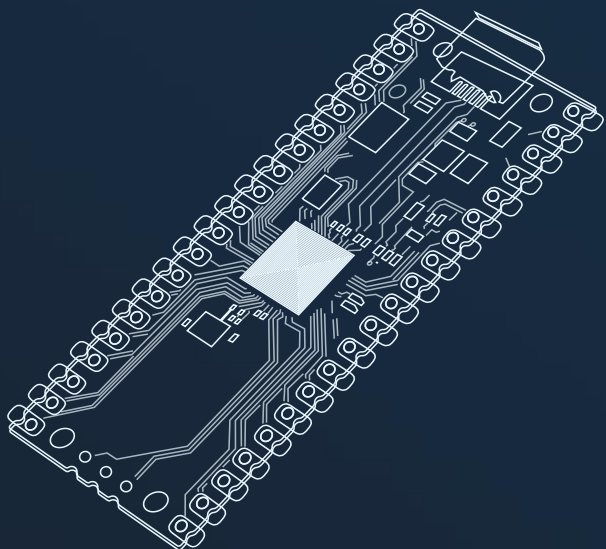
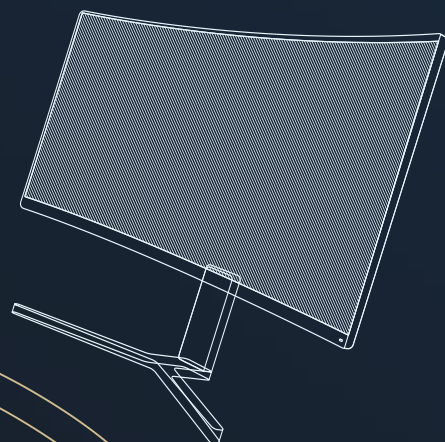
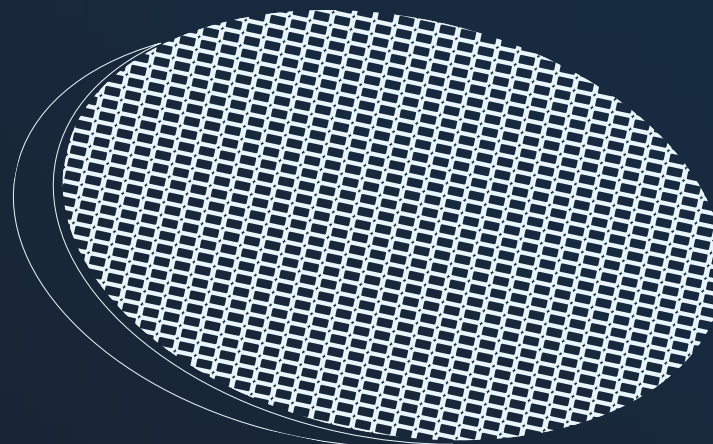


Parametric LCA as a collaboration layer:
bring your expertise, leave the complexity!



Thibault Simon

thibault.simon@resilio-solutions.com





Context



naKnow addresses the lack of transparent, reliable, and actionable environmental intelligence for electronic components.



Eco-design and responsible innovation suffer from this situation:

- Limited access to high-quality, component-level data
- Information that is often outdated or incomplete
- Knowledge that is fragmented and difficult to mobilize

naKnow Association



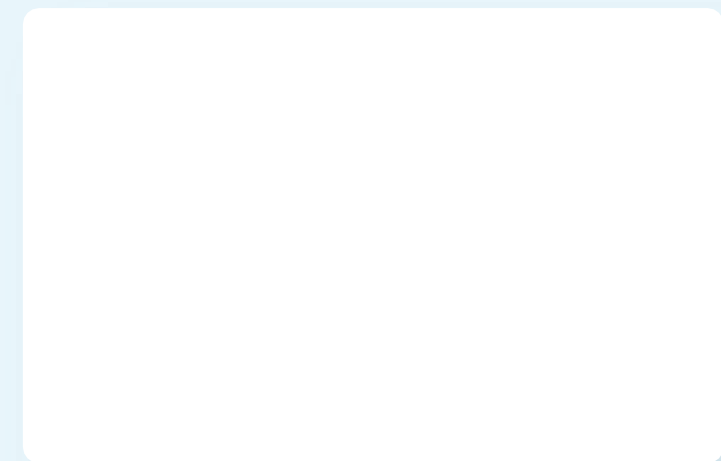
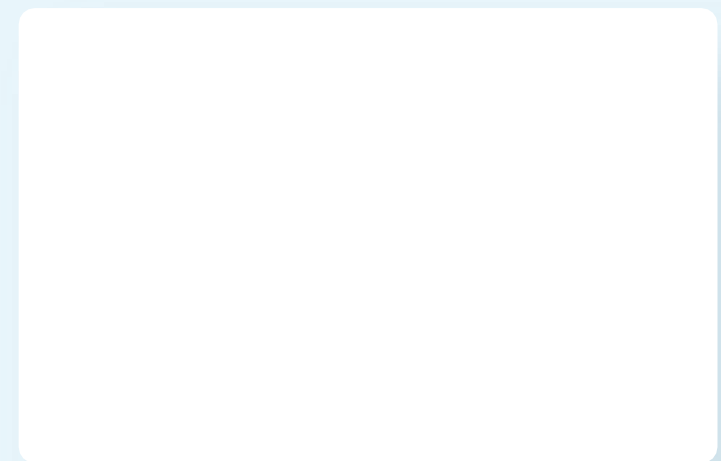
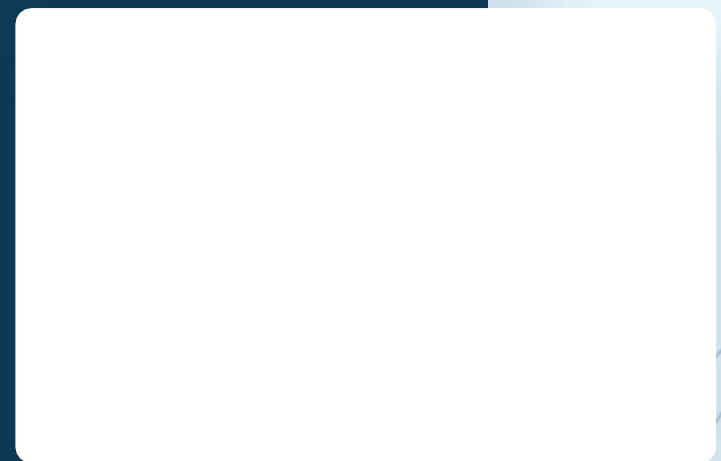
01 ASSOCIATION GOVERNANCE

A board with diverse representation



02 OPEN KNOWLEDGE BASE

Reviewed and traceable knowledge



Overview of the Method



LITERATURE
RESEARCH



EXISTING
MODELS



PARAMETRIC
LCA MODELS



LABORATORY
EXPERIMENTS

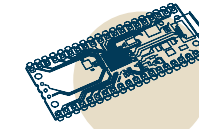
support

comparison

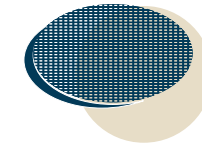
testing

correction

Five components



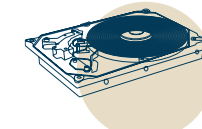
Printed Circuit Board



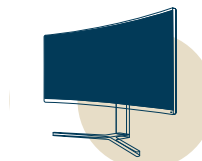
Integrated Circuits



Optical Sensors



Hard Disk Drive



Screens

From unstructured data...



PCB specialisation

The specialisation of the PCBs ⁴⁾ refers to categories of PCBs with a specific need, thus requiring specific properties.

- **High temperature:** It is the type of PCB required when the component is exposed to very high temperatures or is assembled with high temperature technologies. The substrate is made of specific high glass transition temperature that remain stable under high temperature.
- **Heavy copper:** this PCBs contains a high thickness of copper. It is used for application where current is high in order to avoid voltage drops, overheating and limit current loss. It is selected for power converters, power distribution or battery management systems.
- **High frequency:** it is used for application where a high frequency of interconnection is required and thus must ensure signal integrity and minimize signal loss and distortion. The substrates are made of hydrocarbon ceramics or modified epoxies in such cases. It is used for high-frequency systems like 5G/6G antennas, radar systems or communication system of satellites.
- **Metal core:** This kind of PCB contains a metal core, in addition to copper traces. The metal core, often made of aluminium, helps to dissipate heat for component with high power like LEDs or power transistors.
- **High Density Interconnect (HDI):** The high-density interconnect PCBs aim at concentrate a high density of interconnections between several components. It is possible thanks to burried vias and micro-vias, in addition to through-hole vias, as displayed in [Figure 2](#). The drills are performed using laser drillers. It is mainly used for compact devices, smarhones and high-end equipment (servers...).
- **Substrate-like PCB ⁵⁾:** This kind of PCBs embeds even more dense interconnections with very thin traces than HDI PCBs. Its manufacturing process is highly inspired from IC industry. It requires semi-additive process for plating steps and UV laser direct imaging technology to maintain very thin interconnections. This is particularly useful for high-perfomance components with a high compactivity like high-end smartphones.
- **Standard PCB:** The standard PCB structure is usually made of FR4 substrate. It is employed when none of the previously mentioned specialization are required.

Assembly technologies

Once the bare PCB is manufactured, elements to be interconnected need to be assembled on top of it. Among the elements that populates PCBs, we can find CPU sockets RAM slots but also capacitors, resitances. The PCB can be populated according to two technologies ⁶⁾:

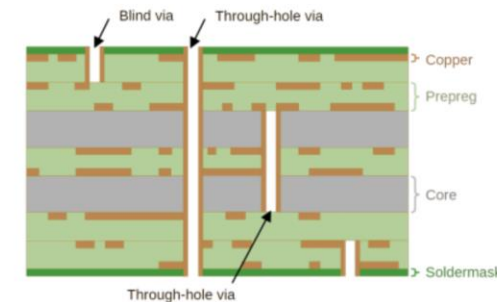


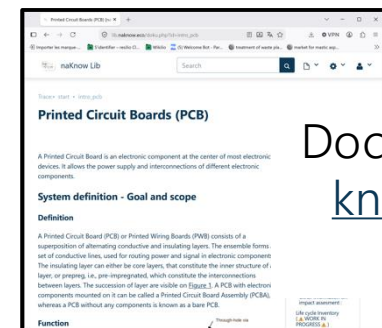
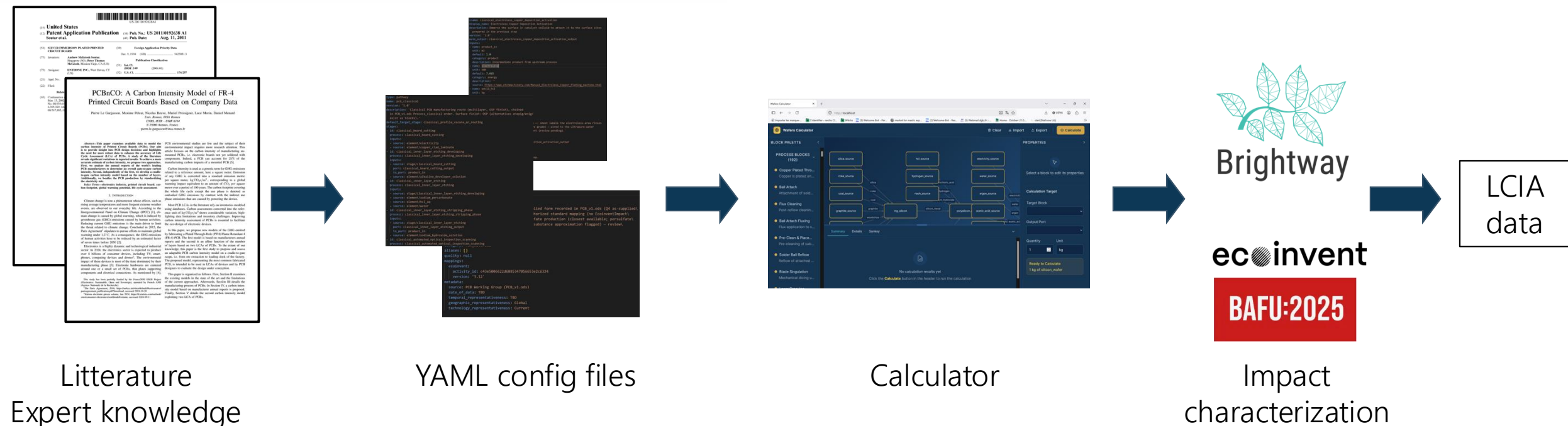
Figure 2: The structure of an example High Density Interconnect board, including blind and burried vias

Table of Contents

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 - Market overview
 - Perimeter
 - Functional unit and reference flows
 - State of the art: environmental impacts
 - Other information on impact assesment :
 - Life cycle Inventory (WORK IN PROGRESS)
 - Raw materials
 - Manufacturing
 - Next steps
 - Bibliography
 - Discussion

<https://lib.naknow.eco/>

...to LCIA data, at scale!



Documented in the knowledge base



Why this approach?



- **A co-owned modeling process:** Enable non-LCA experts to contribute and review results
- **Collaboration:** Model a process once, share it, re-use it and improve it!
- **Parametric & scalable LCA:** Automate calculations across scenarios and models with a reproducible parameter space
- **Version control:** Track changes to models, data, and results
- **Data confidentiality:** Publish the logic to audit the process, not all the data
- **Background DB:** Ease the change of background DB, centralize mappings

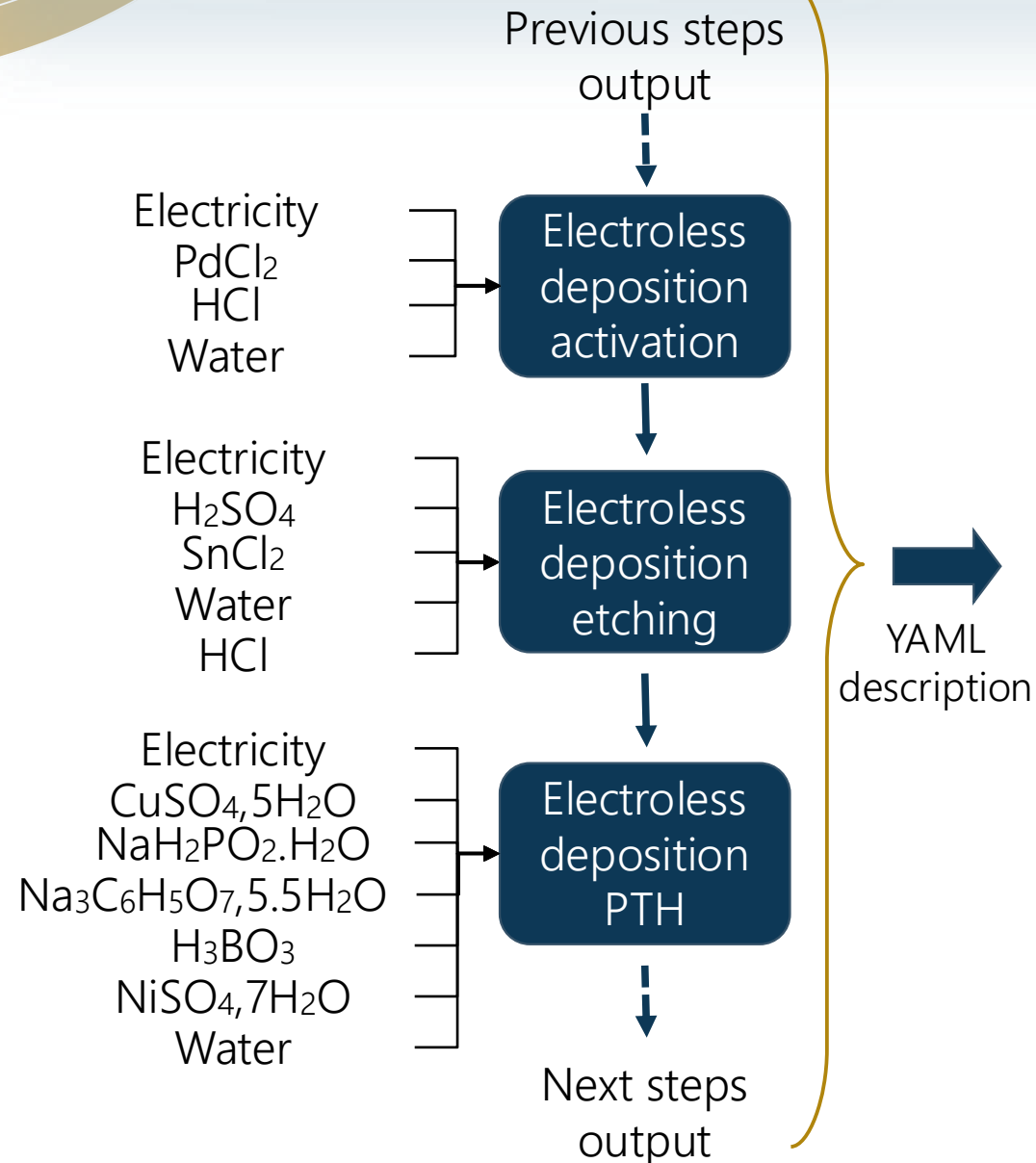


HOW DOES THIS COLLABORATIVE APPROACH ACTUALLY WORK?





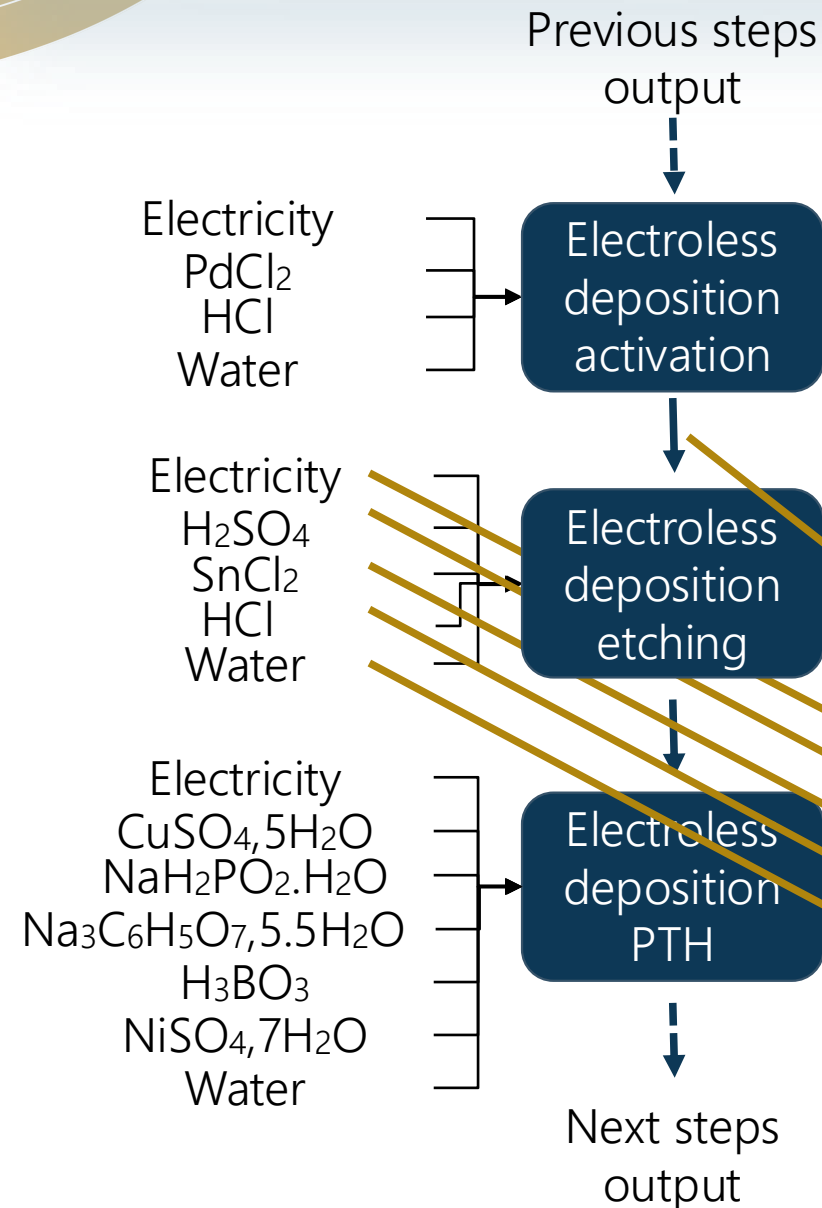
A structured format



```
parameters:
  pcb_surface:
    type: float
    unit: mm
    required: true
    default: 150
    min: 30
    max: 10000
default_target_stage: classical_profile_vscore_or_routing
stages:
- id: classical_electroless_copper_deposition_activation
  process: classical_electroless_copper_deposition_activation
  inputs:
    - source: stage/classical_electroless_copper_deposition_cleaning
    - source: element/electricity
    - source: element/pdcl2
    - source: element/hcl
    - source: element/rinse_water
- id: classical_electroless_copper_deposition_etching
  process: classical_electroless_copper_deposition_etching
  inputs:
    - source: stage/classical_electroless_copper_deposition_activation
    - source: element/electricity
    - source: element/h2so4
    - source: element/sncl2
    - source: element/hcl
    - source: element/rinse_water_1
```



A structured format

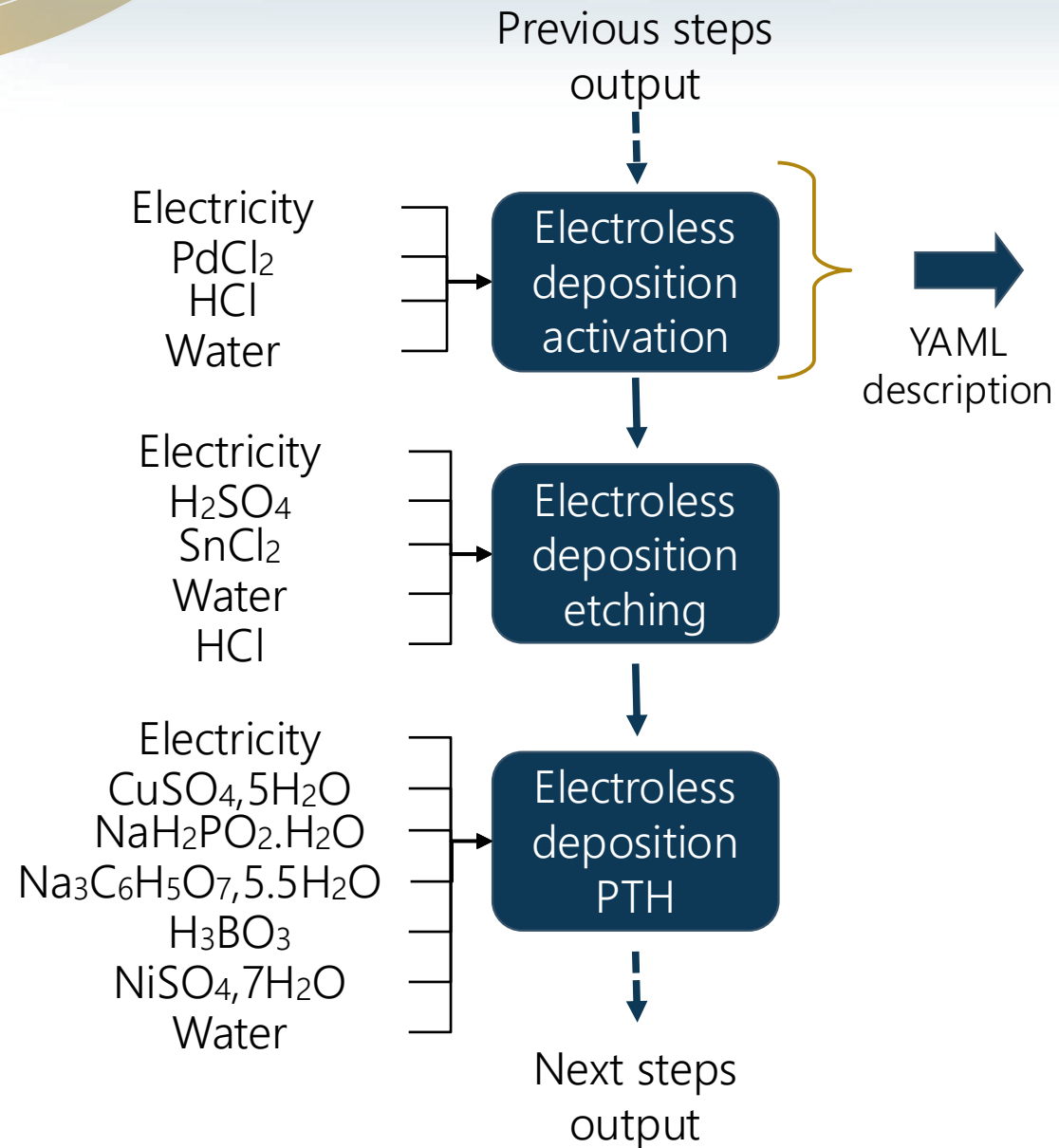


PATHWAYS

Parameter definition

```
parameters:
  pcb_surface:
    type: float
    unit: mm
    required: true
    default: 150
    min: 30
    max: 10000
  default_target_stage: classical_profile_vscore_or_routing
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    - id: classical_electroless_copper_deposition_activation
      process: classical_electroless_copper_deposition_activation
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        - source: element/electricity
        - source: element/pdcl2
        - source: element/hcl
        - source: element/rinse_water
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      process: classical_electroless_copper_deposition_etching
      inputs:
        - source: stage/classical_electroless_copper_deposition_activation
        - source: element/electricity
        - source: element/h2so4
        - source: element/sncl2
        - source: element/hcl
        - source: element/rinse_water_1
```

A structured format

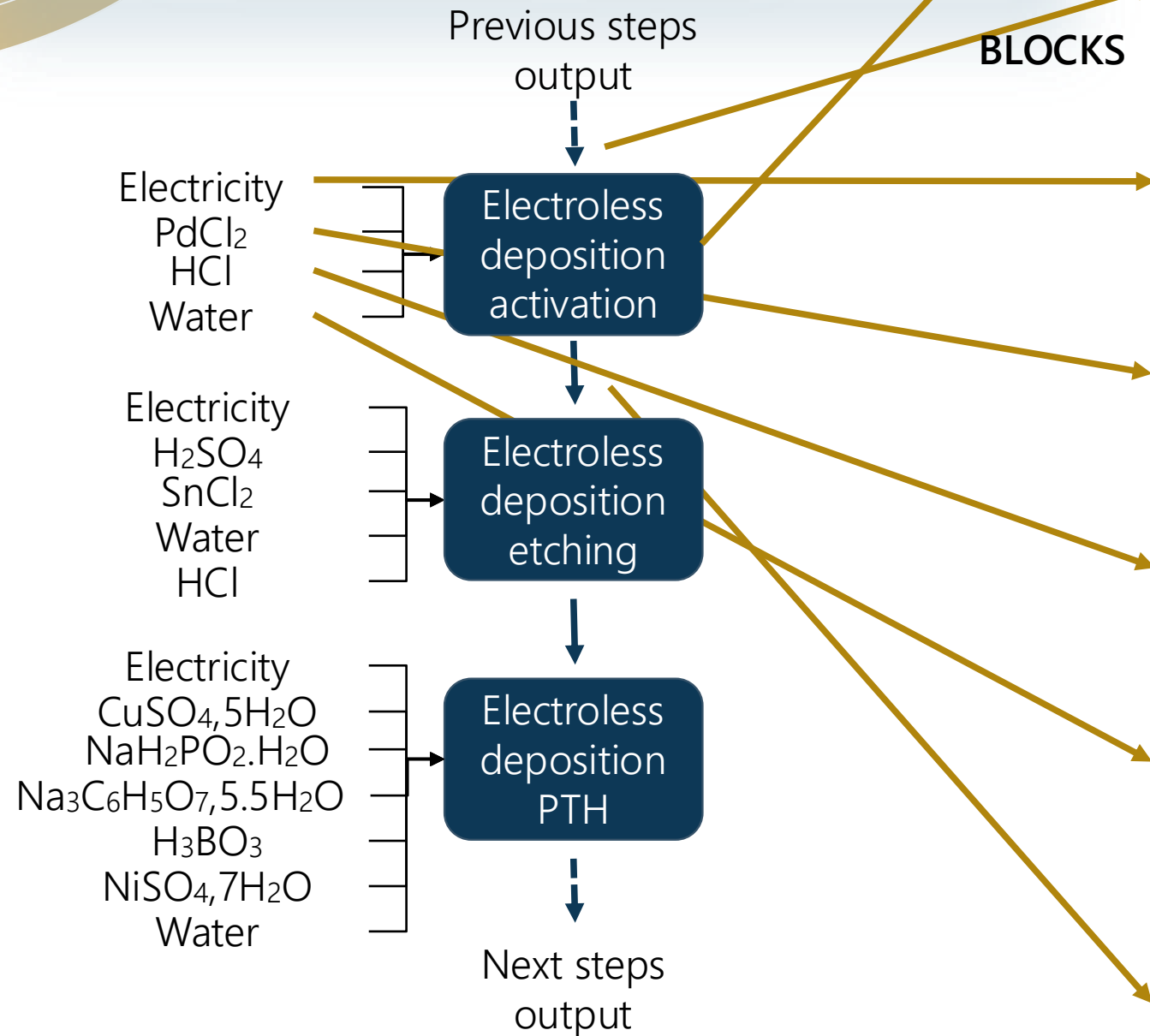


BLOCKS

```
name: electroless_copper_deposition_activation
display_name: Electroless Copper Deposition Activation
description: Immerse the surface in catalyst colloid to
version: '1.0'
main_output: electroless_copper_deposition_activation_o
inputs:
- name: product_in
  unit: m2
  default: 1.0
  category: product
  description: Intermediate product from upstream proces
- name: electricity
  unit: kWh
  default: 7.665
  category: energy
  description: ''
  source: https://www.etchmachinery.com/Manual\_Electroless
- name: pdcl2
  unit: kg
  default: '0.0000005*pcb_surface'
  category: raw_material
  description: ''
- name: hcl
  unit: kg
  default: '0.0000005*pcb_surface'
  category: raw_material
  description: ''
- name: rinse_water
  unit: kg
  default: '0.0030113*pcb_surface'
  category: water
  description: ''
  source: Custom computation
outputs:
- name: electroless_copper_deposition_activation_output
  unit: m2
  default: 1.0
  category: product
```



A structured format

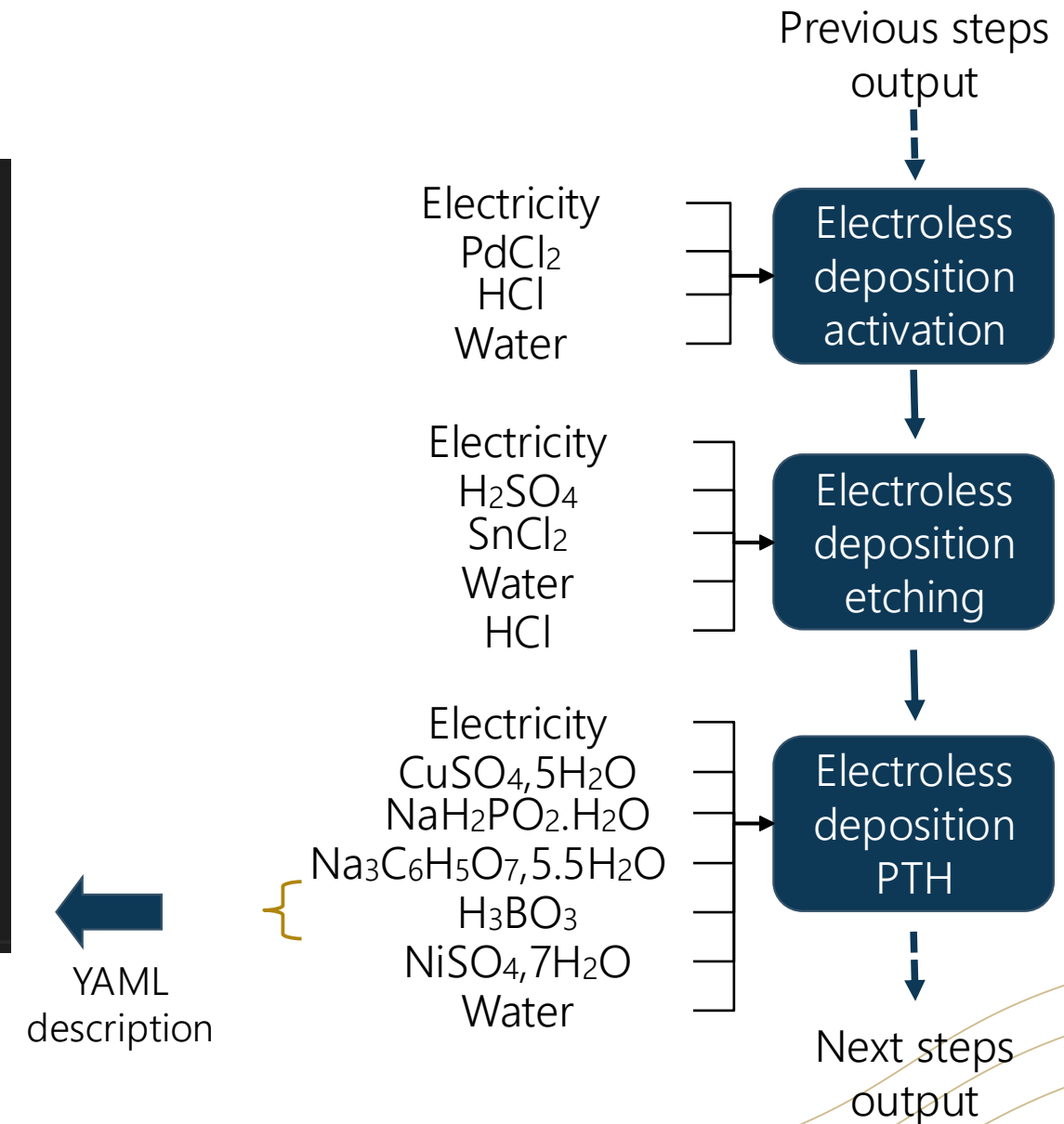


```
name: electroless_copper_deposition_activation
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  category: raw_material
  description: ''
- name: rinse_water
  unit: kg
  default: '0.0030113*pcb_surface'
  category: water
  description: ''
  source: Custom computation
outputs:
- name: electroless_copper_deposition_activation_output
  unit: m2
  default: 1.0
  category: product
```

Parametric
math formula

A thick, yellow, hand-drawn wavy line that spans the width of the page, positioned below the 'QUESTION' section and above the 'ANSWER' section.

```
type: element
name: h3bo3
display_name: H3Bo3
description: "H3Bo3, as-supplied form recorded in PCB_v1.ods (Q4 as-supplied policy)\n\n\
  \ Ecoinvent mapping: activity chosen in PCB_v1.ods (EcoinventImpact sheet) (Q14);\n
  \ the sheet does not record a location, so the geographic variant was selected by\n
  \ the GLO > RoW > RER default policy – review pending."
version: '1.0'
unit: kg
category: raw_material
aliases: []
quality: null
mappings:
  ecoinvent:
    activity_id: 788b1de360201eb68d018e900d9d26b1
    version: '3.12'
metadata:
  source: PCB Working Group (PCB_v1.ods)
  date_of_data: TBD
  temporal_representativeness: TBD
  geographic_representativeness: Global
  technology_representativeness: Current
```





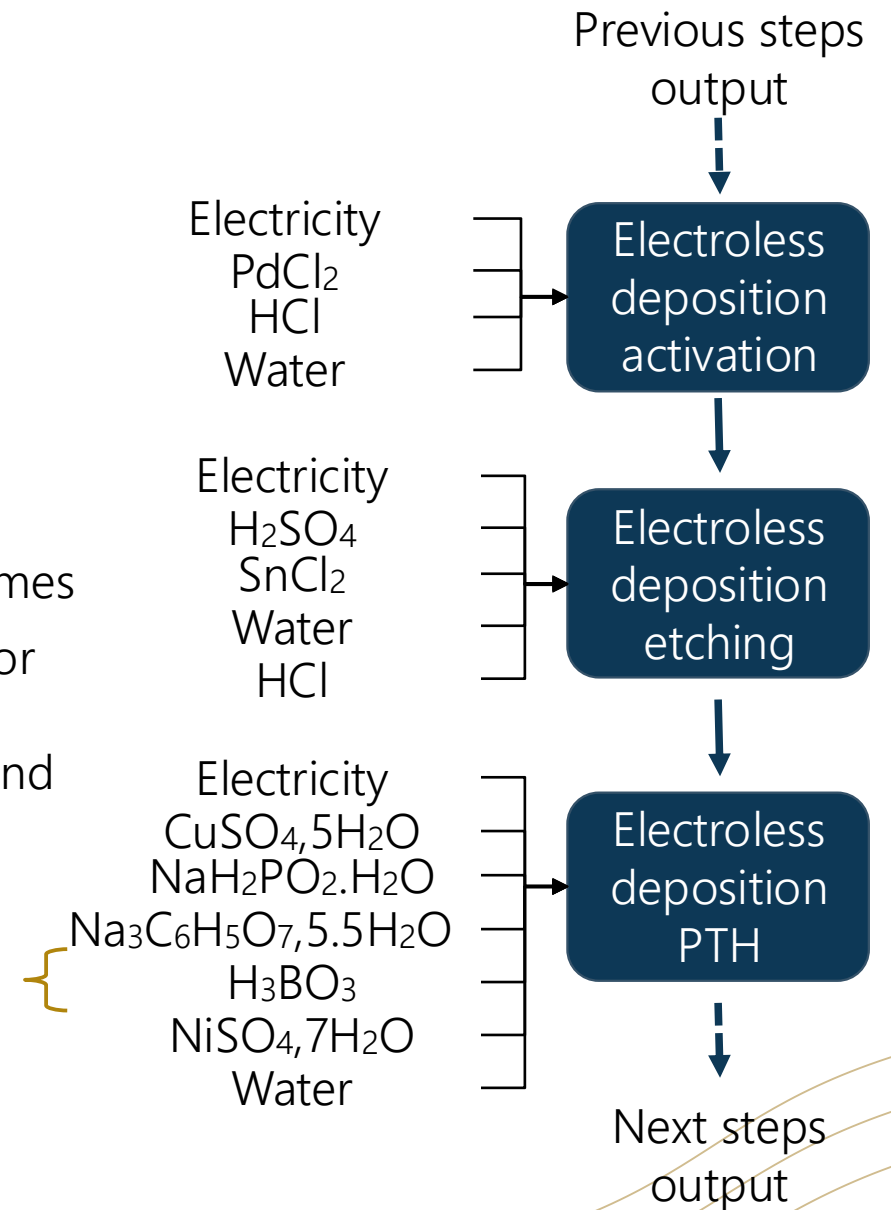
A structured format



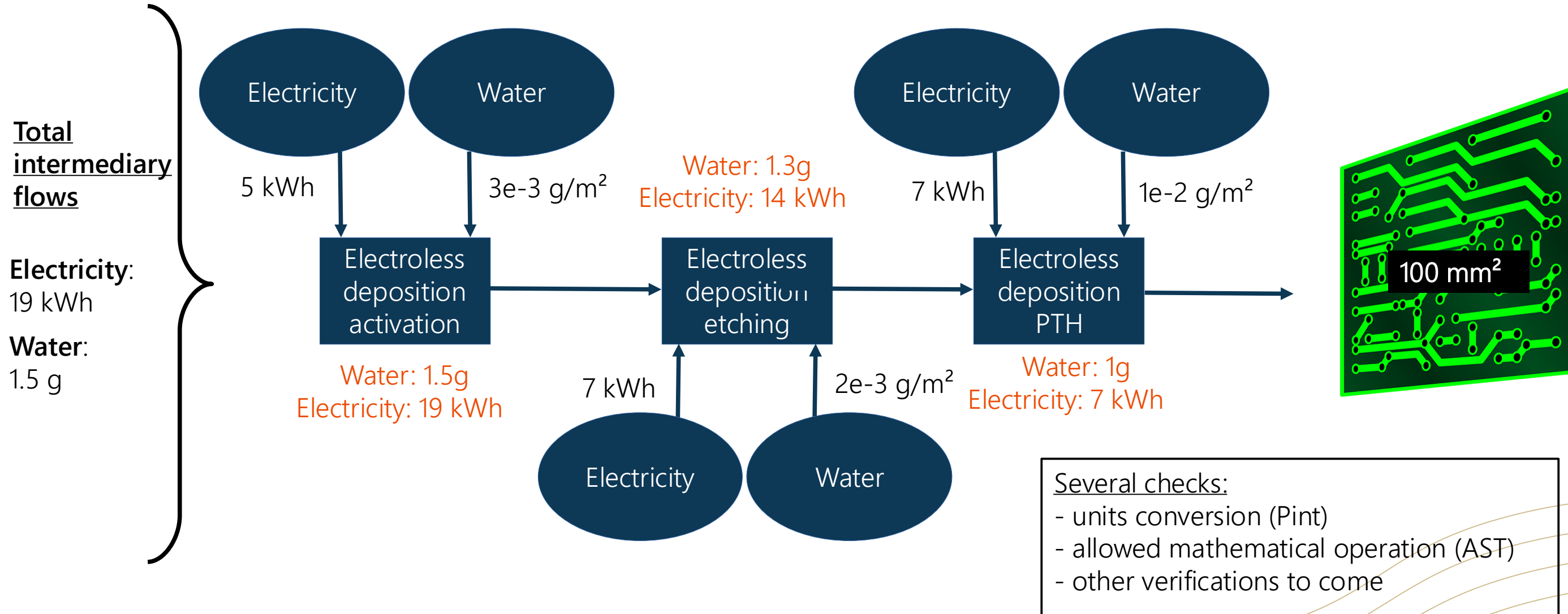
ELEMENTS

```
type: element
name: h3bo3
display_name: H3Bo3
description: "H3Bo3, as-supplied form recorded in PCB_v1.ods (Q4 as-supplied policy)\n\n\
  \ Ecoinvent mapping: activity chosen in PCB_v1.ods (EcoinventImpact sheet) (Q14);\n\
  \ the sheet does not record a location, so the geographic variant was selected by\n\
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version: '1.0'
unit: kg
category: raw_material
aliases: []
quality: null
mappings:
  ecoinvent:
    activity_id: 788b1de360201eb68d018e900d9d26b1
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  date_of_data: TBD
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  geographic_representativeness: Global
  technology_representativeness: Current
```

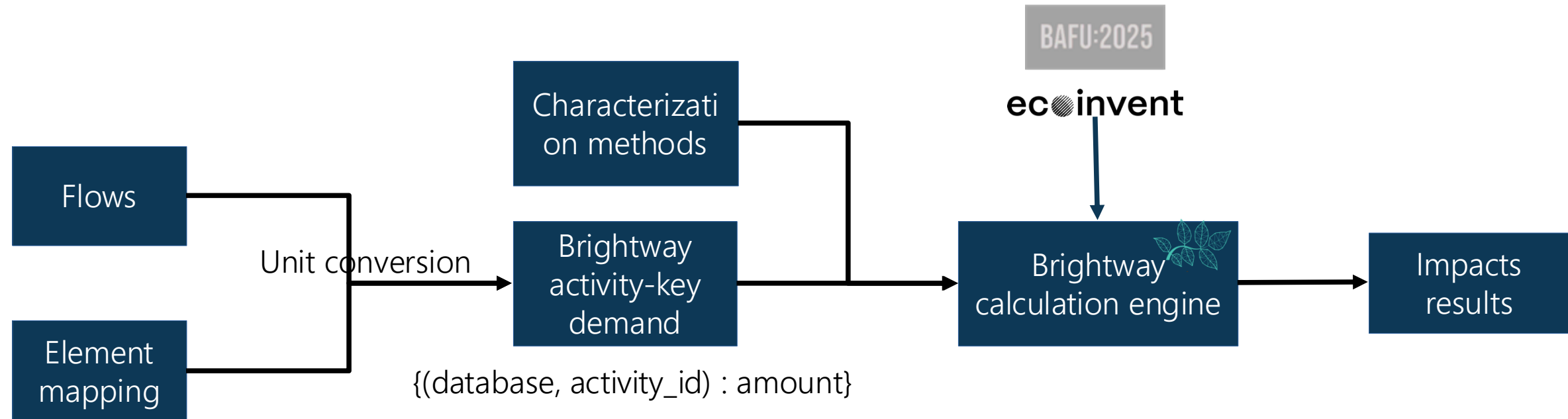
Other names
Dataset for
each
background
database

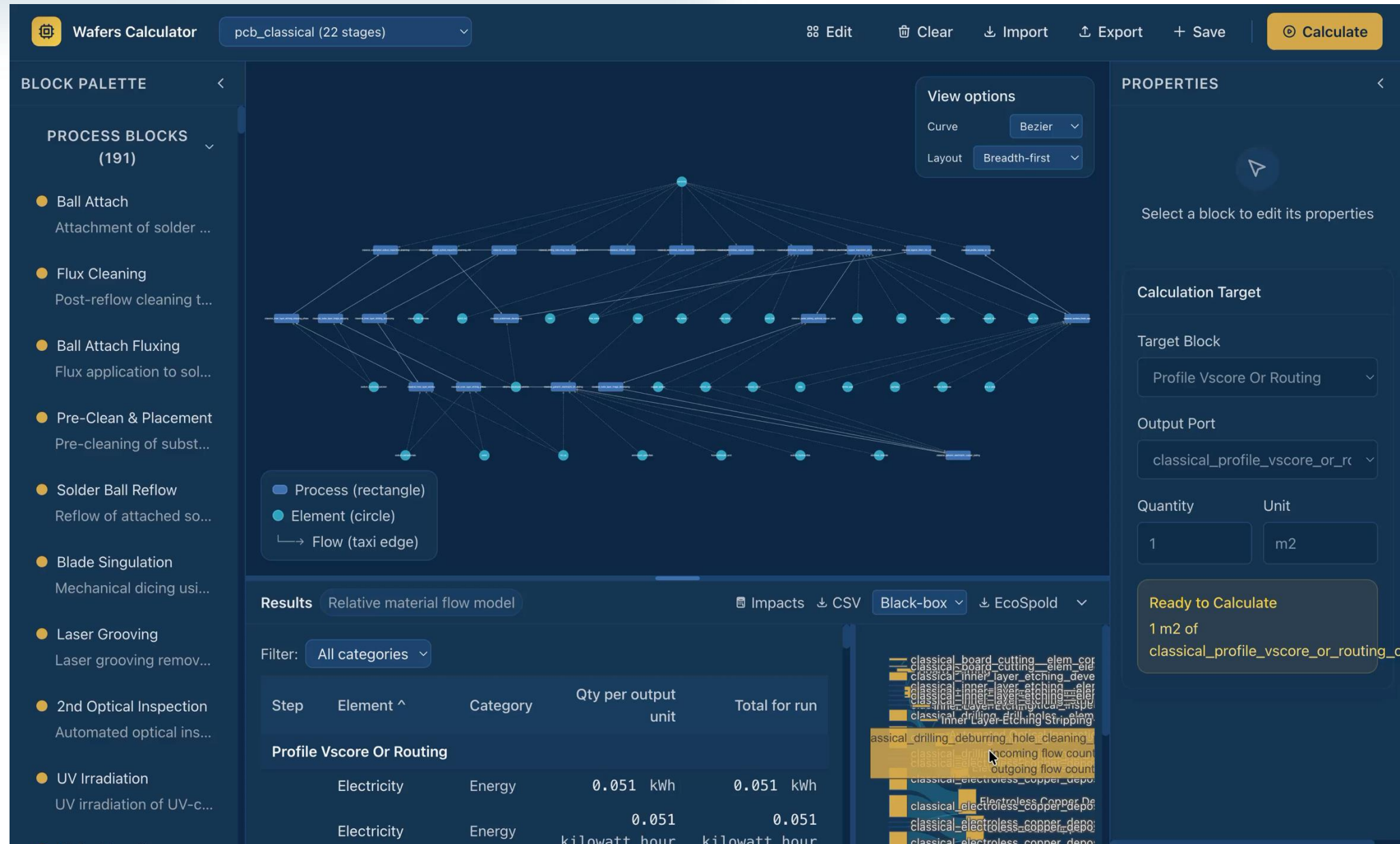


From blocks to results



From blocks to results





Demo time!



Wafers Calculator

backend_flip_chip (47 stages)

Edit

Clear

Import

Export

Save

Calculate

BLOCK PALETTE

PROCESS BLOCKS (191)

Ball Attach

Attachment of solder ...

Flux Cleaning

Post-reflow cleaning t...

Ball Attach Fluxing

Flux application to sol...

Pre-Clean & Placement

Pre-cleaning of subst...

Solder Ball Reflow

Reflow of attached so...

Blade Singulation

Mechanical dicing usi...

Laser Grooving

Laser grooving remov...

2nd Optical Inspection

Automated optical ins...

UV Irradiation

UV irradiation of UV-c...

Process (rectangle)

Element (circle)

Flow (taxi edge)

electricity

lape_pvc

View options

Curve Taxi

Layout Layered

Results

Relative material flow model

Impacts

CSV

Black-box

EcoSpold

wafer_diameter 300

qty 1

kg

Filter: All categories

Step	Element ^	Category
Electrical Testing		
	Electricity	Energy
	Electricity	Energy

Impact Assessment

ecoinvent_cutoff v3.12

Functional unit: testing.testing_electrical_output:1.0kg

global warming potential (GWP100)	35.9974
ozone depletion potential (ODP)	0.0000
comparative toxic unit for human (CTUh)	0.0000
comparative toxic unit for human (CTUh)	0.0000

PROPERTIES

Select a block to edit its properties

Calculation Target

Target Block

Electrical Testing

Output Port

testing_electrical_output

Quantity

1

Unit

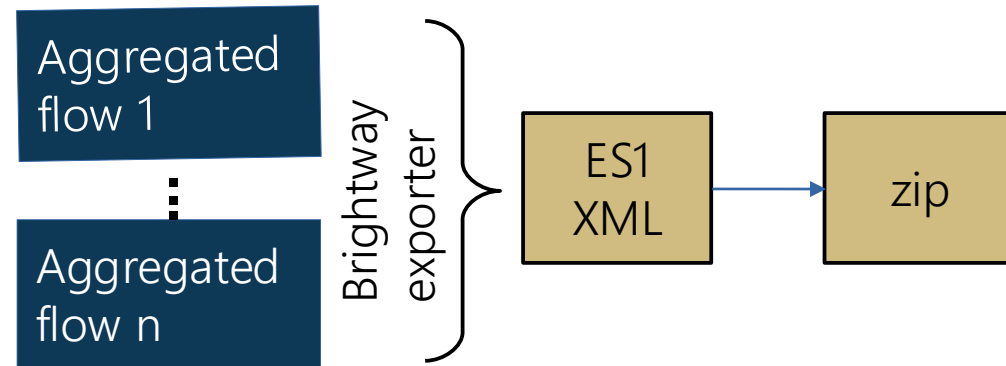
kg

Ready to Calculate

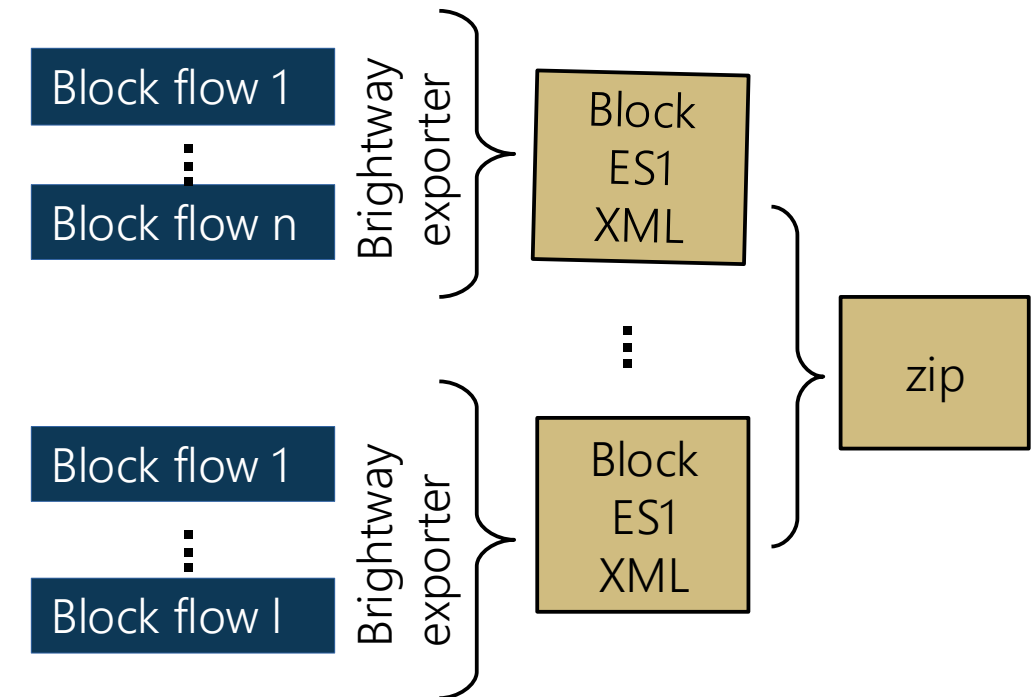
1 kg of testing_electrical_output

Transparent data, while keeping the community's secrets

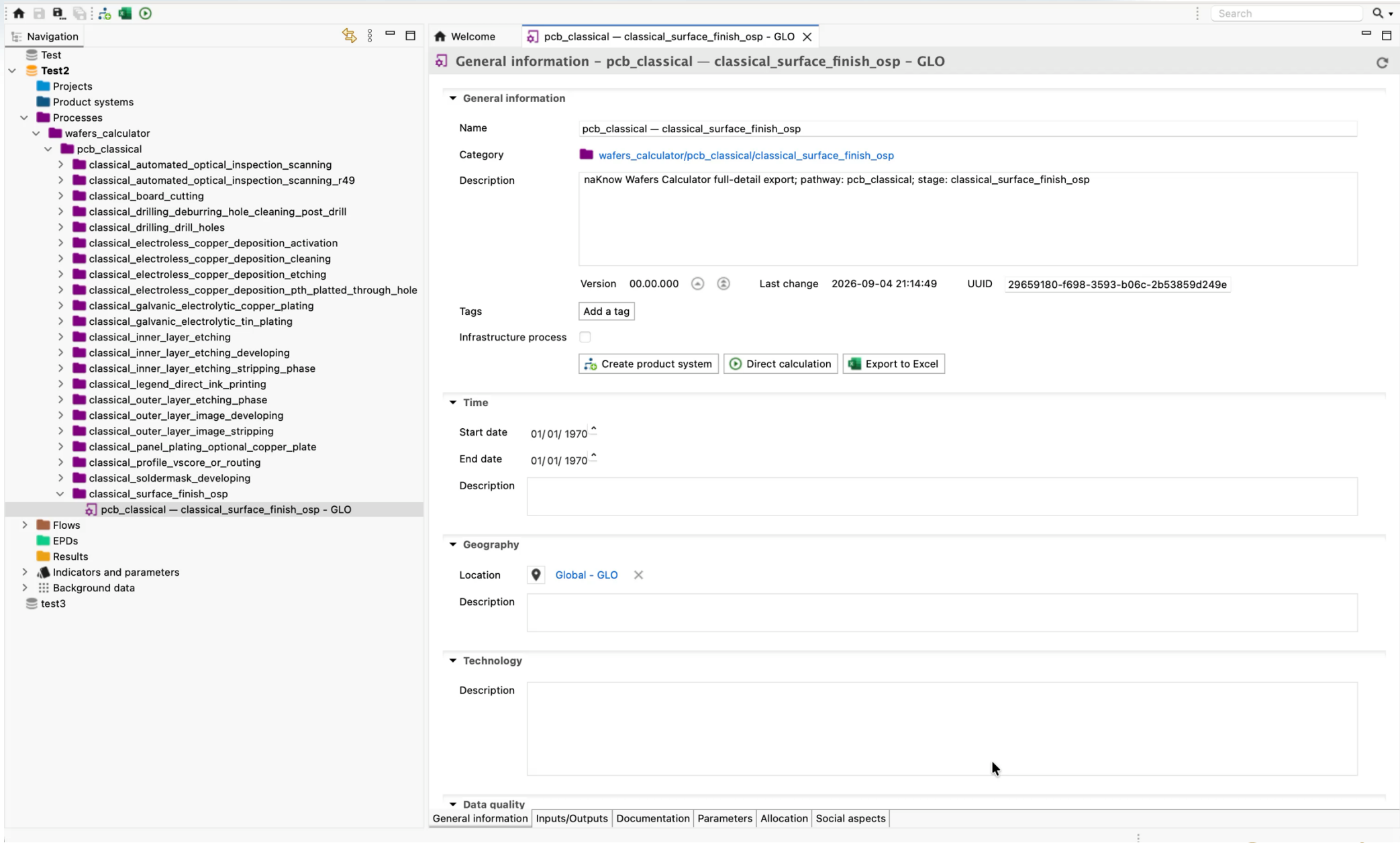
Aggregated export



Disaggregated export



Parametric and at scale, yet well integrated



Collaboration potential



- **Non-LCA experts:** can contribute, build their own models from existing nodes, and compute results
- **Non-programmers:** can build parametric models without coding skills. Conversion from other formats to YAML could be made available.
- **Version control:** Track changes to models, data, and results
- **Auditability:** anyone knowledgeable on the modeled device can review the data, propose changes, or build its own version

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display_name: Electroless Copper Deposition Activation
description: Immerse the surface in catalyst colloid to
version: '1.0'
main_output: electroless_copper_deposition_activation_o
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  unit: kWh
  default: 7.665
  category: energy
  description: ''
source: https://www.etchmachinery.com/Manual\_Electroless
```



Printed Circuit Boards (PCB) [na X]

lib.naknow.eco/doku.php?id=intro_pcb

naKnow Lib

Search

Trace: start • intro_pcb

Printed Circuit Boards (PCB)

A Printed Circuit Board is an electronic component at the center of most electronic devices. It allows the power supply and interconnections of different electronic components.

System definition - Goal and scope

Definition

A Printed Circuit Board (PCB) or Printed Wiring Boards (PWB) consists of a superposition of alternating conductive and insulating layers. The ensemble forms a set of conductive lines, used for routing power and signal in electronic components. The insulating layer can either be core layers, that constitute the inner structure of a layer, or prepreg, i.e., pre-impregnated, which constitute the interconnections between layers. The succession of layer are visible on [Figure 1](#). A PCB with electronics components mounted on it can be called a Printed Circuit Board Assembly (PCBA), whereas a PCB without any components is known as a bare PCB.

Function

Through-hole via

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- Other information on impact assessment :
- Life cycle Inventory (WORK IN PROGRESS)



Conclusion



- Let the community focus on what matters most: not the tool, but building a **transparent, reliable knowledge base, together!**
- Provides **open methodologies** and **tools** for **LCA parametric modelling**
- The **calculator**:
 - ▶ **Graph-based** built from **YAML** format, connected to **Brightway** and different **background databases**
 - ▶ Favors **collaborations** via **human-readable** and **reviewable** by **anyone** input, including non-coders and non LCA experts

Join us!

