1.   Appendix A; Life Cycle Assessment Method

28.   Appendix A Methodology Scope and Boundaries

LCA Author	**The Evah Institute as described at** www.evah.com.au
Study Period	Factory data was collected from 2015 to 2018
LCA Method	Compliant with ISO 14040 and ISO 14044 Standards
LCIA method	ReCiPe, EcoIndicator 99 and TRACI Life Cycle Impact Assessments (LCIA)
Scope	Cradle to Fate including all supply chain phases and stages depicted in Figure A1.
Phases	The LCA covered all known flows in all known stages cradle to gate.
Assumptions	Use is to typical Australian Facility Management professional practice.
Scenarios	Use, cleaning, maintenance plus disposal and re-use were scenario-based using Facility Management Association denoted and published typical operations.
System Boundaries	The LCA covers operations A1, A2, A3 cradle to gate in the system boundary depicted in Figure 3. Packaging, however is cradle to grave.
Processes	All known processes are included from resource acquisition, water, fuel & energy use, power generation & distribution, freight, refining, intermediates, manufacture, scrap re-use, packing and dispatch, installation, use, maintenance and landfill. All significant waste and emission flows from all supply chain operations involved to make, pack and dispatch the product are included.

Figure A1 Phases and Stages Cradle to Grave

Evah industry databases cover all known domestic and global scope 1 and 2 operations. They exclude scope 3 burdens from capital facilities, equipment churn, noise and dehydration as well as incidental activities and employee commuting. The databases exist in top zones of commercial global modelling and calculating engines. Quality control methods are applied to ensure:

- Coverage of place in time with all information for each dataset noted, checked and updated[151];
- Consistency to Evah guidelines for all process technology, transport and energy demand[152];
- Completeness of modeling based on in-house reports, literature and industry reviews;
- Plausibility in 2 way checks of LCI input and output flows of data checked for validity, plus
- Mathematical correctness of all calculations in mass and energy balance cross checks.

Electricity supply models in active databases are updated annually. As each project is modelled and new data is available the databases are updated and audited by external Type 1 ecolabel certifiers.

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151 Jones D G (2004) LCI Database for Commercial Building Report 2001-006-B-15 Icon.net, Australia
152 Evah Tools, Databases and Methodology Queensland, Australia at http://www.evah.com.au/tools.html

Appendix A; Life Cycle Assessment Method

29. Appendix A Methodology Supply Chain Modeling

Processes to acquire, refine, transport, fabricate, coat, use, clean, repair, reuse and dispose of metal, masonry, ceramic, timber, glass, plastic and composites are modelled. A flow chart in Figure A2 shows most key product supply chain operations from cradle to fate. These include those of:

- Mining, extracting and refining resources to make commodities and packaging;
- Acquiring, cultivating, harvesting, extracting, refining produce and biomass;
- Fuel production to supply power and process energy and freight;
- Chemicals use in processing resources, intermediates and ancillaries;
- Process energy, fuel and freight of resources, intermediates and ancillaries;
- Intermediates use, cleaning, repair, recycling, re-use and landfill, as well as
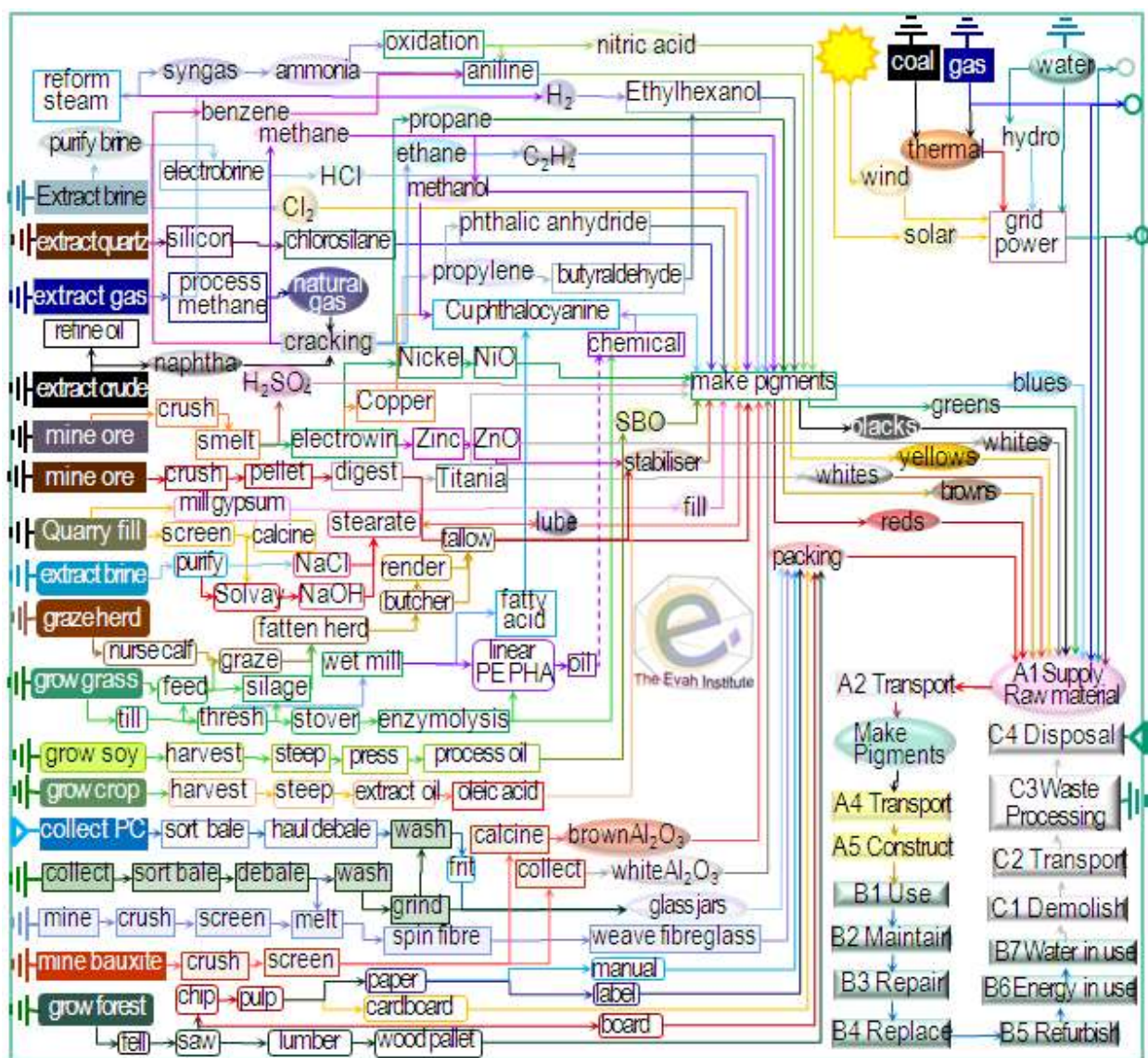- Infrastructure process energy transformed and material wear loss e.g. tyres.

Figure A2 Major Product Operations

30. Appendix A Methodology Data Sources Representativeness and Quality

Primary data used for modelling the state of art of each operation includes all known process for:

- Technology sequences;
- Reliance on raw and recycled material;
- Energy and water use;
- High and reduced process emissions;
- Landfill and effluent plus
- Freight and distribution systems.

Primary data is sourced from clients, Annual Reports and their publications on corporate locations, logistics, technology use, market share, management systems, standards and commitment to improved environmental performance. Information on operations is also sourced from client:

- Supply chain mills, their technical manuals, corporate annual reports and sector experts, and
- Manufacturing specifications websites and factory site development license applications.

Background data is sourced from the International Energy Agency, IBISWorld, USGS Minerals, Franklin Associates, Boustead 6, Plastics Europe, CML2, Simapro 8, EcoInvent 3 and NREL USLCI model databases. Information on operations is also sourced from:

- Library, document, NPI and web searches, review papers, building manuals and
- Global Industry Association and Government reports on Best Available Technology (BAT).

For benchmarking, comparison and integrity checks inventory data is developed to represent BAT, business as usual and worst practice options with operations covering industry sector supply and infrastructure in Australia and overseas.

Such technology, performance and license conditions were modelled and evaluated across mining, farming, forestry, freight, infrastructure and manufacturing and building industry sectors since 1995.

As most sources do not provide estimates of accuracy, a pedigree matrix of uncertainty estimates to 95% confidence levels of Geometric Standard Deviation^2 (σ_g) is used to define quality as in Table A1[153].

No data set with >±30% uncertainty is used.

Table A1 Data Quality Uncertainty (U) for 2018

Correlation	Metric σ_g	U ±0.01	U ±0.05	U ±0.10	U ±0.20	U ±0.30
Reliability	Reporting	Site Audit	Expert verify	Region	Sector	Academic
	Sample	>66% trend	>25% trend	>10% batch	>5% batch	<1% batch
Completion	Including	>50%	>25%	>10%	>5%	<5%
	Cut-off	0.01%w/w	0.05%w/w	0.1%w/w	0.5%w/w	1%w/w
Temporal	Data Age	<3 years	≤5 years	<10 years	<15 years	>16 years
	Duration	>3 years	<3 years	<2 years	1 year	<1 year
Geography	Focus	Process	Line	Plant	Corporate	Sector
	Range	Continent	Nation	Plant	Line	Process
Technology	Typology	Actual	Comparable	In Class	Convention	In Sector
	Reflects	Process	Mill	Company	Group	Industry
Certainty	Error Margins	>99±1%	>95±5%	>90±10%	>80±20%	≤70±30%
	Confidence	Very High	High	Typical	Adequate	Low

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[153] Evah Institute data quality control system accords with UNEP SETAC Global LCI Database Quality 2010 Guidelines

Appendix A; Life Cycle Assessment Method

31. Appendix A Methodology Supply Chain Modeling Assumptions

Global and Australian built sector rules and Evah assumptions applied are defined in Table A2.

Table A2 Scope Boundaries Assumptions and Metadata

Quality/Domain	National including Import and Export
Process Model	Typical industry practice with currently most common or best (BAT) technology
Resource flows	Regional data for resource mapping, fuels, energy, electricity and logistics
Temporal	Project data was collated from 2016 to 2018
Geography	Designated client, site, regional, national, Pacific Rim then European jurisdiction
Representation	Designated client, their suppliers and energy supply chains back to the cradle
Consistency	Model all operations by known given operations with closest proximity
Technology	Pacific Rim Industry Supply Chain Technology typical of 2015 to 2018
Functional Unit	Typical product usage with cleaning& disposal/m^2 over the set year service life
System Control	
Primary Sources	Clients and suppliers mills, publications, websites, specifications & manuals
Other Sources	IEA 2018, GGT 2018, IBIS 2018, EcoInvent 2018, Simapro 2016, Boustead 2013
Data mix	Power grid and renewable shares updated to latest IEA 2018 reports
Operational	Company data for process performance, product share, waste and emissions
Logistics	Local data is used for power, fuel mix, water supply, logistics share & capacity
New Data Entry	VliegLCA, Evah Institute 2018; Global Green Tag Researchers 2018
Data Generator	Manufacturers, Evah Institute 2018; GGT 2018; Meta: IBIS 2018, Other pre 2018
Data Publisher	The Evah Institute Pty Ltd to Global GreenTag and designated client only
Persons input	All contributors cited in Evah & Global GreenTag records or websites
Data Flow & Mix	
System Boundary	Earth's cradle of all resource & emission flows to end of use, fitout or build life
System flows	All known from and to air, land, water and community sources & sinks
Capital inclusions	Natural stocks∆, industry stockpiles∆, capital wear ∆, system losses and use
Arid Practice	Dry technology adopted, Water use is factored by 0.1 as for e.g. Mining
Transportation	AU distance >20% than EU; >20% fuel efficient larger vehicles, load & distance
Industrial	Company or industry sector data for manufacturing and minerals involved
Mining	All raw material extraction is based on Australian or Pacific Rim technology
Imported fuel	Mix is from nearest sources is e.g. UAE, SE Asia, Canada or New Zealand
Finishes	Processing inputs with finishing burdens are factored in. If not that is denoted
Validation	
Accuracy	10th generation study is >± 5 to 15% uncertain as stipulated per unit operation
Completeness	All significant operations are tracked and documented from the cradle to grave
Precision	Tracking of >90% flows applies a 90:10 rule sequentially to 99.9% and beyond
Allocation	%100 to co products on reaction stoichiometry by energetic or mass fraction
Burdens	All resource use from & emissions to community air land, water are included
Plausibility	Results are checked and benchmarked against BAT, BAU & worst practice
Sensitivity	Calculated U reported & compared to Bath U RICE & EcoInvent 3.2 libraries
Validity Checks	Are made versus Plastics Europe, Ecobilan, GaBi & or Industry LCA Literature

Appendix A; Life Cycle Assessment Method

32.   References

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Reviewer Conclusion

The LCA reviewer's report confirmed that the LCA was ISO 14025 compliant. The verifier was not involved in developing the LCA and has no conflict of interests from organisational position. The reviewer confirmed that documentation according to ISO requirements was provided including evidence from the:

The Evah Institute, the LCA developer:

a) Recipes of input and output data of unit processes used for LCA calculations   √

b) Datasheets of measures, calculations, estimates and emails with sources as in Table 6   √

e) References to literature and databases from which data was extracted as noted in Table 6   √

g) Notes on supply chain processes and scenarios satisfying requirements of this Standard   √

i) Embodied Energy shares as used for sensitivity analyses re ISO 14044:2006, 4.5.3.3   √

j) Proof percentages or figures in calculations in the end of life scenario   √

k) Notes on proof of % and allocation calculations   √

o) All operations covered Vs criteria and substantiation used to determine system boundaries   √

Product Manufacturers in:

c) Specifications used to create the manufacturer's product   √

d) Citations, references, specifications or regulations & data showing completeness   √

f) Specification demonstrating that the product can fulfill the intended use   √

The Verifier Vlieg LCA on:

l) Notes and calculation of averages of different locations yielding generic data   √

m) Substantiating additional environmental information ISO 14025:2006, 7.2.4   √

n) Procedures for data collection, questionnaires, instructions, confidentiality deeds   √

Requiring No Evidence:

As the LCA is cradle to gate as well as Evah 14015 PCR compliant the reviewer did not need to:

h) Substantiate a few stages as only Cradle to Gate stages were substantiated   √

p) Substantiate alternatives as no other choices and assumptions were applied   √

q) Demonstrate consistency for few stages as the same rules in Tables A1 and A2 apply to all.   √

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