of the carbon footprint figures against PAS 2050. The Carbon Trust additionally looked at areas that would need minor modification to meet The Carbon Trust's own Footprint Expert™ Rules.

For this review, the Goal & Scope Report and carbon footprint model for the study was reviewed by The Carbon Trust, as well as the draft Technical Report.

5.2 Carbon Trust Critical Review Statement

The critical review of the Monier Roof Tile model undertaken by the Carbon Trust indicates that it is well constructed and of high quality. The model, whilst clearly being constructed in accordance to the broad scope of PAS 2050, requires certain additional/ final amendments to be made in order to be considered as being of a certifiable standard, i.e. to be compliant with the Carbon Trust's Footprint Expert™ Rules.

The required amendments have been described within the critical review and are broadly summarised below as;

- Completed data documentation needs to be made, including stating assumptions and referencing data inputs.
- Footprint Expert™ reference data needs to be used within the model's calculations.
- In some cases, and transport in particular, the Footprint Expert™ calculators need to be applied.

[8] Carbon Trust press release; June 2009

- A higher level of data quality is required for high impact emission inputs, such as cement for concrete tiles, and natural gas for clay tiles.

5.3 Scope of The University of Bath Review

Professor Geoff Hammond, Director of the Institute of Sustainable Energy and the Environment undertook a review of the study in comparison with PAS 2050 and the ISO 14040ff Life Cycle Assessment (LCA) standards.

This review was carried out based on the Goal & Scope Report and the draft Technical Report.

5.4 University of Bath Critical Review Statement

The Technical Report associated with the Monier (UK) Ltd ["Monier"] project entitled 'PAS 2050 Assessment of Concrete and Clay Roof Tiles (Plain and Interlocking)' has been critically reviewed in order to ascertain whether it is consistent with the goal of the study, and that it is in line with the requirements of PAS 2050 on the 'carbon footprinting' of goods and services as well as the ISO 14040 and 14044 standards on environmental life-cycle assessment (LCA). It is confirmed that the report is generally compatible with the goal and scope established for the study and with the requirements of these standards. But even studies that comply with the ISO standards can have wide ranging and significant differences in terms of data consistency and methodology. During the development of ISO 14040 series, and the new PAS 2050 standard in the UK, technical rigour was occasionally sacrificed for practically.

The findings of the study by Ove Arup & Partners Ltd provide very useful data on the embodied energy and carbon associated with the four exemplar types of Monier tiles and fittings that have been examined. It indicates the main contributors to the magnitude of these parameters (raw materials for cement products and heat and electricity for clay ones) and their sensitivity to assumptions about, for example, onward transport of the products to customers.