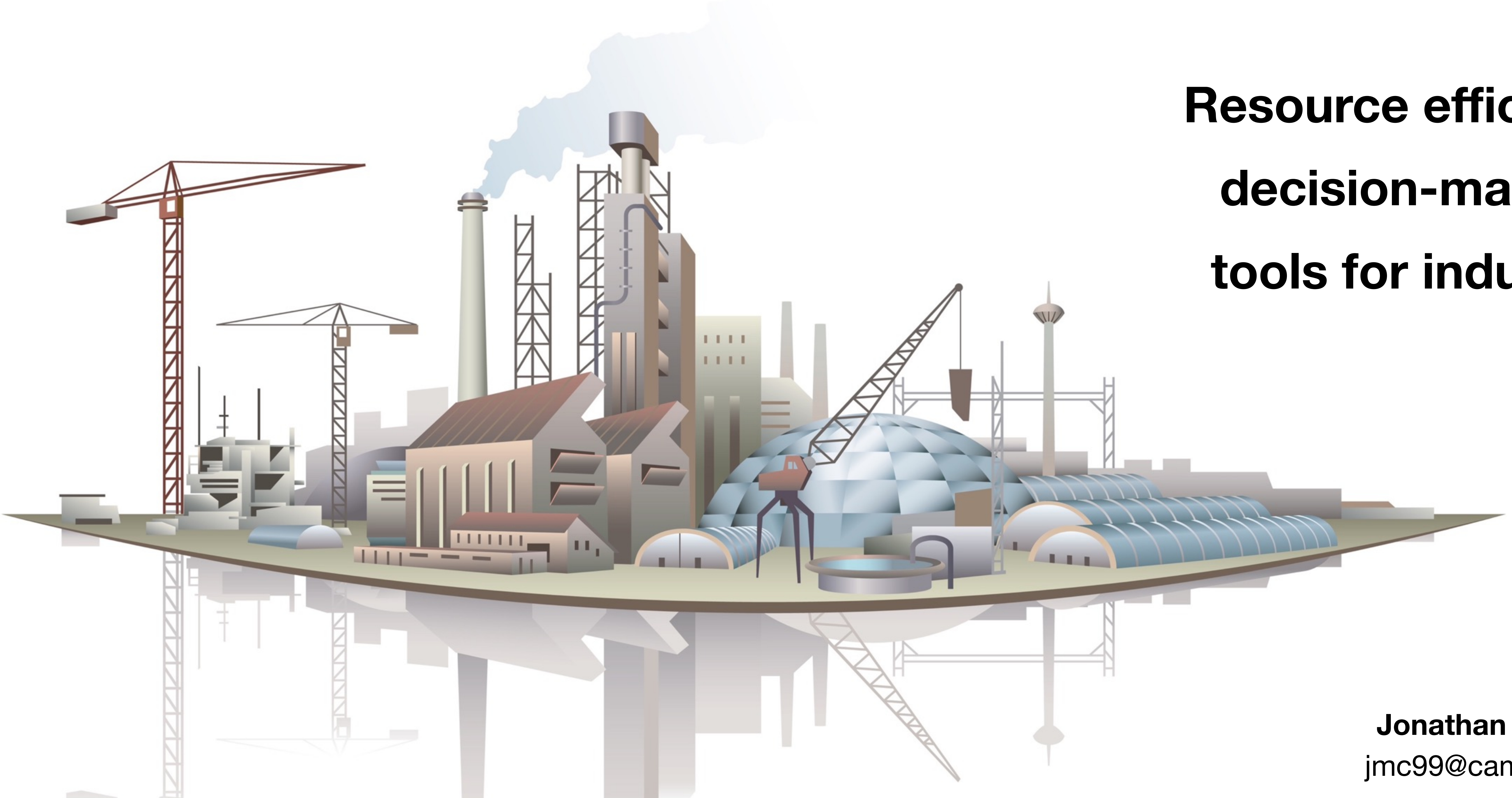


Resource efficient decision-making tools for industry

Jonathan Cullen
jmc99@cam.ac.uk

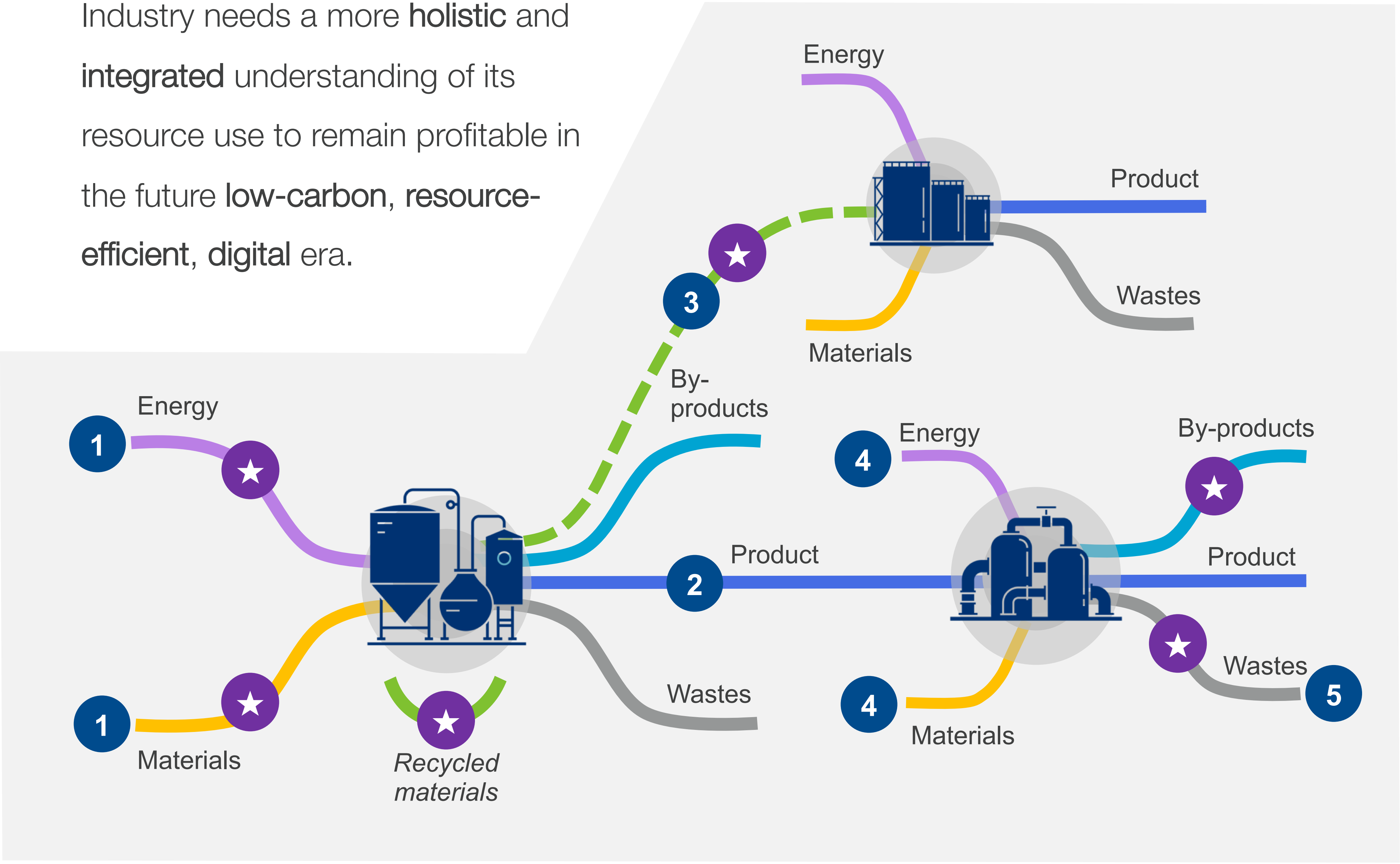
Ana Gonzalez Hernandez
Charalampos Michalakakis

UNIVERSITY OF CAMBRIDGE

Advances in Process Automation and Control 2019
IChemE, Manchester, 18-20 Nov 2019

Resource efficiency in industry

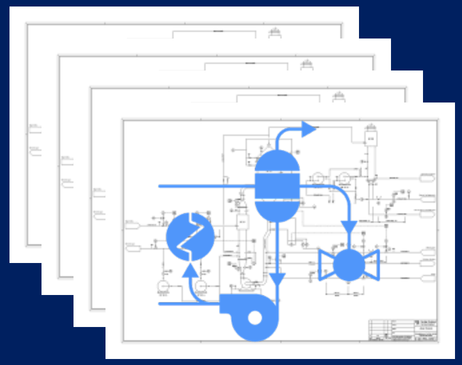
Industry needs a more **holistic** and **integrated** understanding of its resource use to remain profitable in the future **low-carbon**, **resource-efficient**, **digital** era.

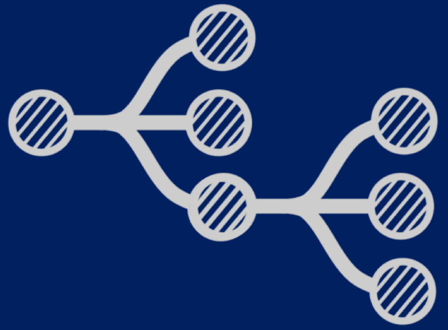


1. **Energy and materials are input into a process**
2. **Main product is then fed into a subsequent process**
3. **By-products are fed as inputs into a third process**
4. **Energy and materials are input to further process main product**
5. **Large investments have been made – lost if material is wasted at this stage**

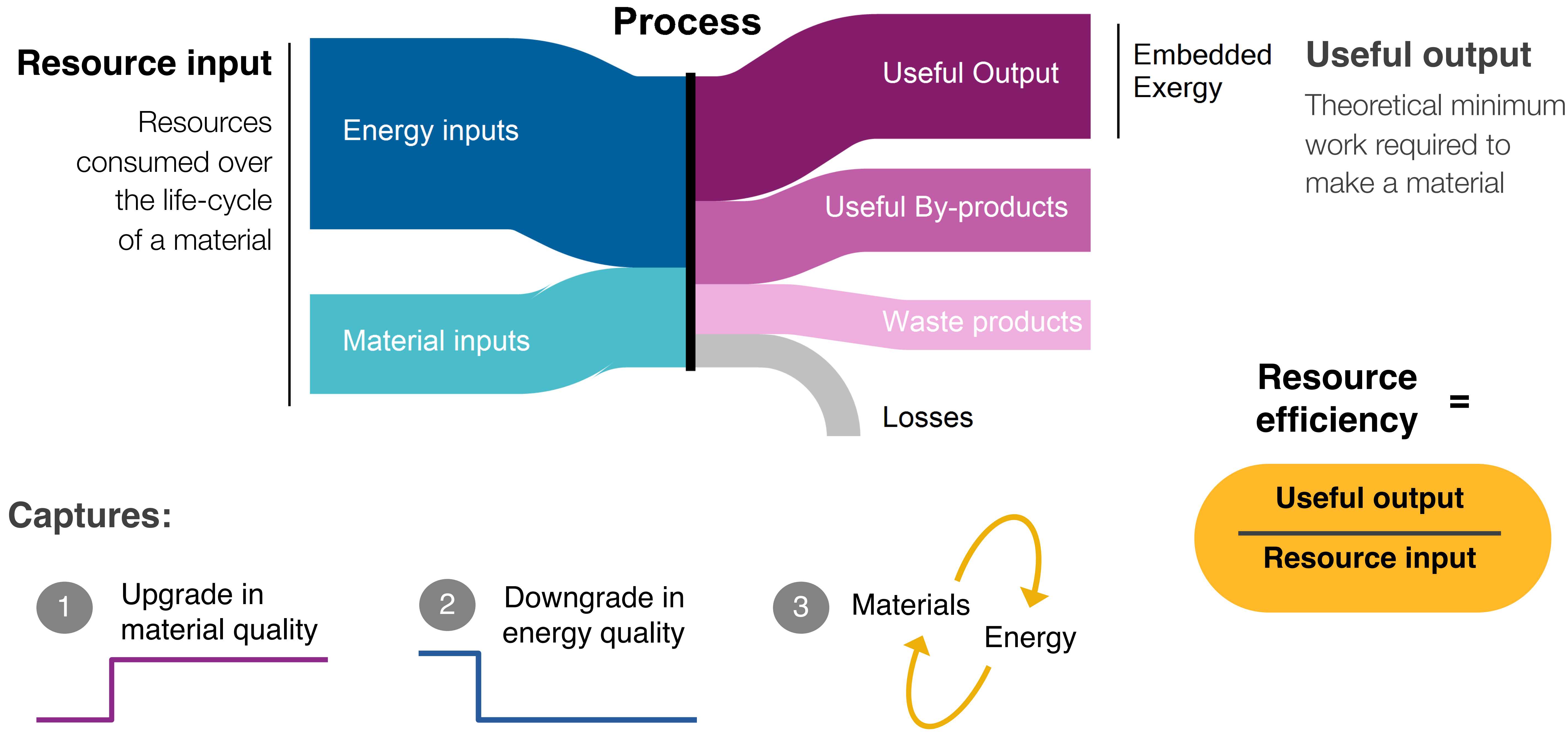
- **Reduce raw material inputs**
- **Reduce process fuel inputs**
- **Recover resource by-products**
- **Reduce resource wastes**
- **Reduce resulting internal recycling**

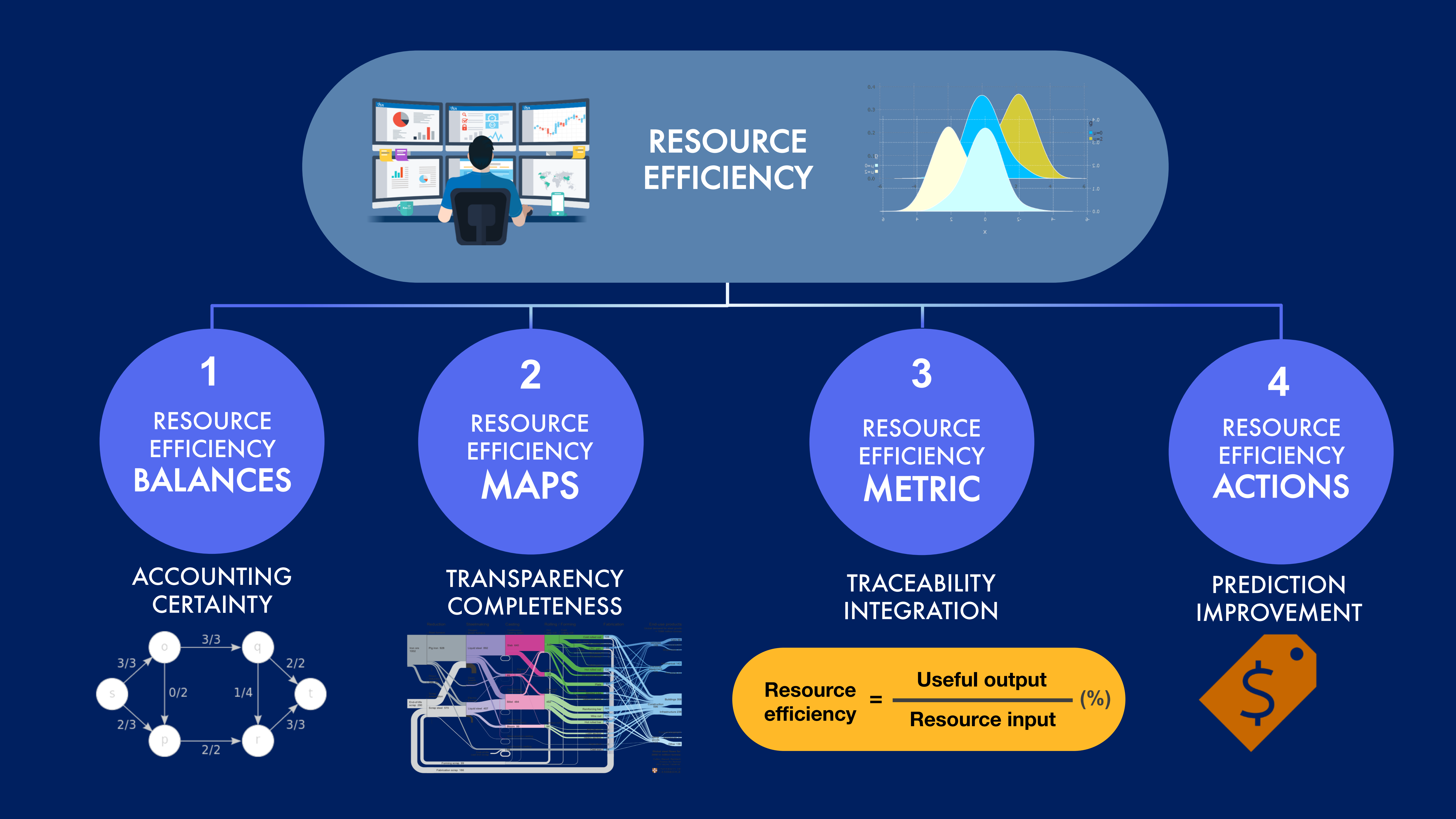
CURRENT		ASPIRATION
ENERGY EFFICIENCY ANALYSIS OF UNITS	→	RESOURCE EFFICIENCY ANALYSIS OF SITES
COMPLEX SYSTEM MODELS REQUIRING EXPERTISE	→	AUTOMATED, PRAGMATIC SYSTEM ANALYSIS
OPAQUE, LEVEL-SPECIFIC PERFORMANCE INDICATORS	→	SCALABLE, TRANSPARENT PERFORMANCE MEASUREMENT





Resource efficiency in industry

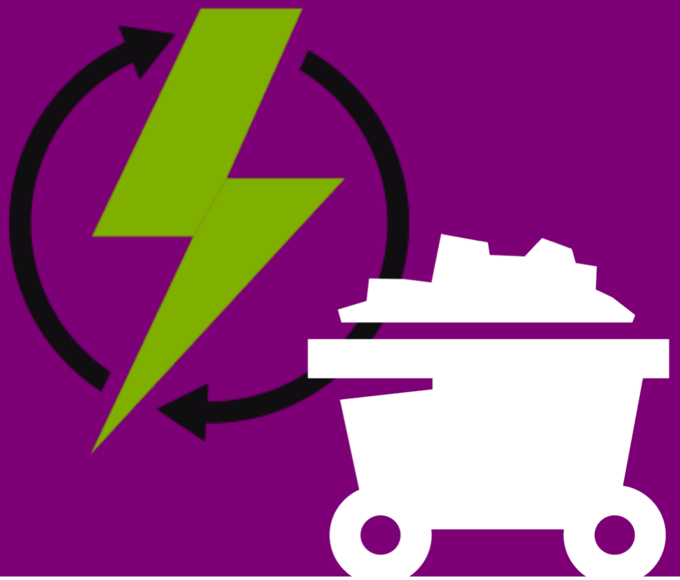




RESOURCE EFFICIENCY
1
RESOURCE EFFICIENCY BALANCES
ACCOUNTING
CERTAINTY
2
RESOURCE EFFICIENCY MAPS
TRANSPARENCY
COMPLETENESS
3
RESOURCE EFFICIENCY METRIC
TRACEABILITY
INTEGRATION
Resource efficiency = Useful output / Resource input (%)
4
RESOURCE EFFICIENCY ACTIONS
PREDICTION
IMPROVEMENT

Basic oxygen steelmaking

Case study



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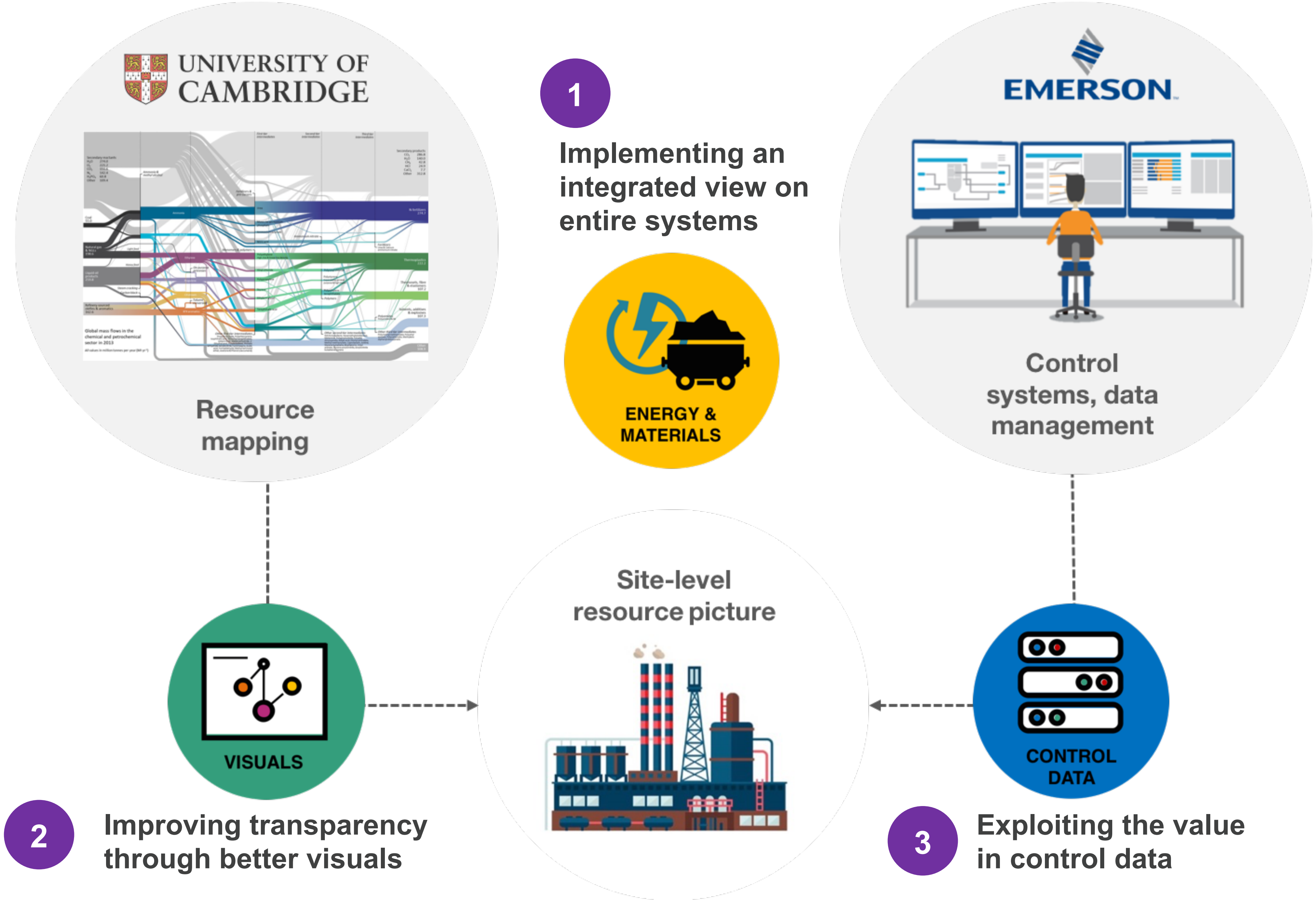
TATA STEEL

EMERSON

Integrated resource efficiency analysis



Ana Gonzalez Hernandez
PhD, Emerson

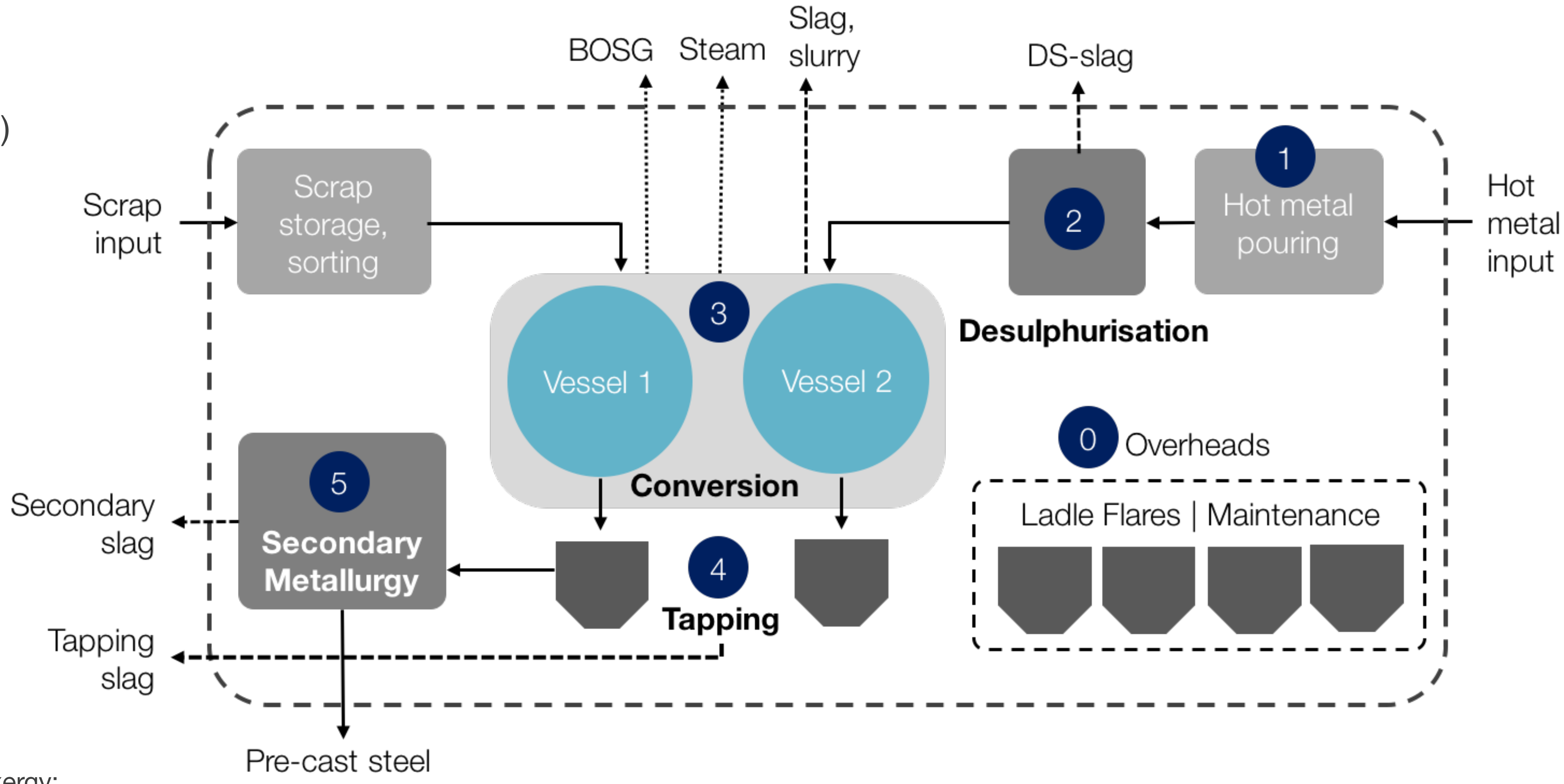
Cambridge University is collaborating with Emerson to develop novel tools that can prepare industry for the future low-carbon and resource-efficient production era

EMERSON UNIVERSITY OF CAMBRIDGE

Basic oxygen steelmaking

Control data

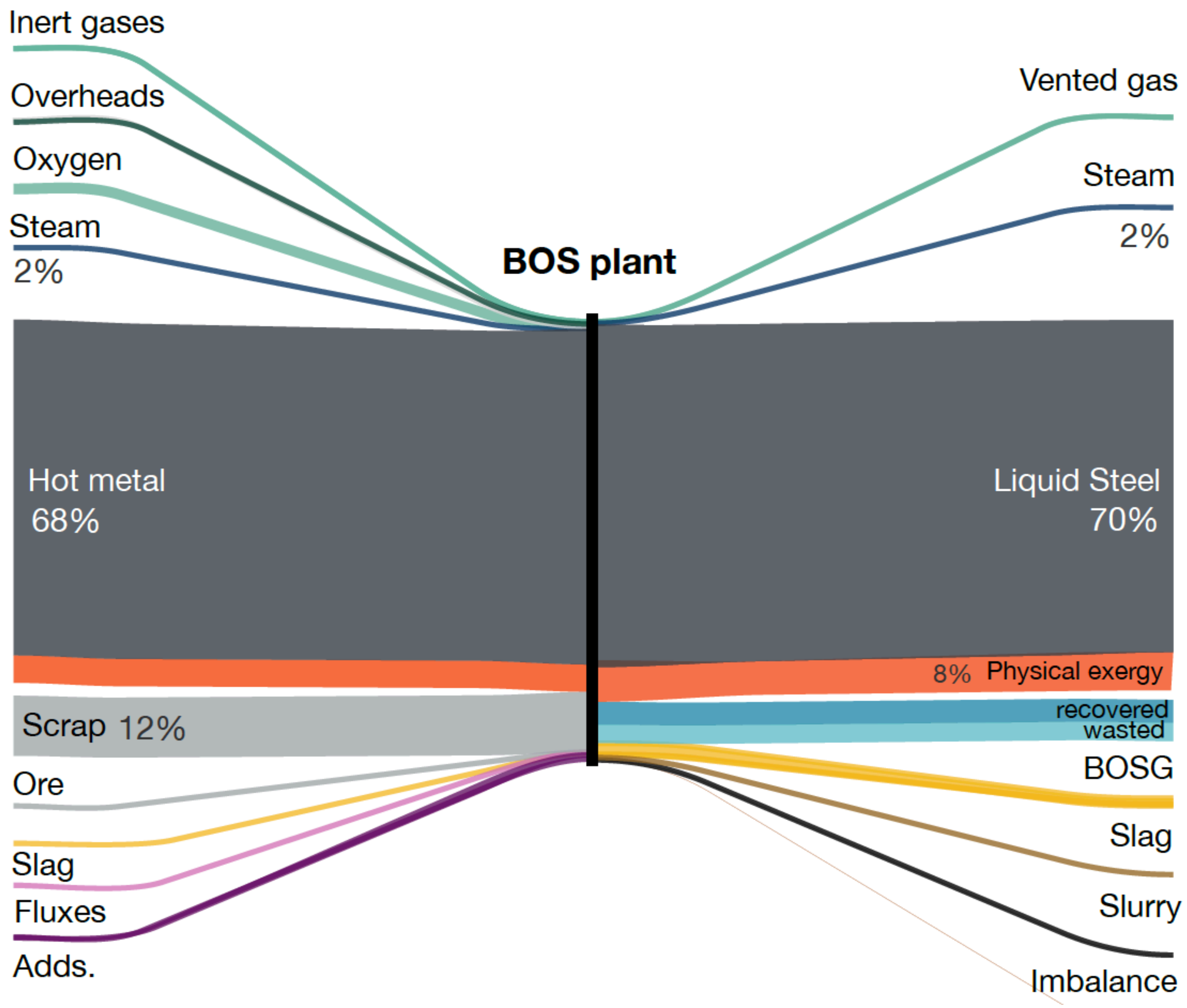
Control data extracted from across 900 ‘heats’ (batches)

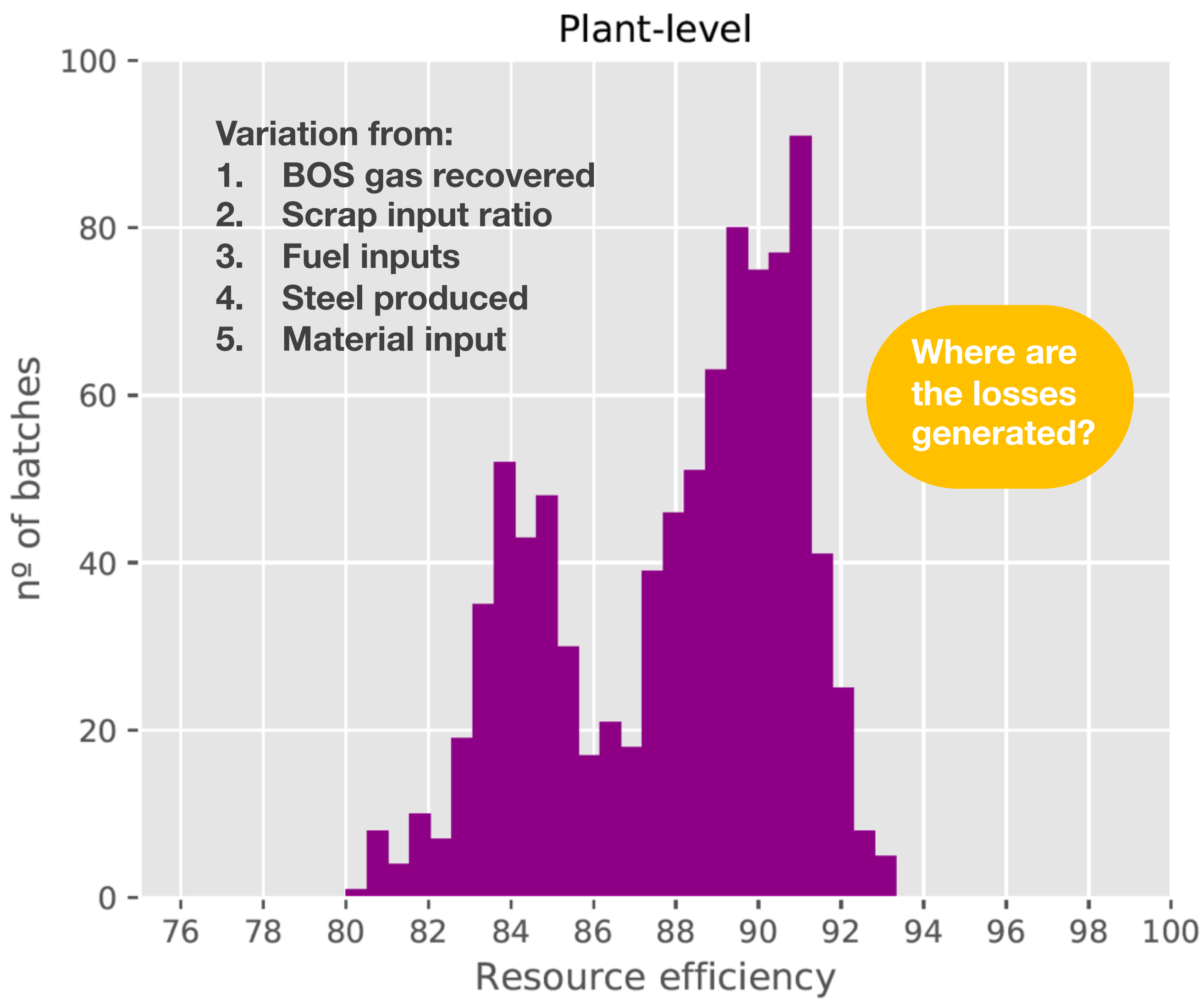


Gonzalez Hernandez A, Lupton RC, Williams C, Cullen JM (2018) Control data, Sankey diagrams, and exergy: Assessing the resource efficiency of industrial plants, Applied Energy, 218: 232–245

Method overview

Exergy flows



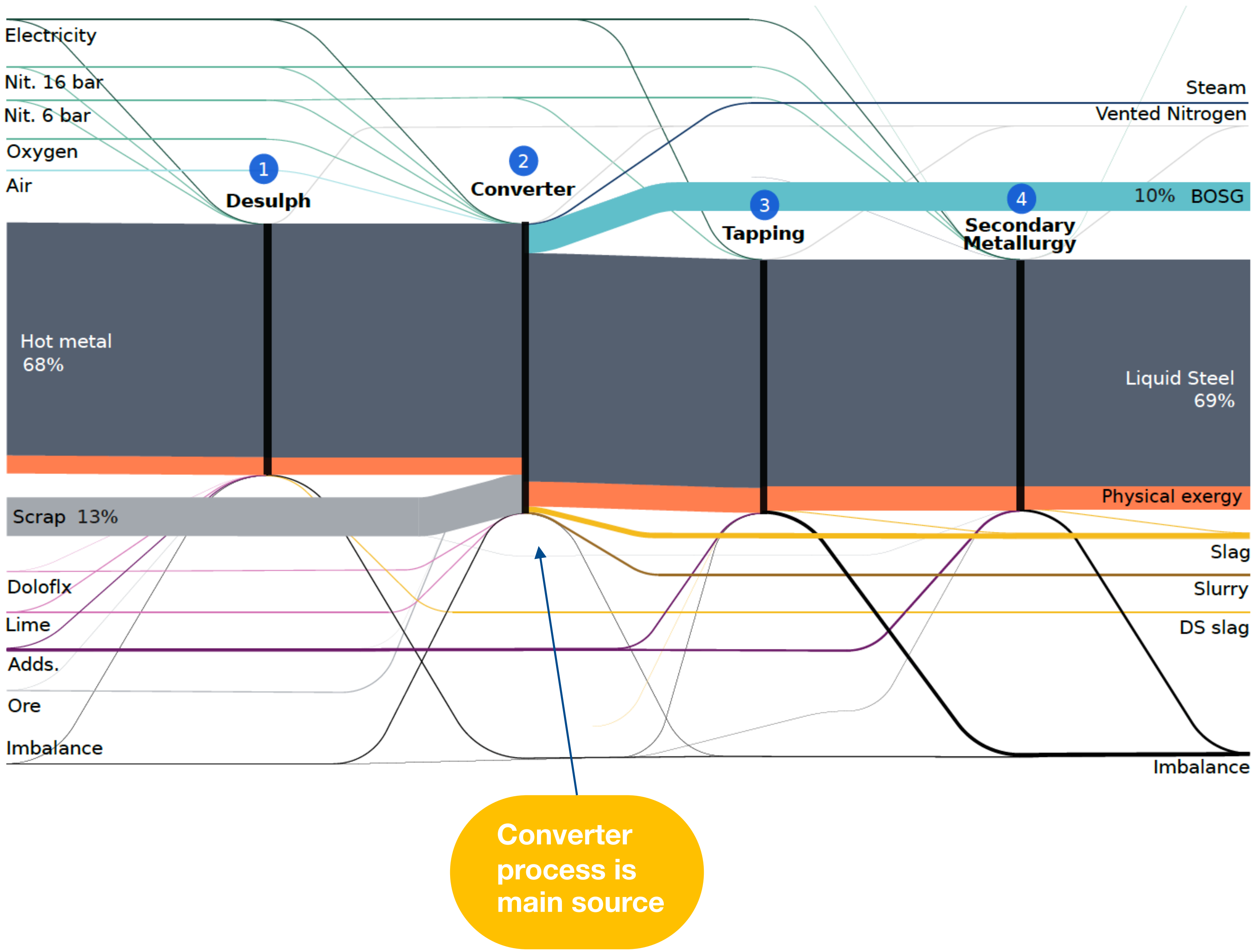


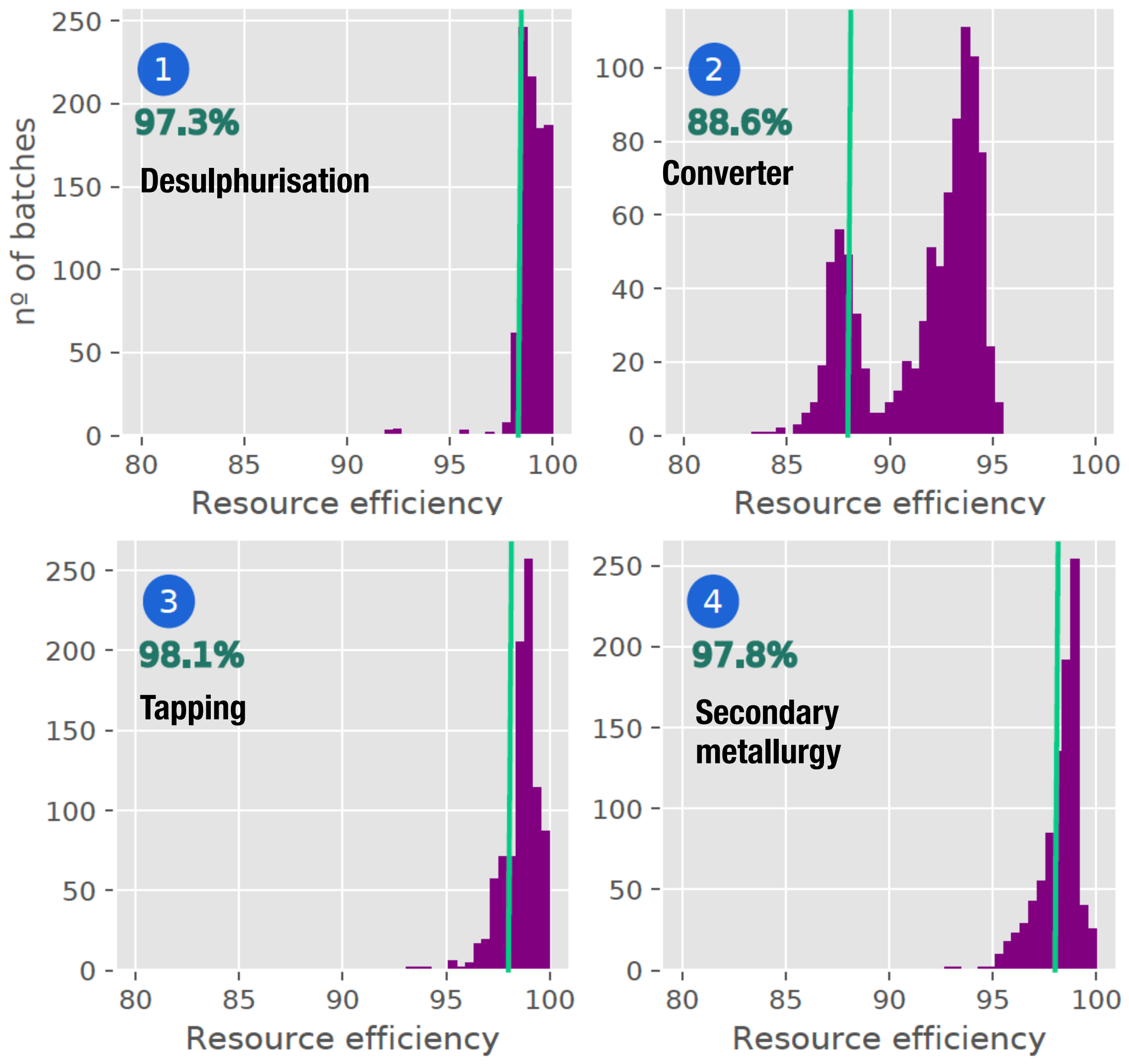
Where are the losses generated?

EFFICIENCY VARIATION
Resource efficiency distributions reveal variability

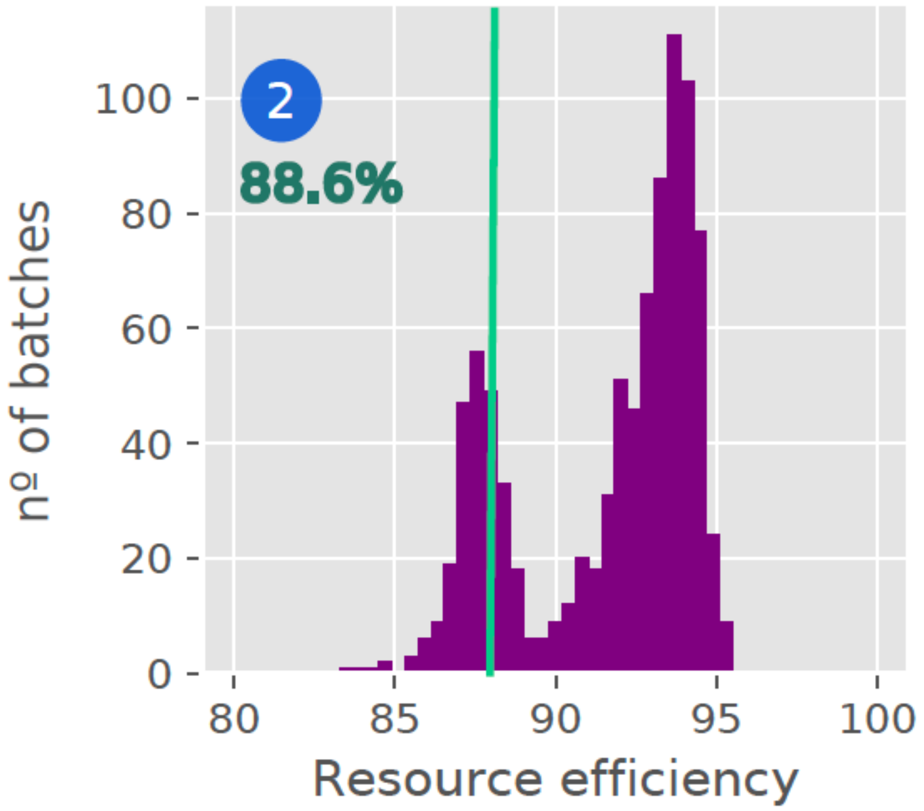
Basic oxygen steelmaking

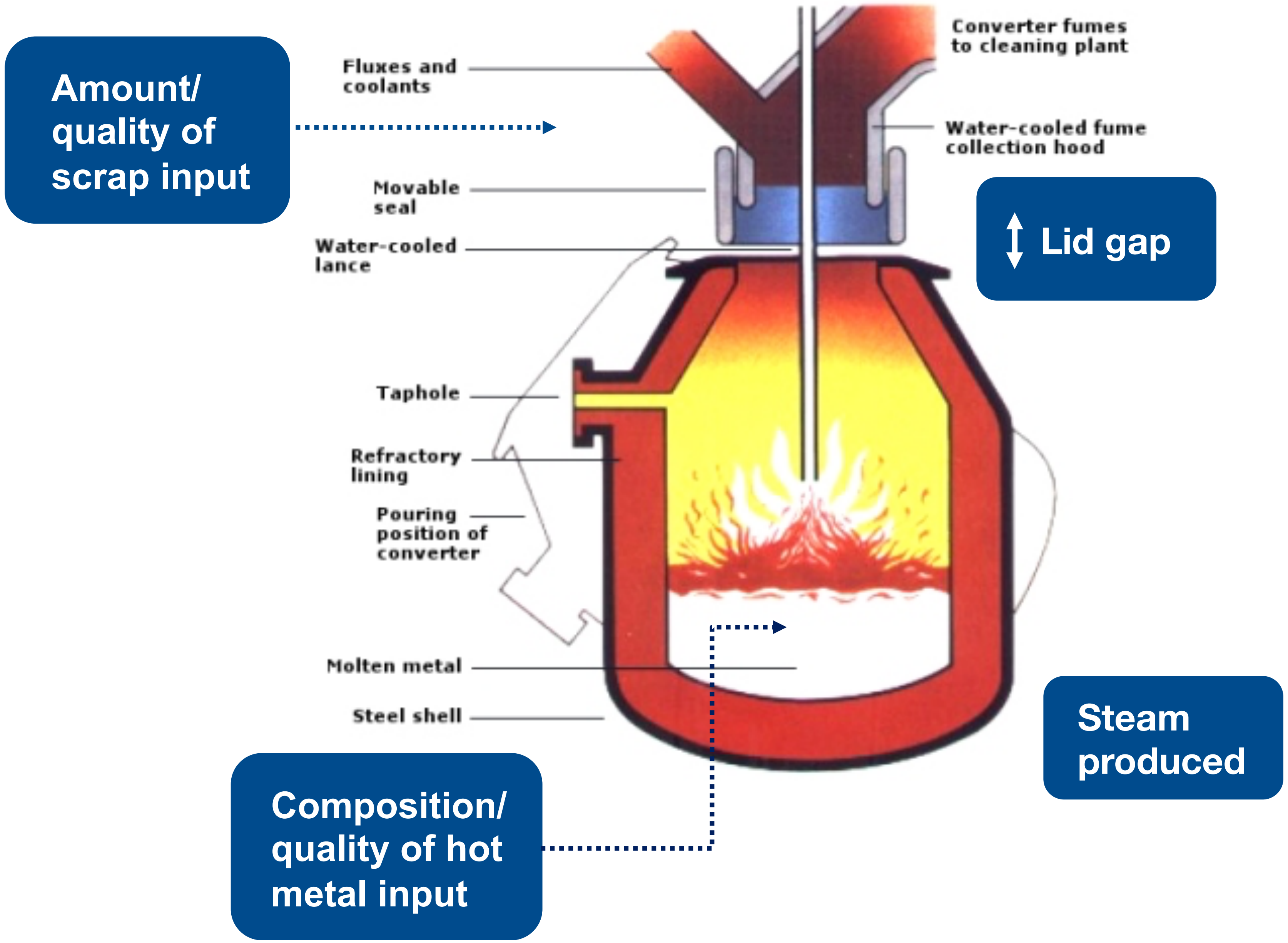
Exergy flows





Basic oxygen steelmaking

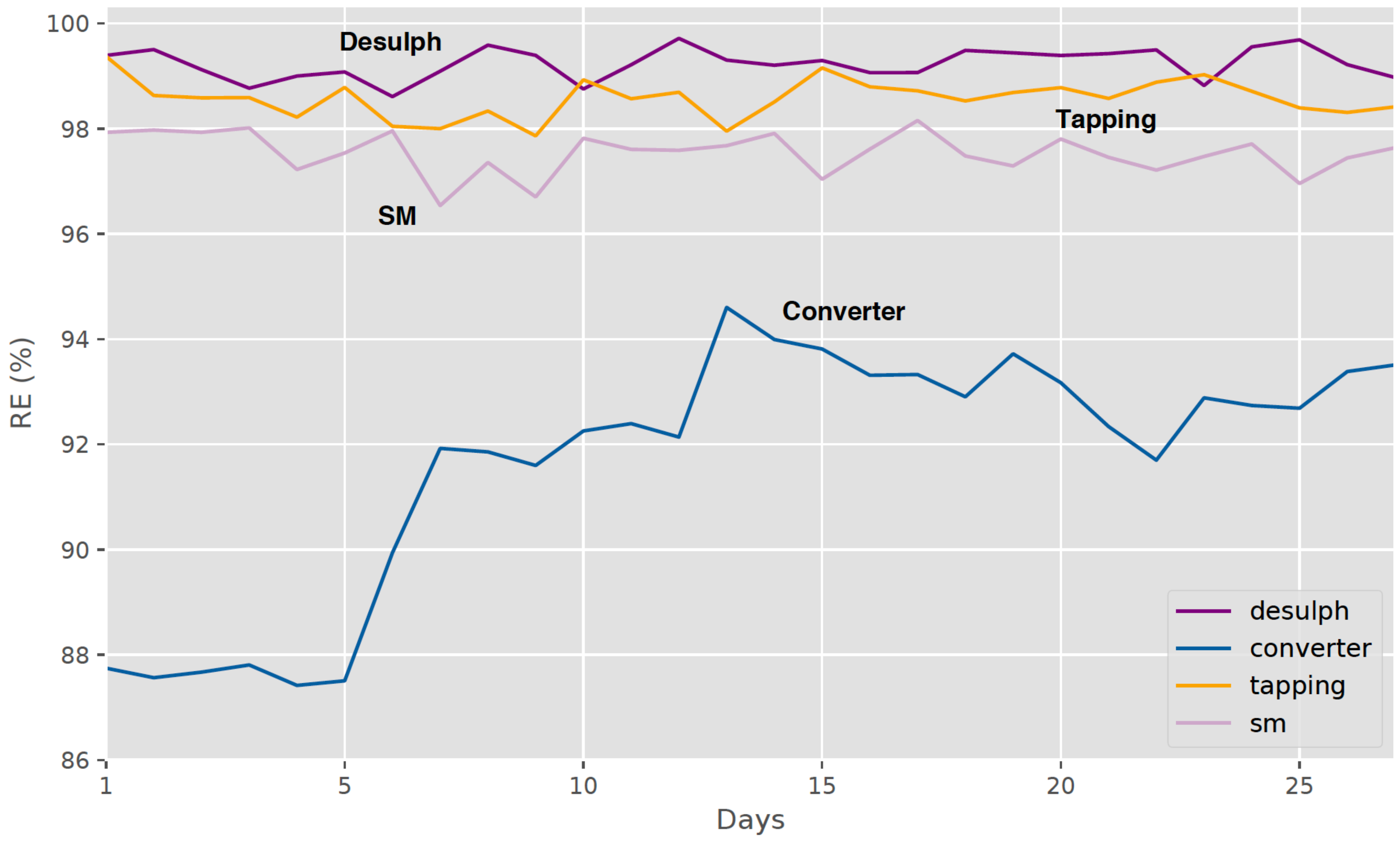


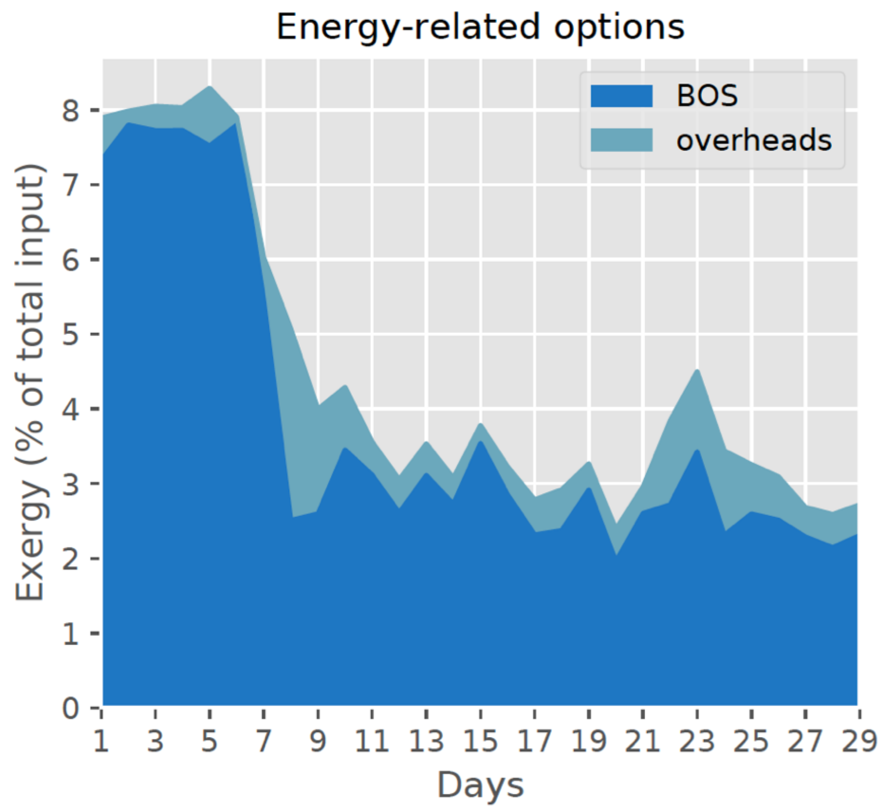


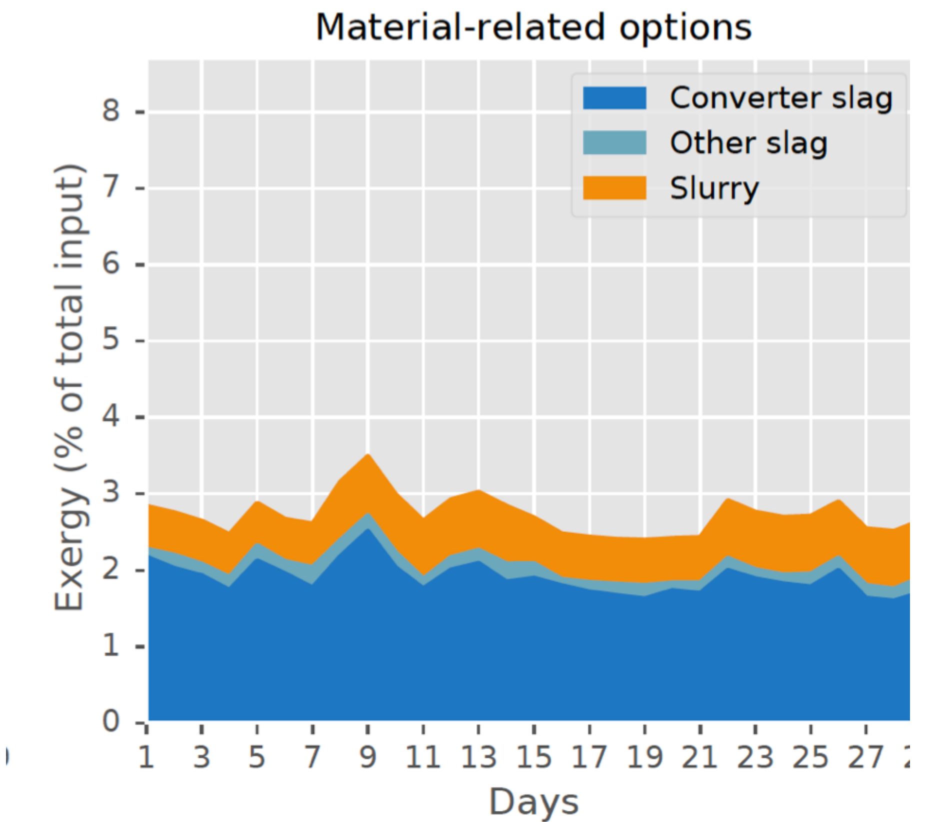
Two performance modes: arise because BOS gas is not recovered for every batch; in some batches it is still flared.

Basic oxygen steelmaking

Resource efficiency over time

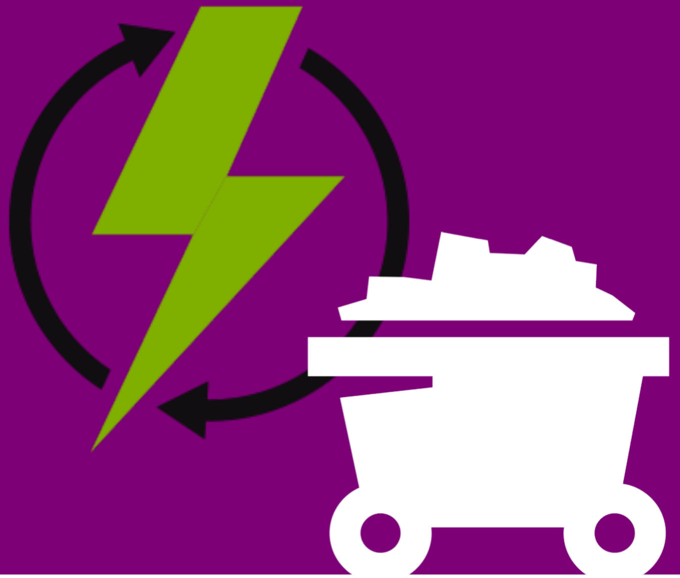






Ammonia production

Case study



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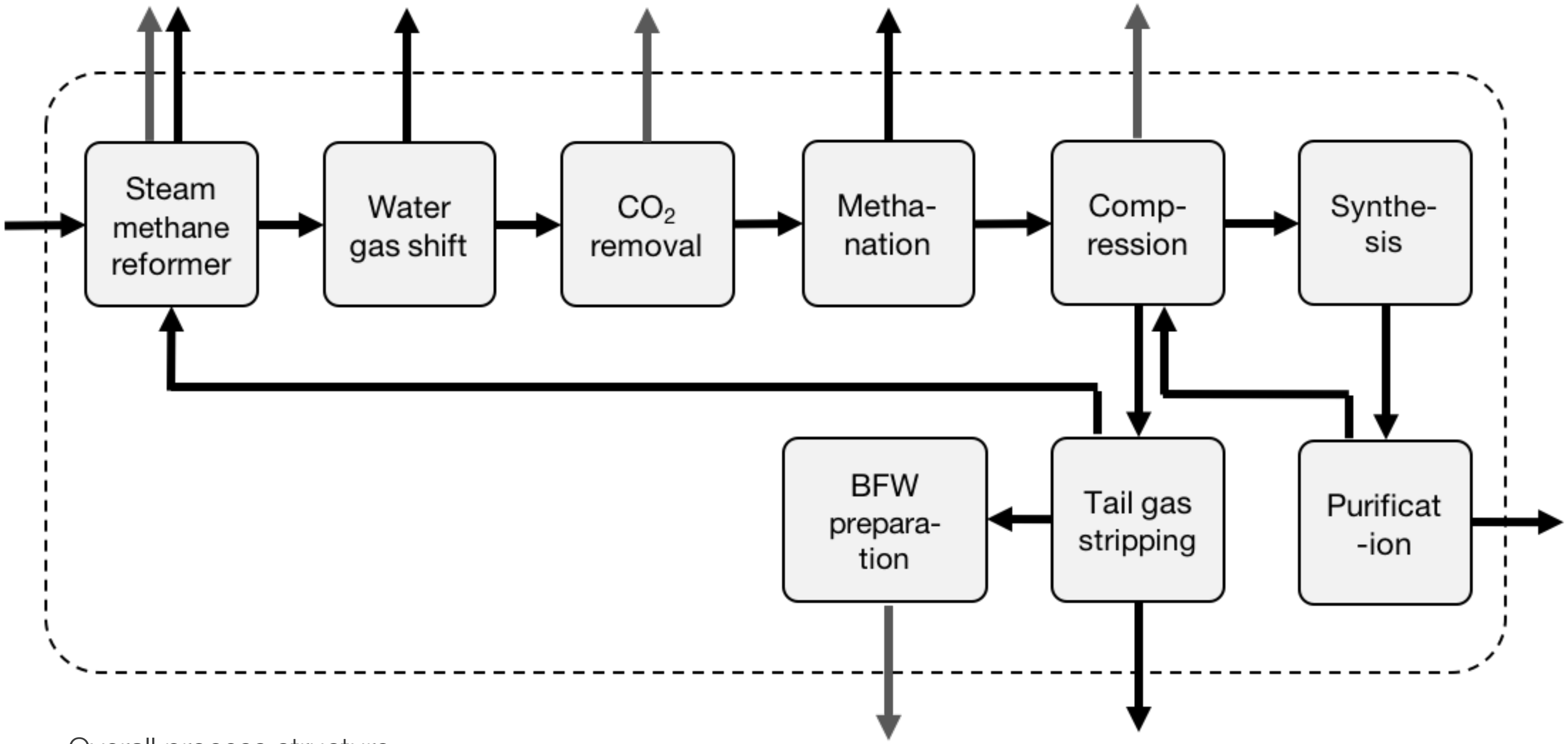
EMERSON

Ammonia production

Simulated data



Overall process structure:

Harry Michalakakis
PhD (Cam)

Analysis of resource efficiency in chemical plants, helps identify improvement opportunities and sources of inefficiency

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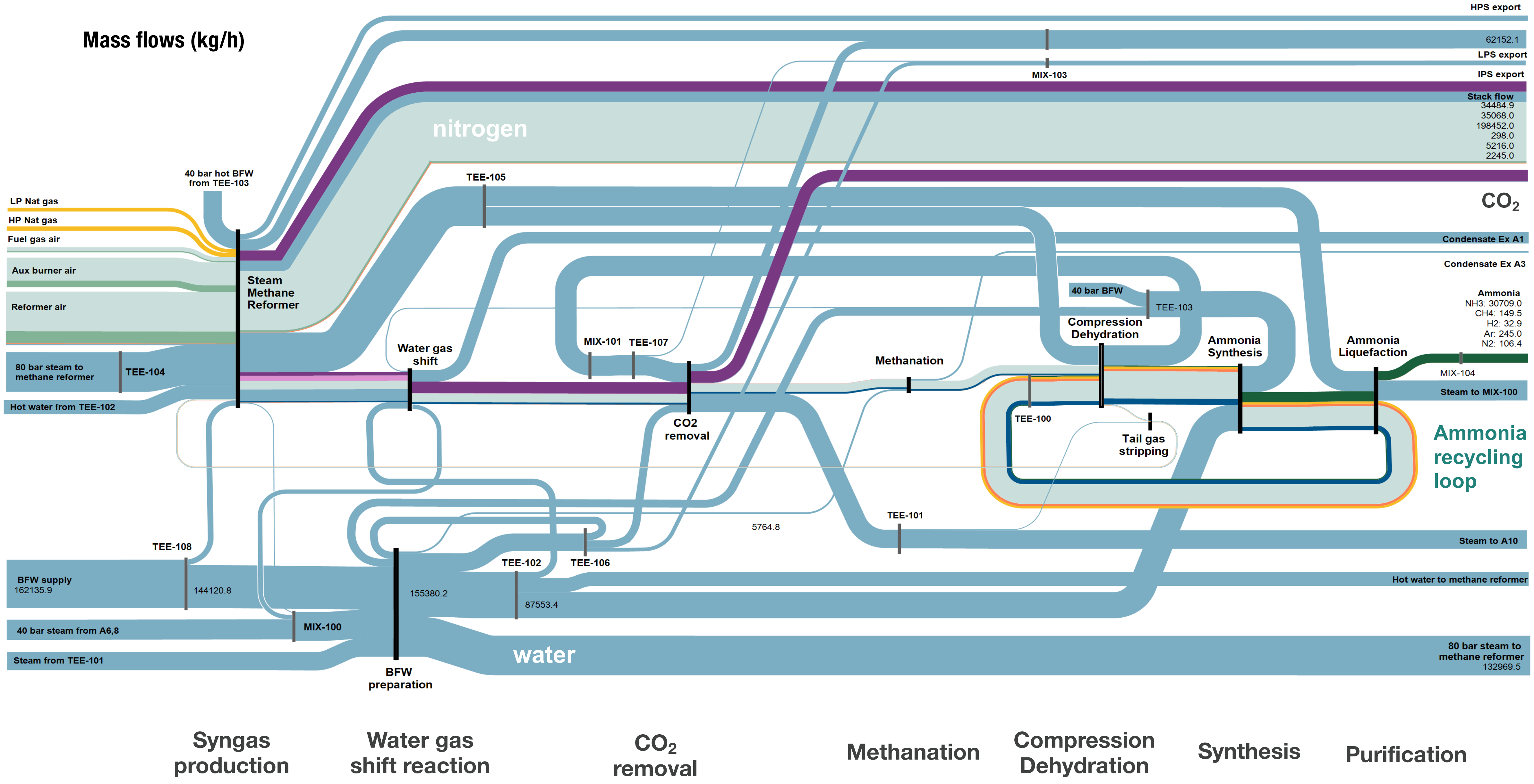
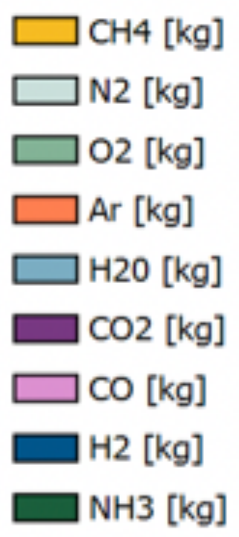
Ammonia production

Mass flows

Mass flows in an ammonia site, created using simulated data, traced from syngas production to the ammonia purification



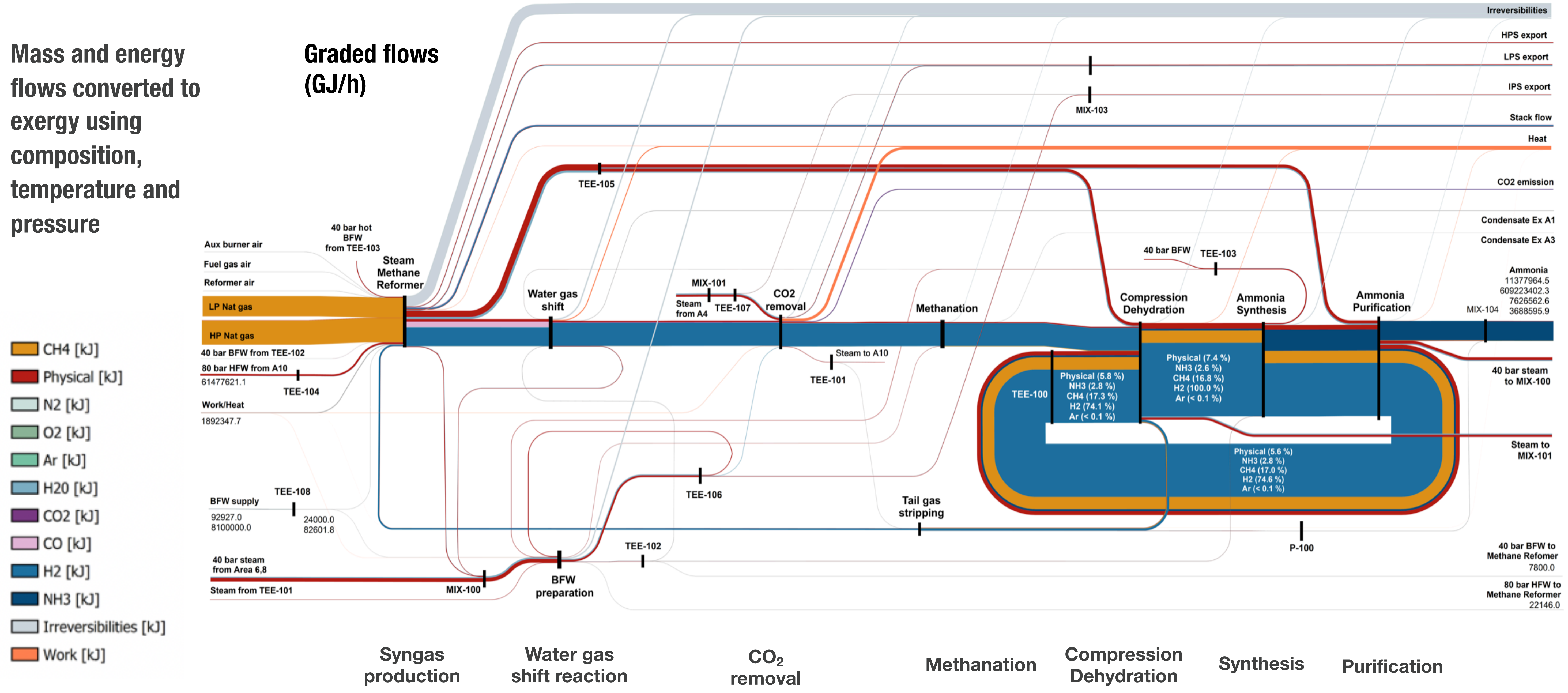


Ammonia production

Exergy flows

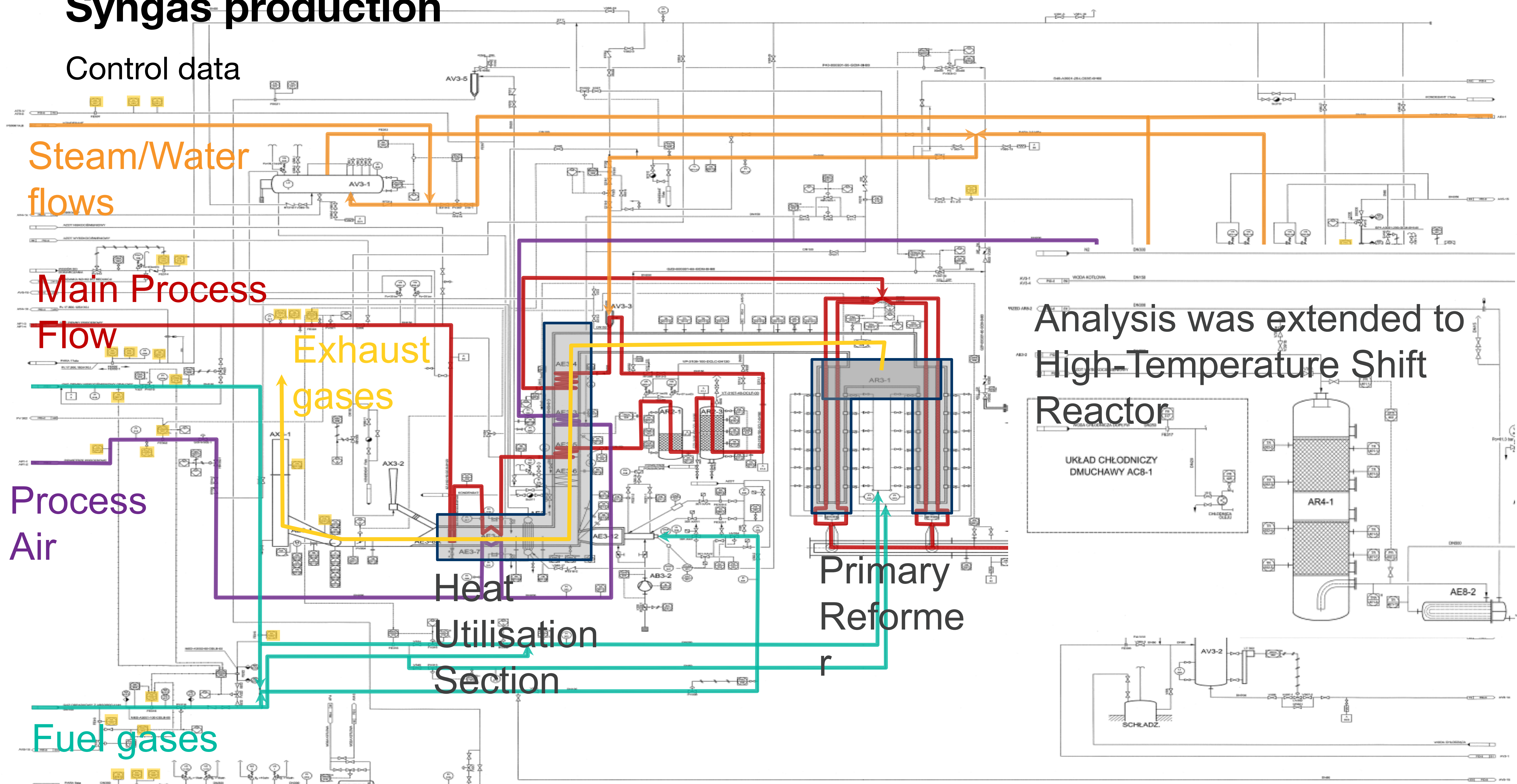
Mass and energy flows converted to exergy using composition, temperature and pressure

Graded flows (GJ/h)



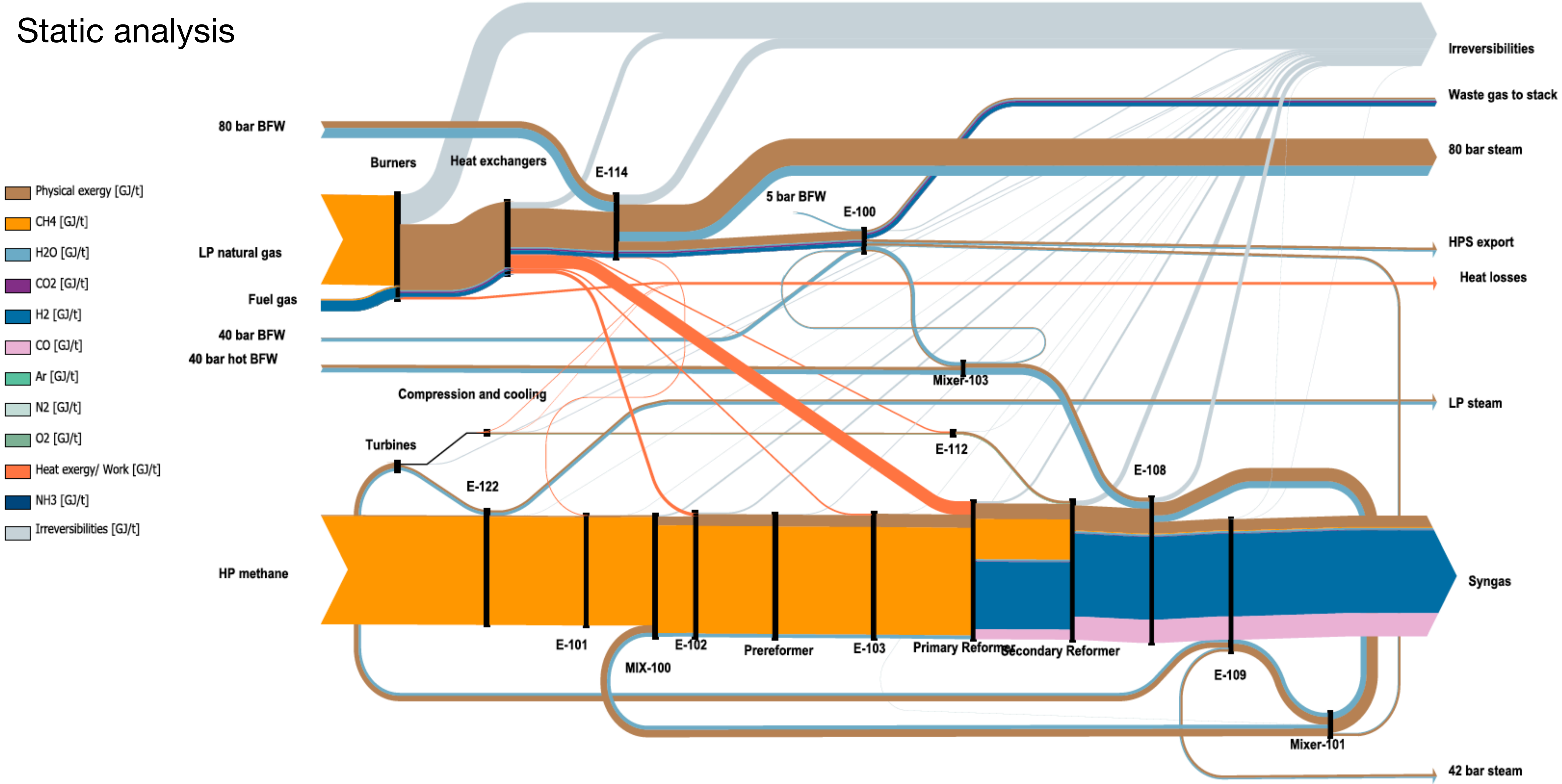
Syngas production

Control data



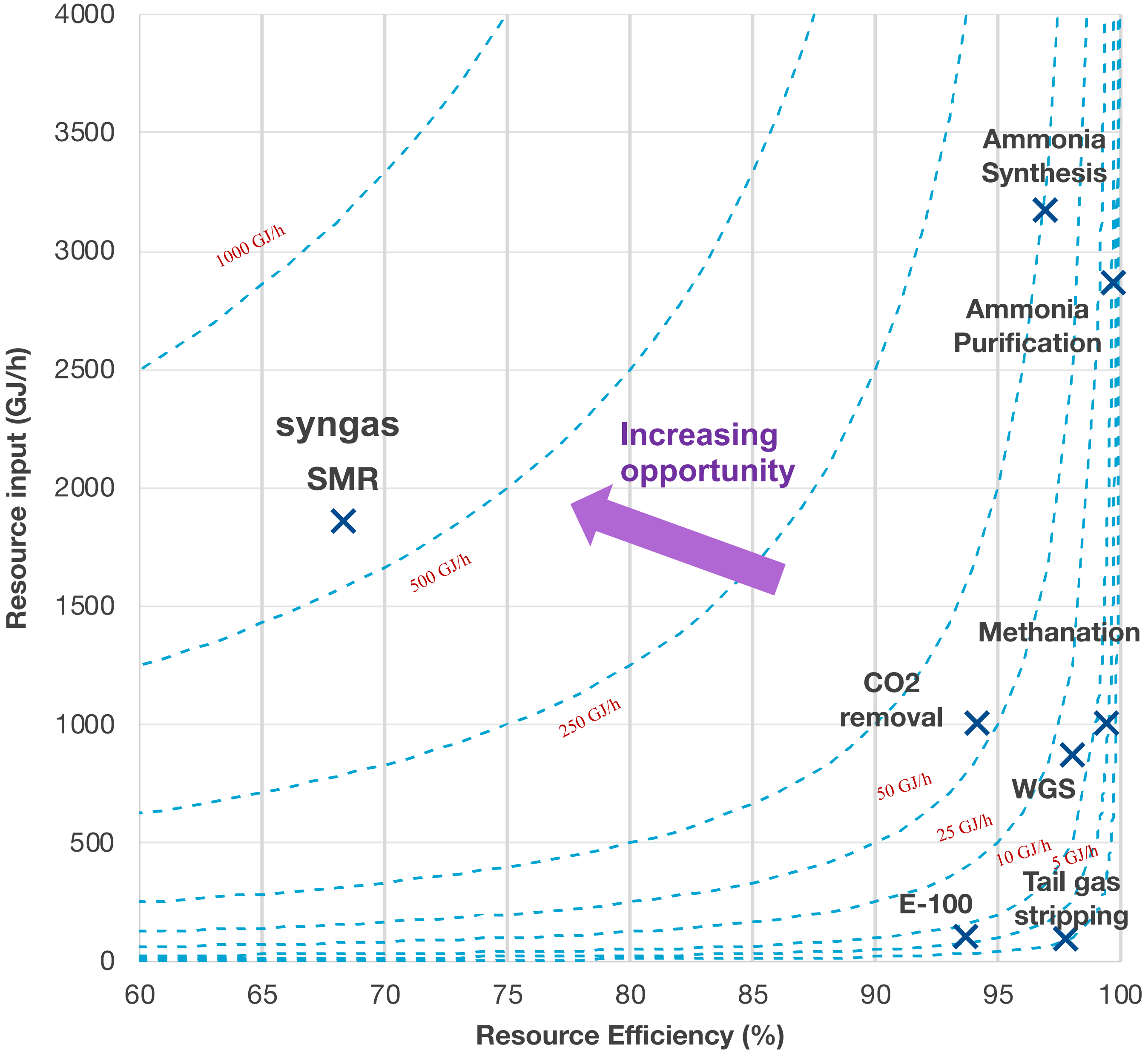
Syngas production

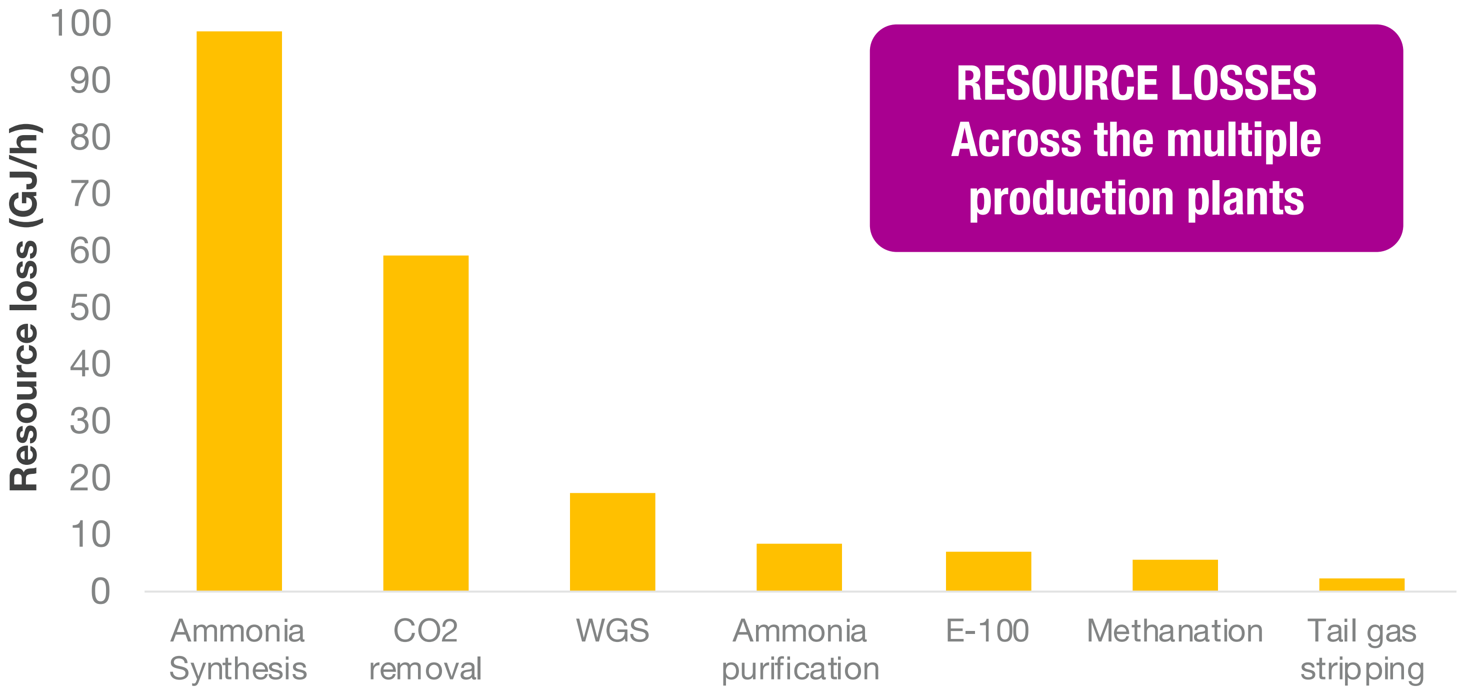
Static analysis

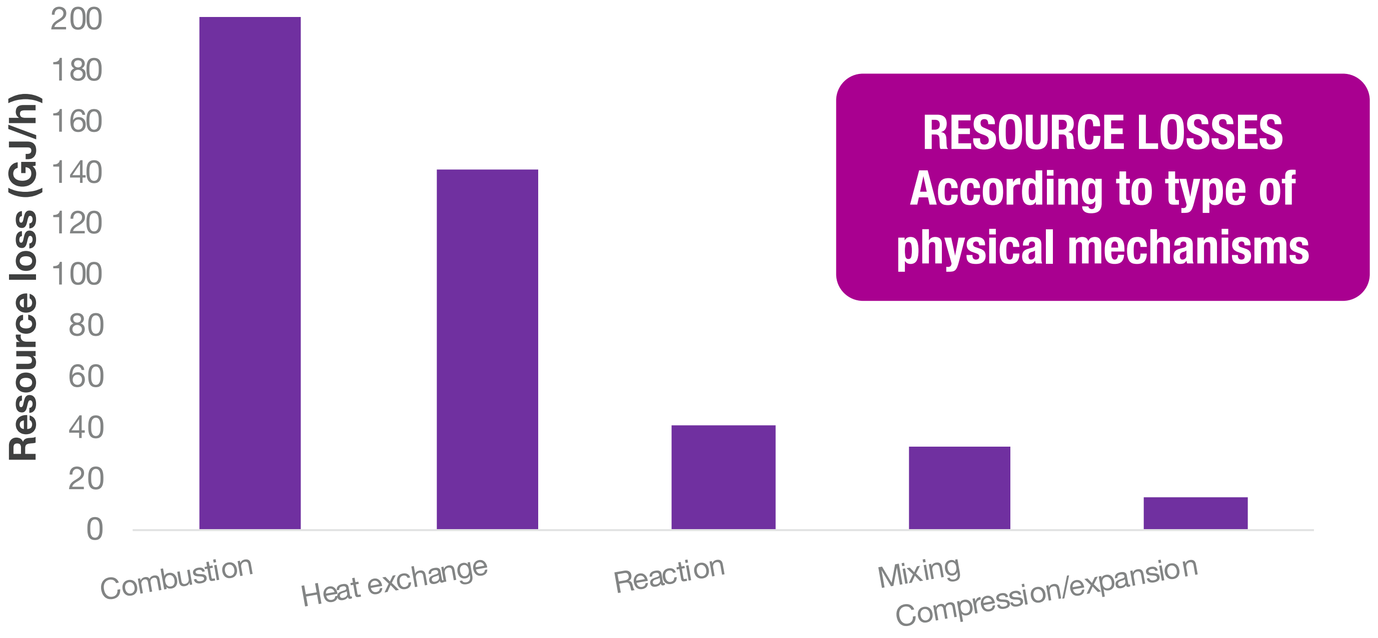


Ammonia production

Resource efficiencies





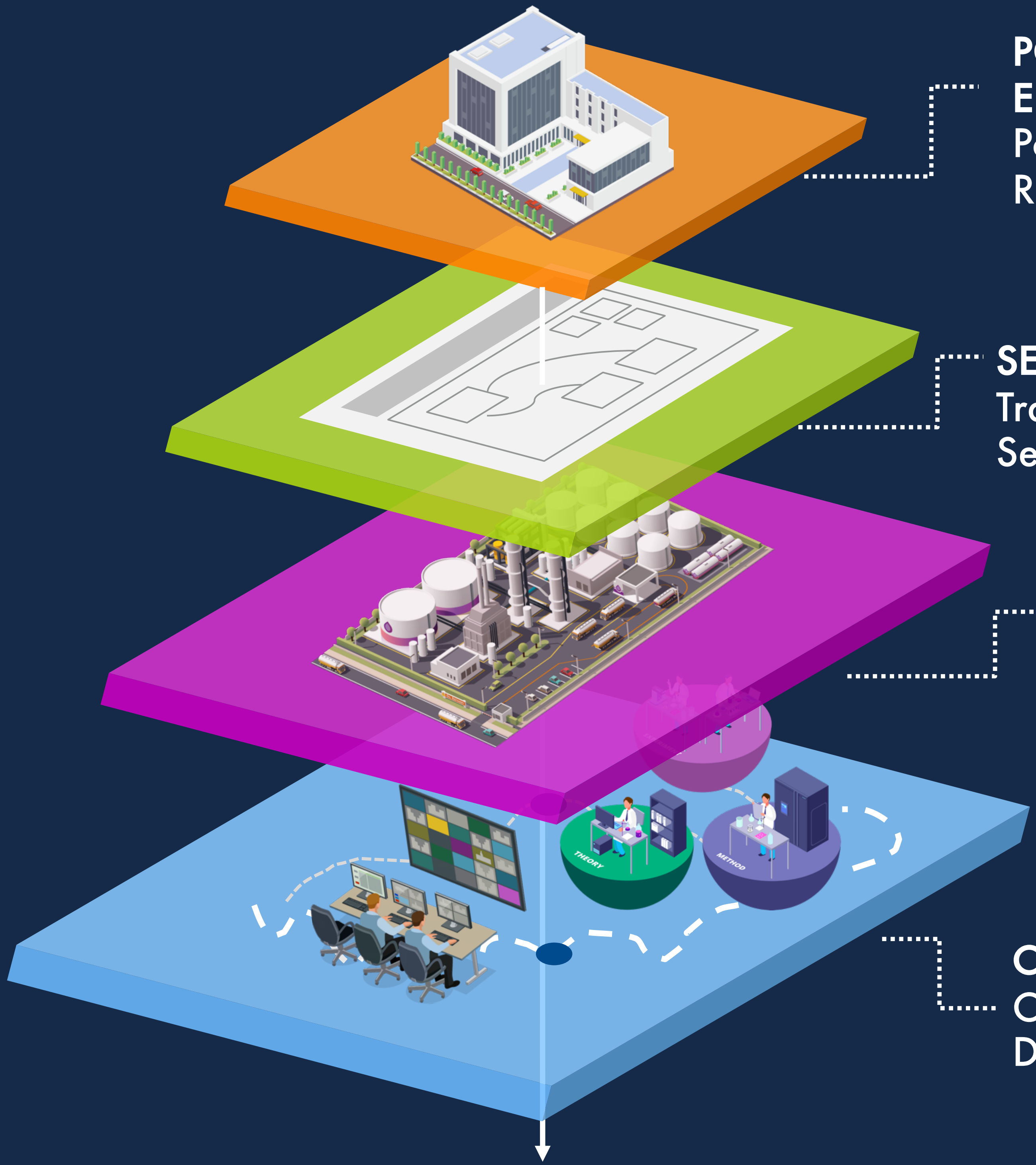


SCALABLE
APPROACH

COMPLETE LINE OF SIGHT

RESOURCE EFFICIENCY

Removing the NEED to interpret performance metrics at EACH LEVEL of management



resource efficiency collective





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Resource Efficiency Collective is a research initiative at Cambridge University. Together, we seek answers to a challenging question: how can we deliver future energy and material services, while at the same time reducing resource use and environmental impact?