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Changes for the Better

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ElecImpact

An Open, Modular, Graph-Based Platform for Collaborative Construction of Life Cycle Inventory Data

Blue: technical solutions
Green: organizational solutions
} **Both matter!**

By GDR DEFIE - https://defie-cnrs.fr/ - French research group to promote collaborative research
Hopefully, we can merge this initiative with other projects in the future

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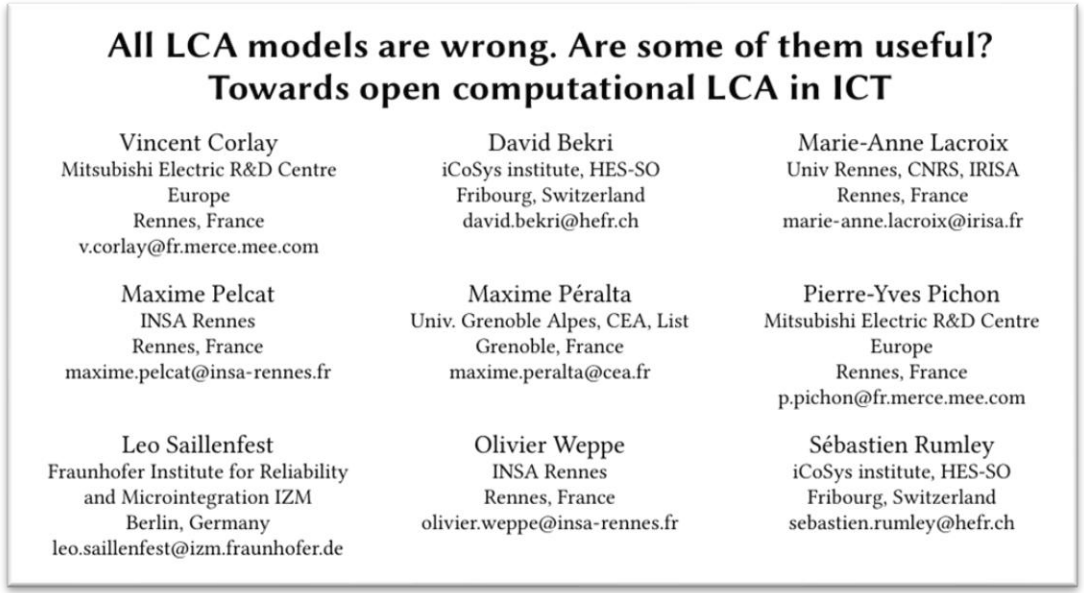
Motivations

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Life Cycle Assessment (LCA) curses

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All LCA models are wrong. Are some of them useful?
Towards open computational LCA in ICT

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- Direct measurement of biosphere flows is difficult ➔ LCA relies on many *models*.

- Two curses of model-based LCA :
  - **Curse 1** : Model validation is difficult.

    Measurement is costly and often impractical.
  - **Curse 2** : We have to compose models because the systems are complex.

    Ensuring consistency is hard and validating the composed models is still difficult

“Extra-high” level of carefulness required in LCA!

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LCA curses → requirements → (high-level) solutions

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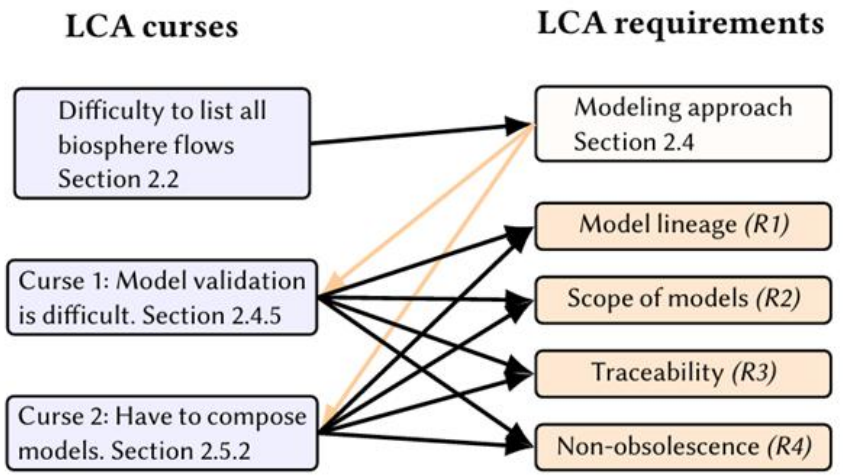
Proposed requirements to address the curses

R1 — Model lineage: Know which models depend on which.

R2 — Scope: Give each model a clear domain of validity and explicit assumptions.

R3 — Traceability: Trace results back to source data and model design.

R4 — Non-obsolescence: Version and maintain models, like software.



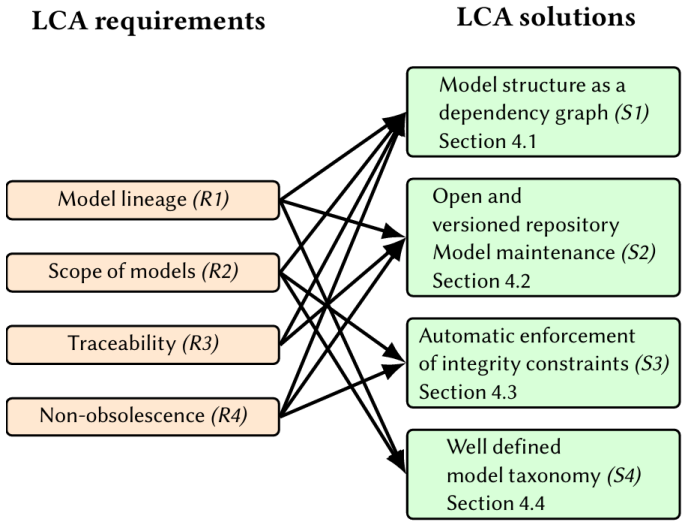
Proposed framework to meet the requirements

S1 — Dependency graph: Manage model structure like software dependencies.

S2 — Open, versioned repository: Record build recipes and ancestry; support model maintenance.

S3 — Automatic integrity checks: Enforce mandatory fields, allowed parent–child relationships, and structure.

S4 — Clear model taxonomy: Cover product/process, impact, conversion, allocation, uncertainty, and validation.

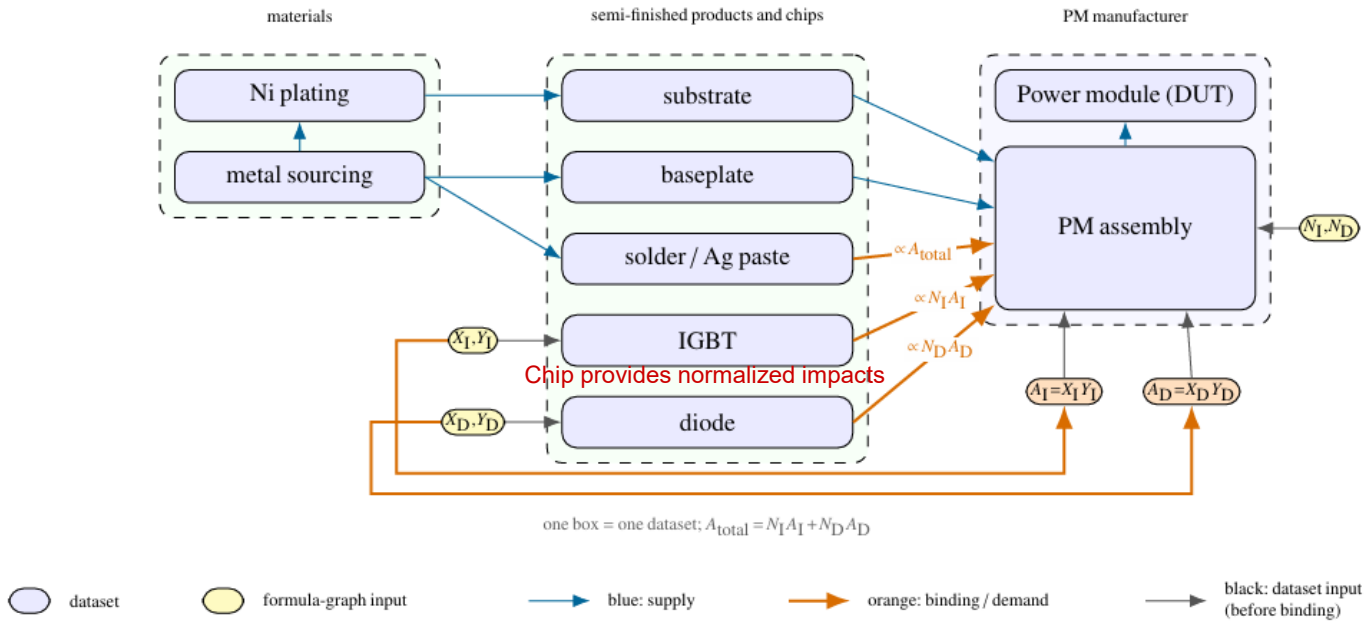


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Example of model-composition risk and how we addressed it with ElecImpact

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N = number of chips
A = area of each chip

- LCI composed of many parametric datasets (sub-LCI), each modelling different steps of a supply-chain.
- Package die-area demand **can conflict with assumed chip** (IGBT) **geometry of impact model**
  - At chip, if the functional unit is only **"1 cm² good-die"**, model geometry assumption hidden.
- Binding of dataset parameters with ElecImpact (Orange arrow).

Ref: A multi-level parametric life-cycle inventory data structure for eco-design space exploration: application to an IGBT power module, Vincent Corlay and Pierre-Yves Pichon.

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Overview of ElecImpact

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What it is

- Targets the collaborative construction of Life Cycle Inventory (LCI) data.
- It is both a **database** of LCI data and a **code stack** (open source) to import, export, validate, and process it.
- On the computational side, it can **bind** parametric datasets and compute impacts in a parallel manner.

Design paradigms (practical implantation of the “solutions” of previous slide)

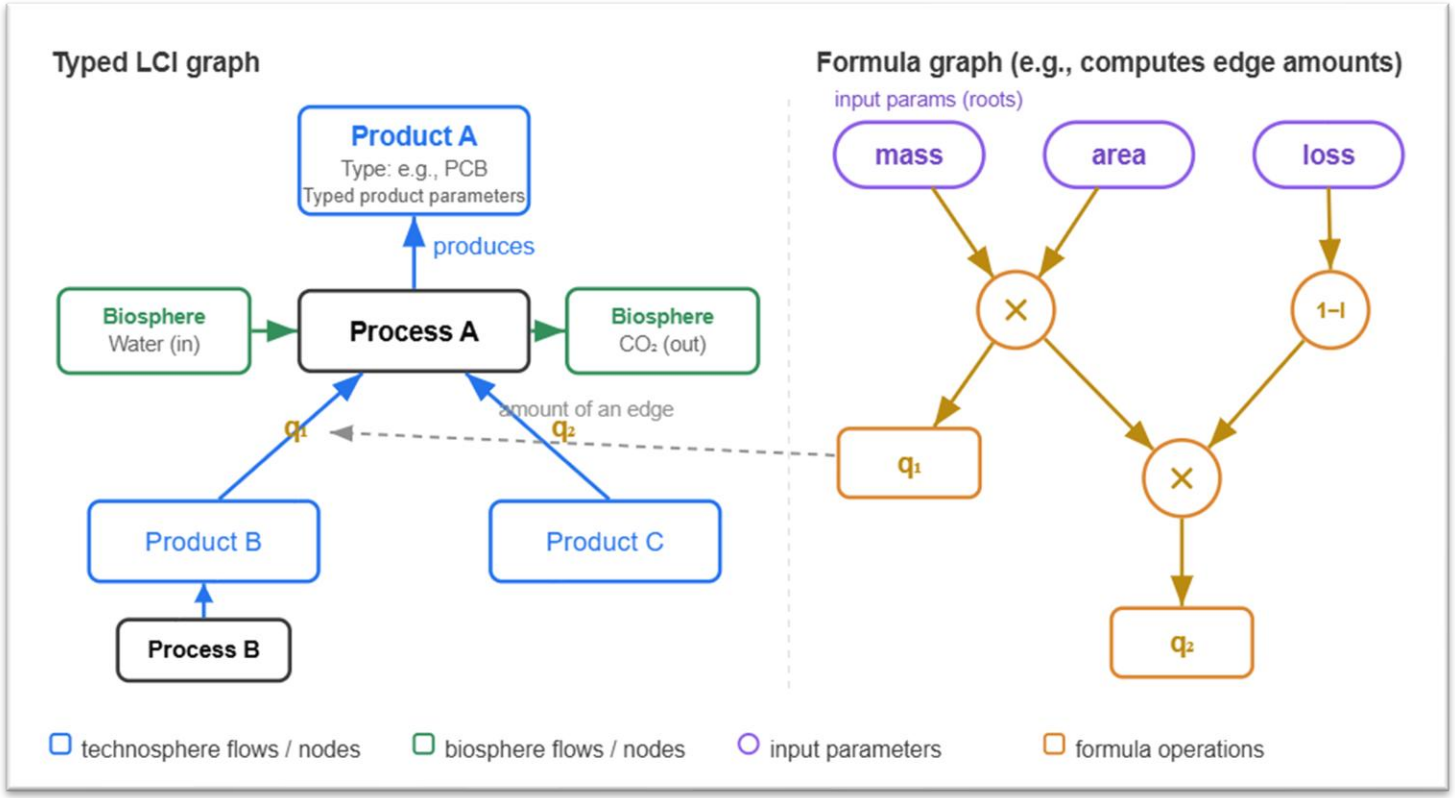
1. **Modular:** The « core » package stays small and domain-agnostic. New data models and parsers can easily be added by anybody as « extensions » (independent package, can be in different repository).
2. **The database is a graph:** Data stored as nodes linked by references (no duplication).
3. **Exposes different manners to assess impacts**, so one can choose the most relevant one.
4. **Models evolve and are versioned:** Graph of models should be easy to update and maintain.
5. **Complement, not replace:** “augmented” Brightway format, reusing Brightway functions.

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Data structure: Graph-based approach

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- One-to-one mapping between LCI graph and BW activity format.
- Product nodes can be **typed** (data model).
  - Technical characteristics saved as parameters (e.g., size, mass, etc…)
- Generic & flexible **data structure** that can **preserves symbolic information** from diverse sources (parameter definitions, formulas, product type …).
- **Data imported** (=mapped to the data structure) via **dedicated parsers** declared in extension**.**
- Notion of **graph of LCI datasets**.

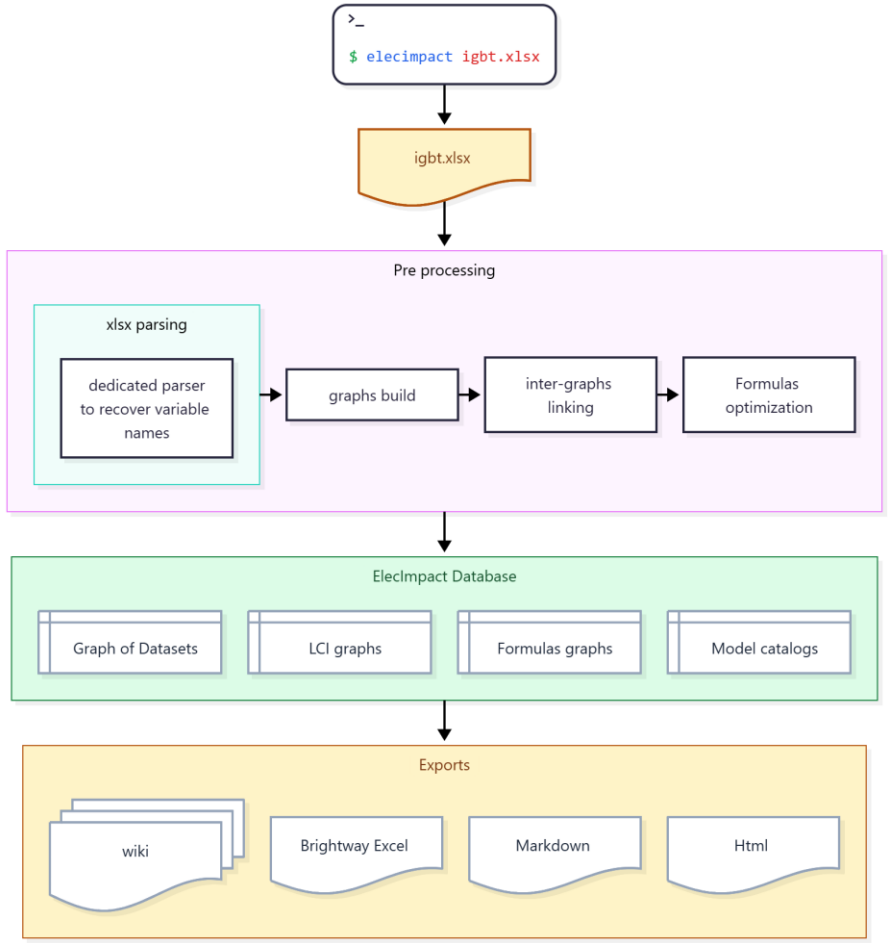
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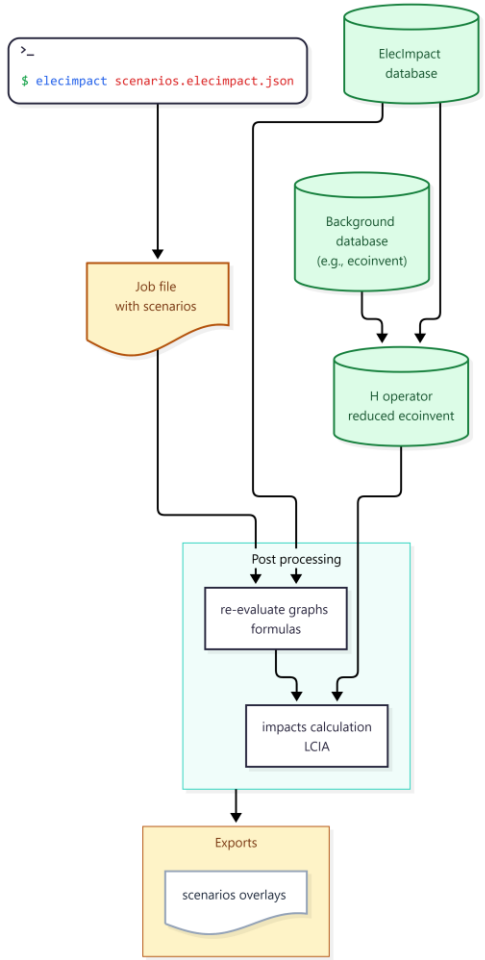
Pipeline overview

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Adding a dataset in the database



Fast impact scoring via *scenarios*

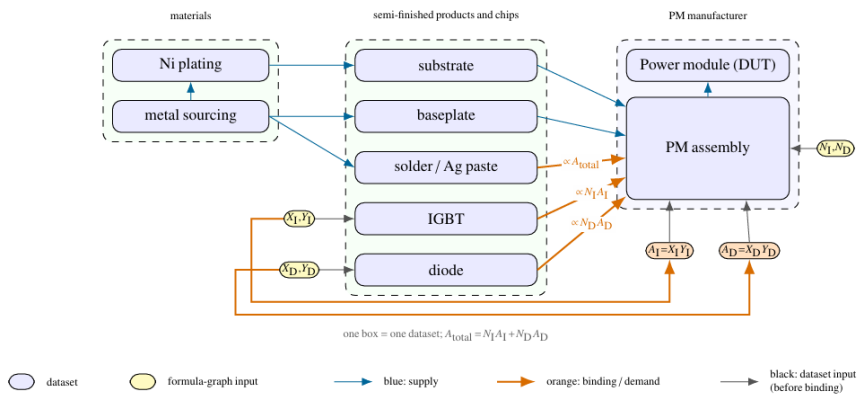


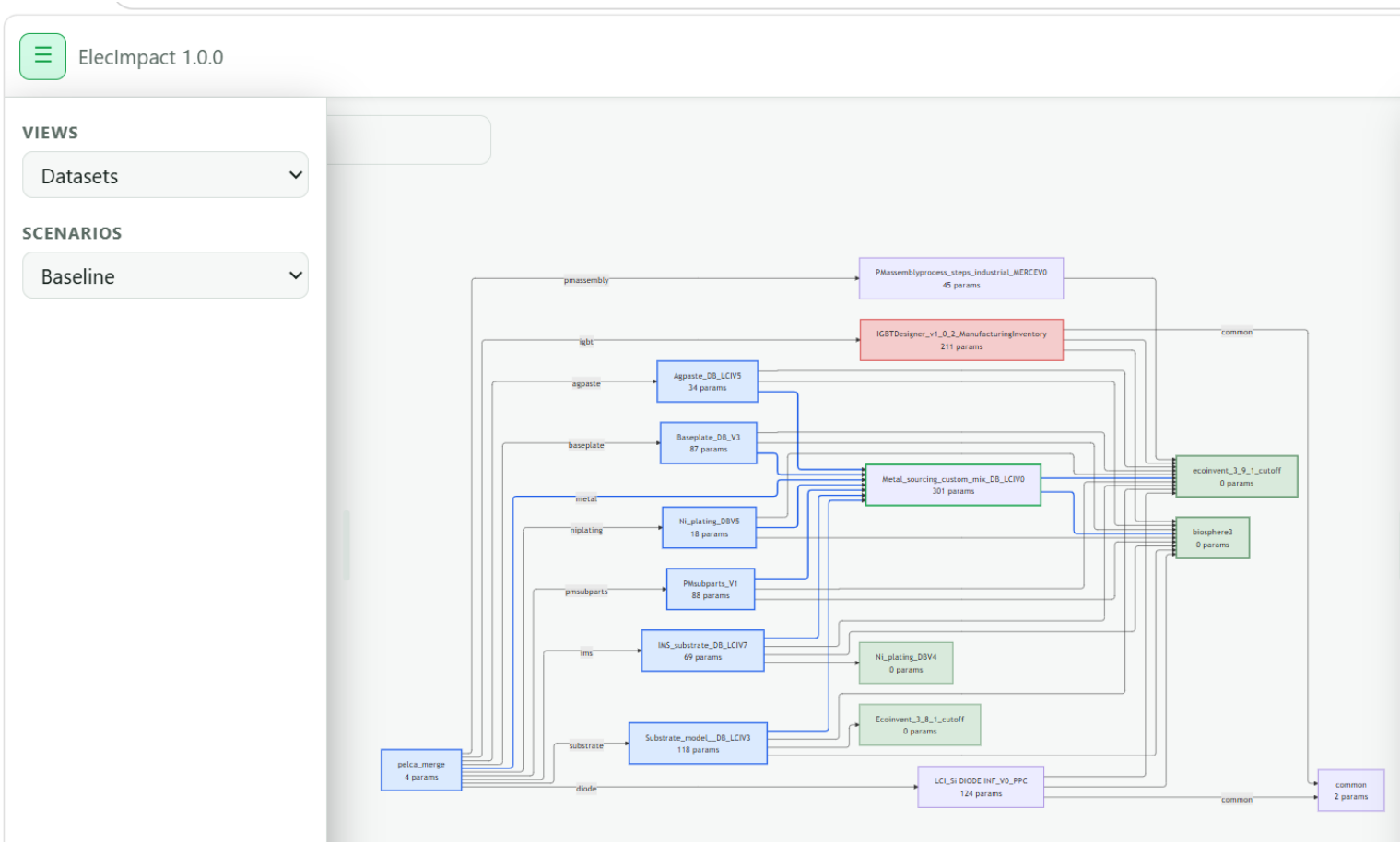
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Demo: Multi-dataset static html export file

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“Augmented” BW export format: new fields with “ei” prefix

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33	Activity	RAW WAFER PRODUCTION (process)												
34	name	RAW WAFER PRODUCTION (process)												
35	reference product	Processed cm² of Si IGBT good die (product)												
36	unit	unit												
37	location	RER												
38	database (process)	IGBT LCI dtb												
39	amount	1												
40	comment	(Unknown)												
41	EI activity parameters													
42	ei_geography (produ	RER												
43	ei_parameters_used	["carbon_dioxide_co2", "carbon_monoxide_co", "hydrogen_h2", "initial_wafer_thickness", "market_for_electricity_medium_voltage", "methane", "nitrous_oxides_nox", "scaling_factor", "silicon_dioxide_sio2", "sulfur_dioxide_so2", "wafer_diameter_dwf", "water_h2o"]												
44	ei_process_uuid (pro	4e798b9cfd604ba702d87a01cd033185												
45	ei_uuid (product)	b732bfb5504783ba60658f77983c2fd6												
46	Exchanges													
47	type	name	amount	unit	databas	referenc	location	categori	ei_external_dataset_node_uuid	ei_exter	ei_proce	ei_uuid		
48	technosphere	market for electricity, medium v	0,49457923	kilowatt hour	ecoinve	electricit	JP				f8c8122	2fe7c85476dc6c1298d32a1852d78159		
49	technosphere	market for silica sand (process)	0,0062549	kilogram	ecoinve	silica sa	GLO				8011d73	38ec58b9844ab3ed92a811ea2f2ee7da		
50	technosphere	market for wood chips, dry, mea	0,0023485	kilogram	ecoinve	wood ch	RoW				f8097da	172074e8bd95462077388f5c1346732c		
51	technosphere	market for petroleum coke (proc	0,00076733	kilogram	ecoinve	petroleu	GLO				fa7657	3b3b99d98cd864d743851a9e41d05b35		
52	technosphere	market for graphite (process)	0,00020927	kilogram	ecoinve	graphite	GLO				36621e	280088e22d86edba7941cbfac65464a0		
53	technosphere	market for hydrochloric acid, wi	0,00867316	kilogram	ecoinve	hydroch	RoW				6bbcde	215fd82c34e9c37b43da28f943ad23b2		
54	biosphere	Carbon dioxide, non-fossil (bio	0,01069612	kilogram	biosphere3			('air')	f8ac66aea40176e34f9c612917bbde28	{"title": "I	f8ac66a	f8ac66aea40176e34f9c612917bbde28_product		
55	biosphere	Carbon monoxide, non-fossil (b	0,00021392	kilogram	biosphere3			('air')	b0009b93c8df8daaa7b5fe8f5e2584a5	{"title": "I	b0009b	b0009b93c8df8daaa7b5fe8f5e2584a5_product		
56	biosphere	Nitrogen oxides (biosphere)	1,7672E-05	kilogram	biosphere3			('air')	822a9a1cd80726e78c57784840fdd7df	{"title": "I	822a9a	822a9a1cd80726e78c57784840fdd7df_product		
57	biosphere	Methanol (biosphere)	0,00010929	kilogram	biosphere3			('air')	079876ad4e2b64f2ea5058f27087f2fe	{"title": "I	079876	079876ad4e2b64f2ea5058f27087f2fe_product		
58	biosphere	Methane, non-fossil (biosphere	8,8359E-05	kilogram	biosphere3			('air')	fb3eb1349fa30054af33fe7fbc5b987c	{"title": "I	fb3eb13	fb3eb1349fa30054af33fe7fbc5b987c_product		
59	biosphere	Ethane (biosphere)	3,7204E-05	kilogram	biosphere3			('air')	f8290e4807758e5d87648babec0d8c12	{"title": "I	f8290e4	f8290e4807758e5d87648babec0d8c12_product		
60	biosphere	Water (biosphere)	2,4183E-06	cubic meter	biosphere3			('air')	c90e473fe49925276b4acfee3e9dc04e	{"title": "'	c90e47	c90e473fe49925276b4acfee3e9dc04e_product		
61	biosphere	Sulfur dioxide (biosphere)	4,418E-05	kilogram	biosphere3			('air')	93234a4b2a6f4d6078adc9ed74dda7c4	{"title": "'	93234a	93234a4b2a6f4d6078adc9ed74dda7c4_product		
62	biosphere	Hydrogen (biosphere)	0,00016044	kilogram	biosphere3			('air')	49b693e8d9aa6cf9a3e37d9783a319cb	{"title": "I	49b693	49b693e8d9aa6cf9a3e37d9783a319cb_product		
63	biosphere	Silicon dioxide (biosphere)	2,0927E-05	kilogram	biosphere3			('water',	e39be372418955f342555da45617d553	{"title": "'	e39be3	e39be372418955f342555da45617d553_product		
64	production	RAW WAFER PRODUCTION (pr	1	unit	IGBT LC	Process	RER							
65	EI formulas													
66	ei_formula_scope	ei_formula_exchange_index	exchange typ	exchange name	exchang	exchang	uuid	name	formula	paramet	paramet	node_	node_	parameter_in
67	exchange	0	technosphere	market for electricity, medium v	electricit	ecoinve	90218c	auto-g	((((market_for_electricity_medium_voltage)*(((initial_wafer_thickness)*((3.1415926535897	ef_thise	child	Unkn	Unkn	["initial_wafer_thickness", "market_for_electricity_medium_voltage", "scaling_factor", "wafe
68	exchange	1	technosphere	market for silica sand	silica sa	ecoinve	f132d84	auto-g	(((26.9)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/1000)/	ef_thise	child	Unkn	Unkn	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
69	exchange	2	technosphere	market for wood chips, dry, me	wood ch	ecoinve	98f4771	auto-g	(((10.1)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/1000)/2	ef_thise	child	Unkn	Unkn	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
70	exchange	3	technosphere	market for petroleum coke	petroleu	ecoinve	fcea4bc	auto-g	(((3.3)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/1000)/2	ef_thise	child	Unkn	Unkn	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
71	exchange	4	technosphere	market for graphite	graphite	ecoinve	62e27f	auto-g	(((0.9)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/1000)/2	ef_thise	child	Unkn	Unkn	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
72	exchange	5	technosphere	market for hydrochloric acid, w	hydroch	ecoinve	81e3f71	auto-g	(((37.3)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/1000)/	ef_thise	child	Unkn	Unkn	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
73	exchange	6	biosphere	Carbon dioxide, non-fossil		biosphe	03f988	auto-g	(((carbon_dioxide_co2)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diame	ef_thise	child	Unkn	Extern	["carbon_dioxide_co2", "initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
74	exchange	7	biosphere	Carbon monoxide, non-fossil		biosphe	c4e416	auto-g	(((carbon_monoxide_co)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_dian	ef_thise	child	Unkn	Extern	["carbon_monoxide_co", "initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"
75	exchange	8	biosphere	Nitrogen oxides		biosphe	7fbf6e6	auto-g	(((nitrous_oxides_nox)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diamet	ef_thise	child	Unkn	Extern	["initial_wafer_thickness", "nitrous_oxides_nox", "scaling_factor", "wafer_diameter_dwf"]
76	exchange	9	biosphere	Methanol		biosphe	2ce415	auto-g	(((0.47)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/1000)/	ef_thise	child	Unkn	Extern	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
77	exchange	10	biosphere	Methane, non-fossil		biosphe	6f84d16	auto-g	(((methane)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/10	ef_thise	child	Unkn	Extern	["initial_wafer_thickness", "methane", "scaling_factor", "wafer_diameter_dwf"]
78	exchange	11	biosphere	Ethane		biosphe	6f7ad9f	auto-g	(((0.16)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/1000)/2	ef_thise	child	Unkn	Extern	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
79	exchange	12	biosphere	Water		biosphe	74d785	auto-g	(((water_h2o)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dwf))/	ef_thise	child	Unkn	Extern	["initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf", "water_h2o"]
80	exchange	13	biosphere	Sulfur dioxide		biosphe	0bfa43f	auto-g	(((sulfur_dioxide_so2)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diamete	ef_thise	child	Unkn	Extern	["initial_wafer_thickness", "scaling_factor", "sulfur_dioxide_so2", "wafer_diameter_dwf"]
81	exchange	14	biosphere	Hydrogen		biosphe	e7dc5c	auto-g	(((hydrogen_h2)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diameter_dw	ef_thise	child	Unkn	Extern	["hydrogen_h2", "initial_wafer_thickness", "scaling_factor", "wafer_diameter_dwf"]
82	exchange	15	biosphere	Silicon dioxide		biosphe	672ccc	auto-g	(((silicon_dioxide_sio2)*(((initial_wafer_thickness)*((3.141592653589793)*((((wafer_diame	ef_thise	child	Unkn	Extern	["initial_wafer_thickness", "scaling_factor", "silicon_dioxide_sio2", "wafer_diameter_dwf"]

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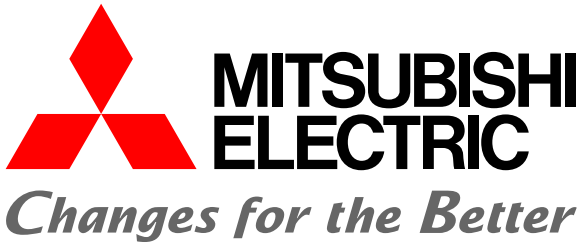
Final words: Towards the notion of « middleground » system ?

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- **Foreground system**: specific to and controlled by the system under study.
- **Background system**: often an external database, outside the direct control of the study.
- Shared foreground systems ➔ **« middleground » system** for someone else's study?

ElecImpact aims at contributing to the collaborative management of « middleground » systems.

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