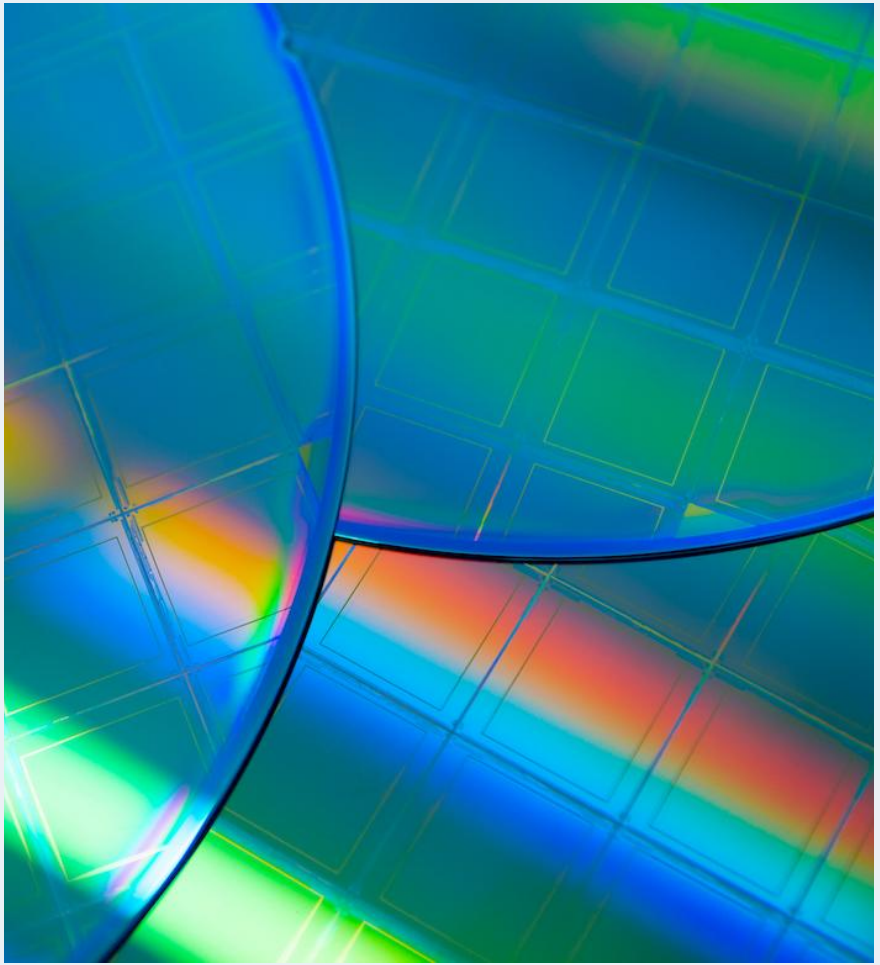
Driving Efficiency of Energy and Emission-intensive Fabrication Processes with the Next-Generation Optimisation-Based Platform.

Smart and Green Manufacturing Summit
SEMICON Europa 2022

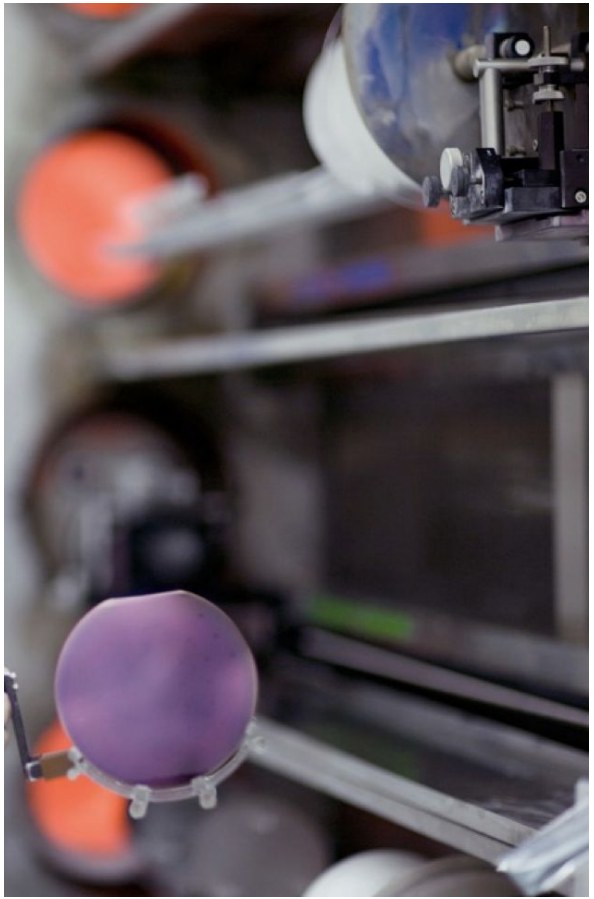


Flexciton

Contents/Agenda

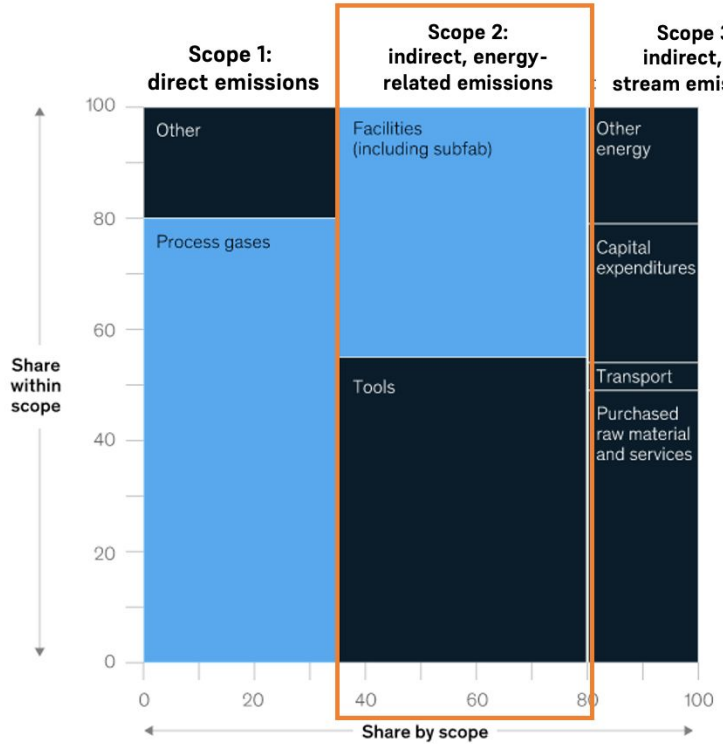
Energy consumption challenge

- A typical semiconductor fabrication plant consumes as much energy as 50,000 homes in a year.
- While the power consumed by semiconductor chips has reduced, improvements in the energy used during the manufacturing process hasn't.
- Energy costs expected to significantly increase, accounting for 30% or more of fab operating expenses.



Semiconductor emission footprint

CO2-equivalent emissions for typical fab profile[1] %share



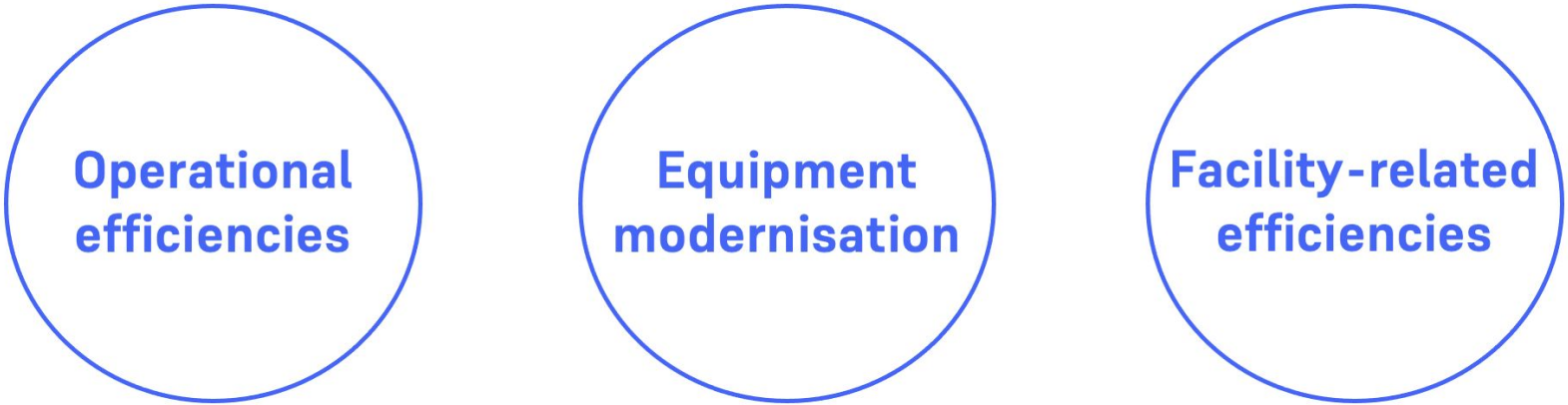
[1]Excluding scope 3 downstream. Emissions averaged across 200-millimeter (mm) and 300-mm semiconductor fabs.

- ~ 55% of energy consumption-related emissions come from running tools.
- Energy consumption is expected to rise as the node size of chips shrink.

Source: McKinsey

Flexciton

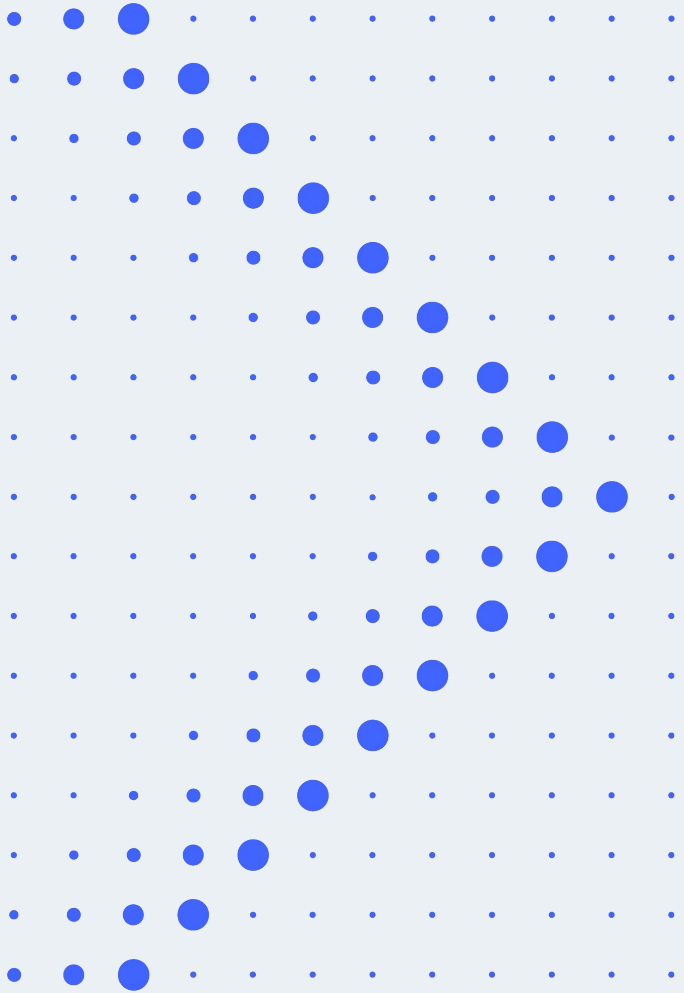
Energy efficiency opportunities



Energy efficiency opportunities

- Fab production equipment require tremendous amounts of energy to process wafers.
- Smarter decisions could bring significant energy savings.
- Energy savings must be brought without sacrificing overall fab performance.

We built Flexciton to help fabs radically improve production efficiency and accelerate progress



Flexciton

Flexciton is the advanced optimisation platform built to simplify and streamline chipmaking

5 years

Experience working with semiconductor manufacturing

40 engineers

The largest team of engineers and scientists dedicated to solve optimisation problem in wafer fabrication

500+ publications

Regular speakers at the industry tech conferences

Winter Simulation Conference, ASMC, INFORMS

HQ

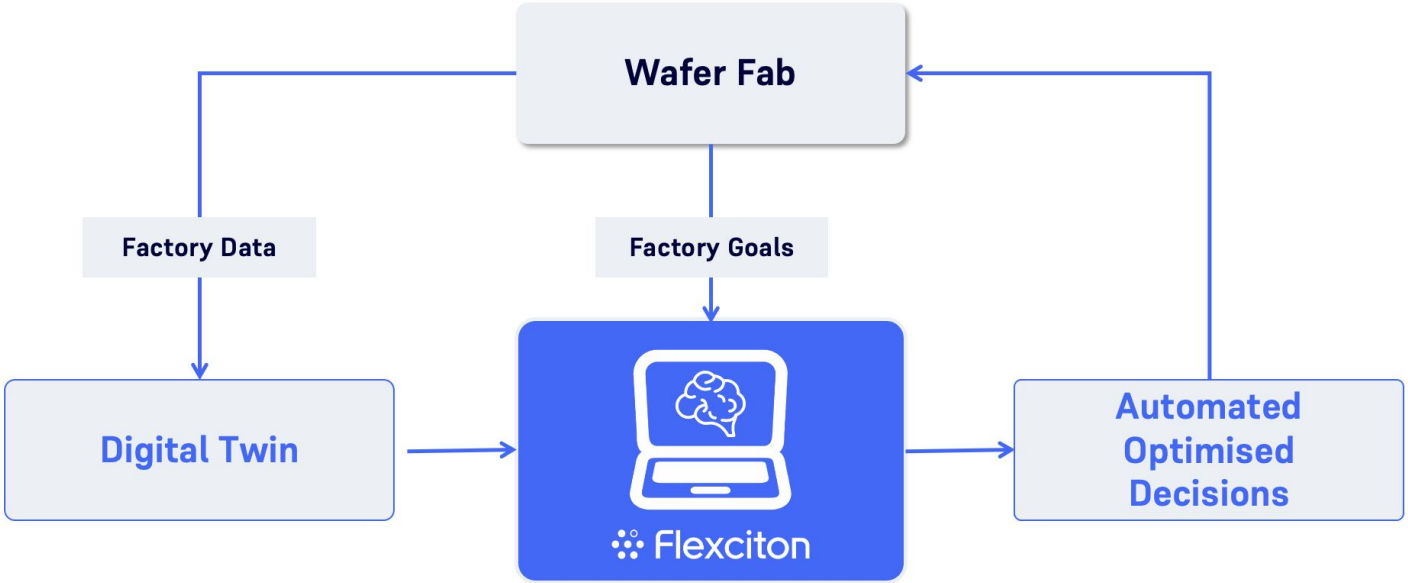
Based in London, working with chipmakers globally

2020

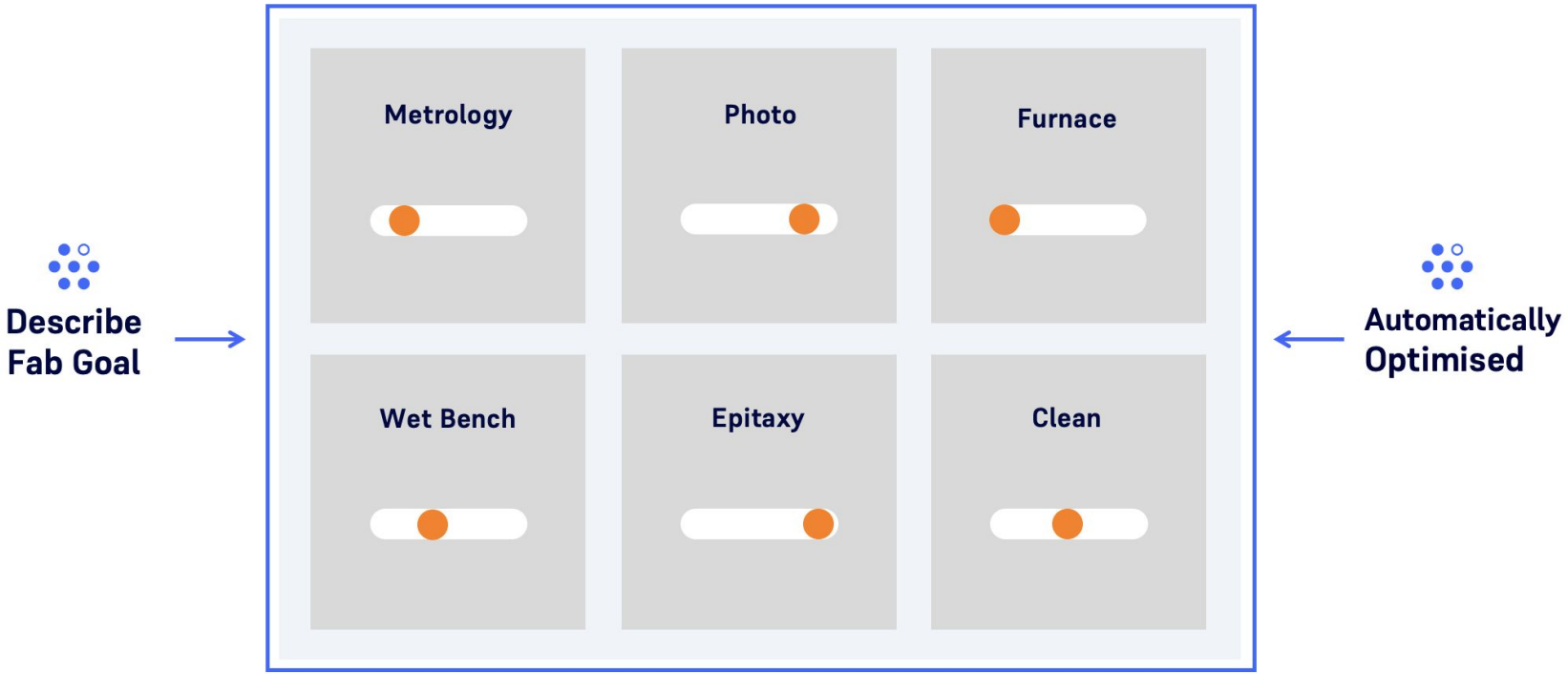
Semicon West Best of West Award The finalist

The Flexciton Optimisation Platform

Our core application: The Scheduler



Describe what you want and get it automatically



Flexciton

How does Flexciton work

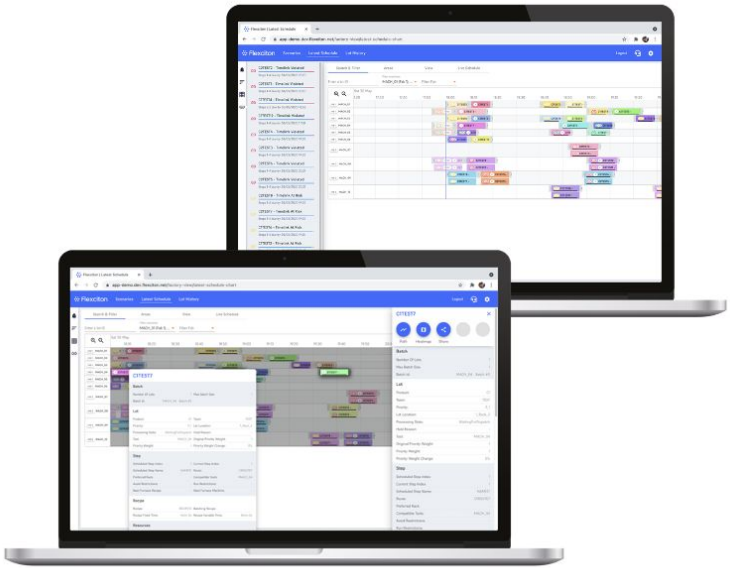
Our core application: Scheduling Optimiser

➔ Designed to solve any scheduling problem, including:

- whole line balancing
- multistep constraints (timelinks)
- photo tools (reticles)
- batch tools

➔ Modern interface allowing effortless configuration and consistent performance

➔ Cloud-native, globally hosted



How does Flexciton work

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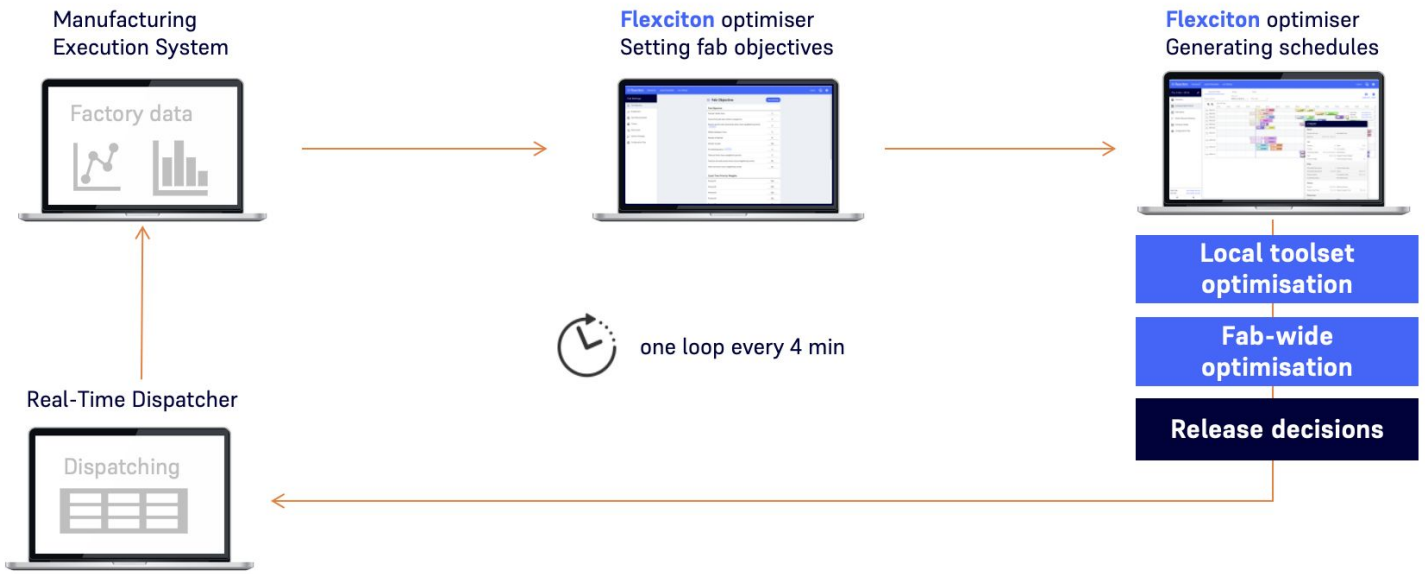

Flexciton

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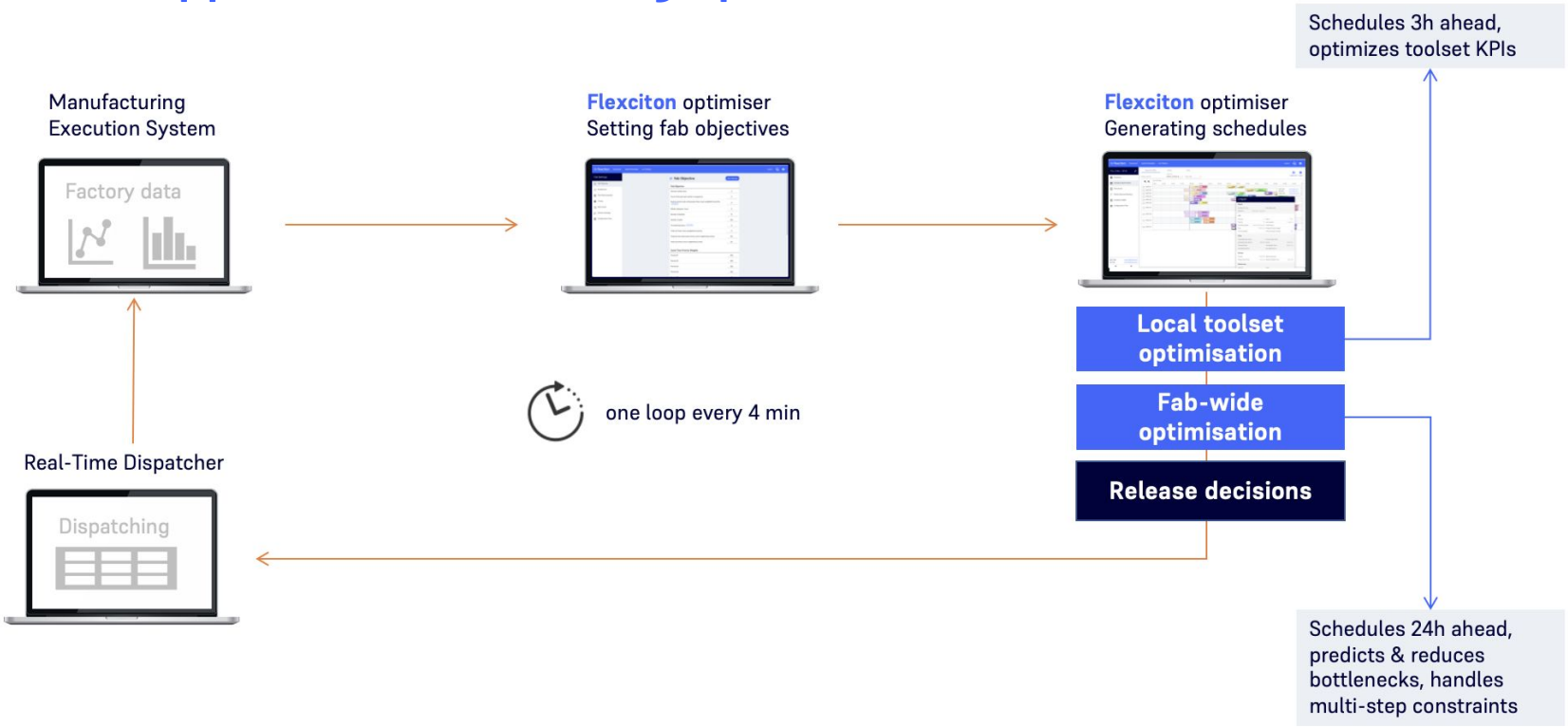
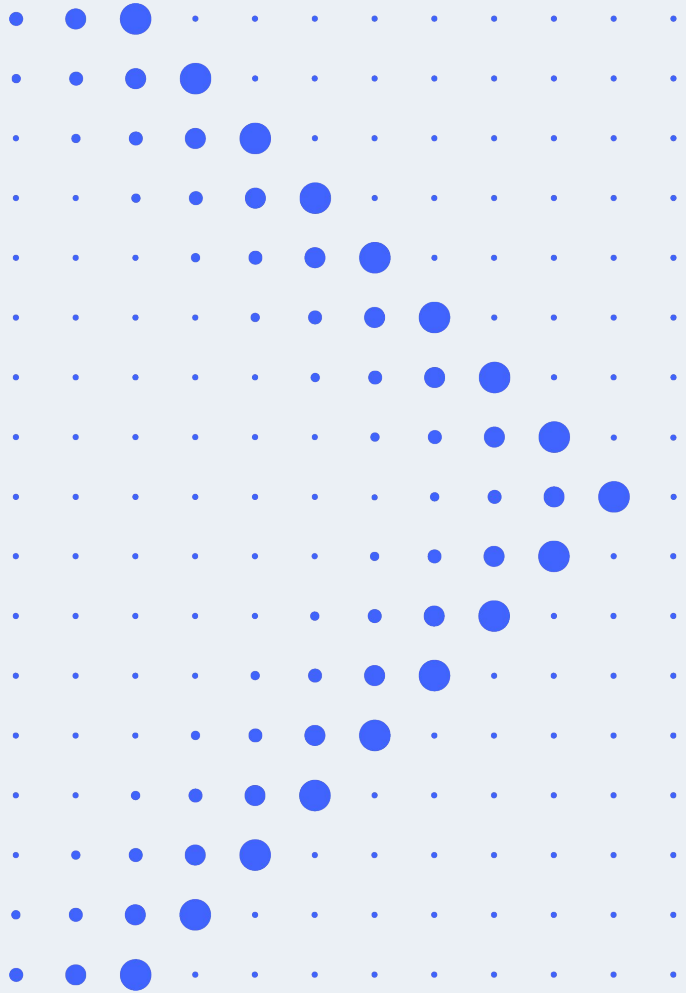


Energy efficiency opportunities with Flexciton



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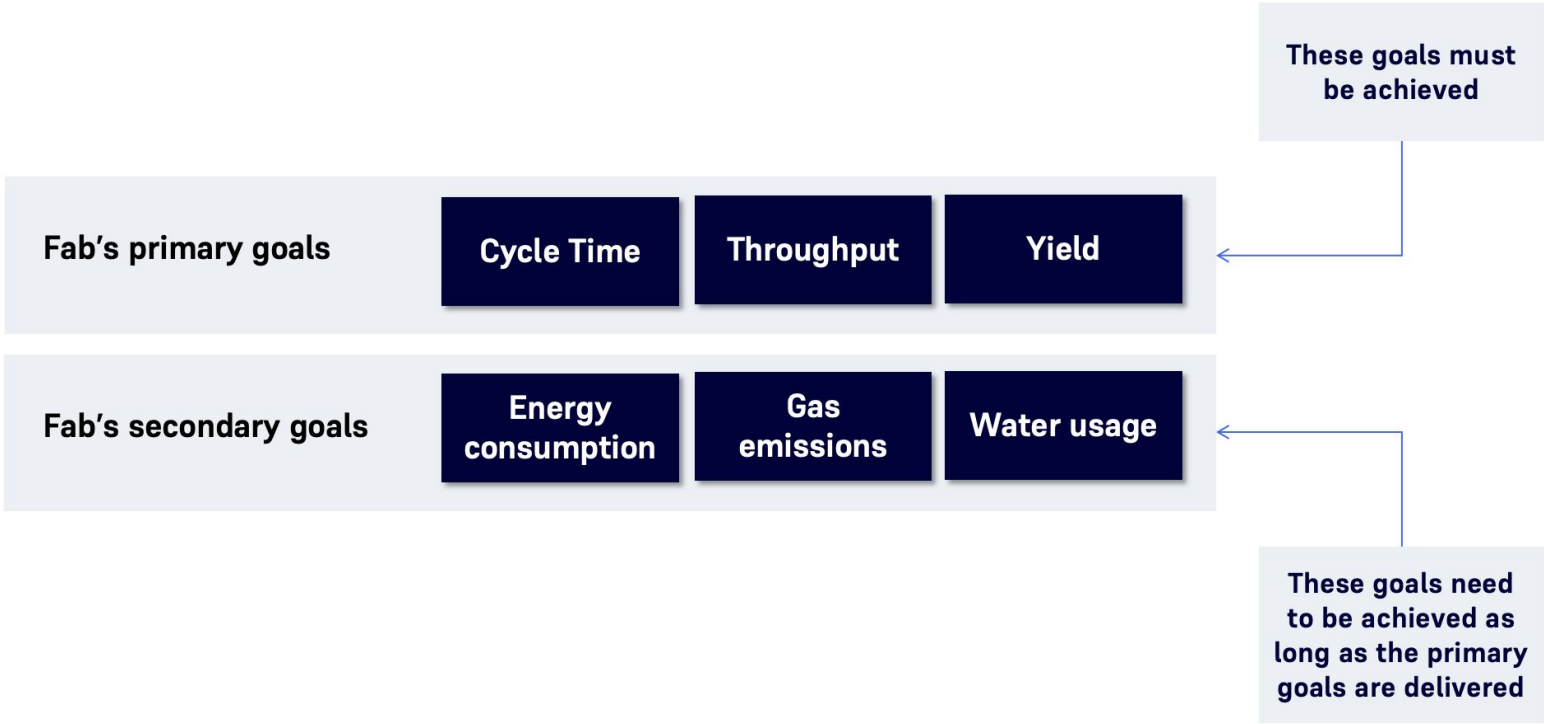


Energy efficiency opportunities with Flexciton

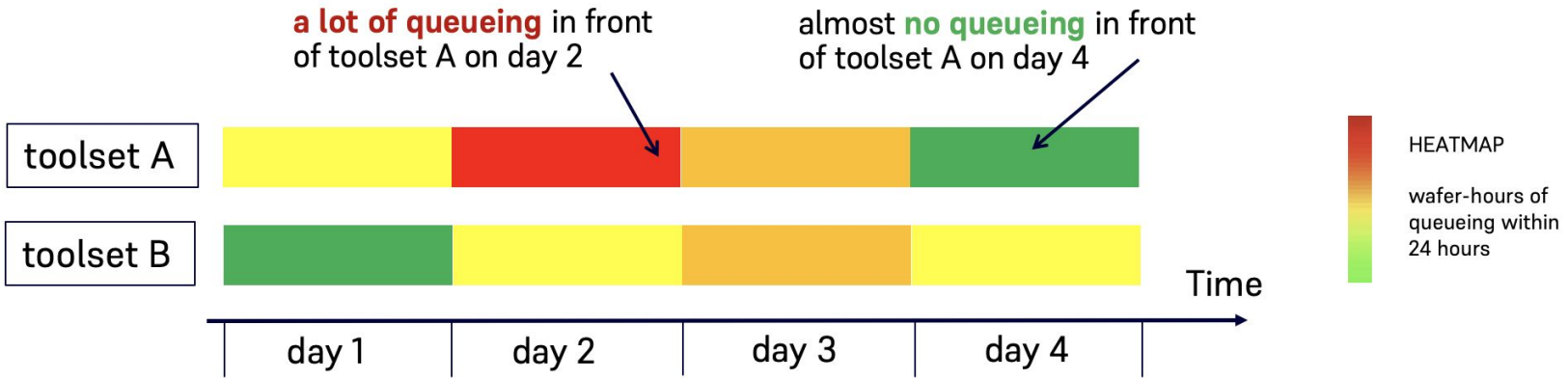
01 Optimising bottleneck tools to meet the fab's primary objectives

- Photolithography, Clean and Furnace are typically bottleneck tools.
- Optimising performance at these tools will ensure delivery of primary KPIs.
- Optimising for the primary KPIs can also help energy efficiency.

Energy efficiency opportunities with Flexciton

An overview of the fab status quo

Our system analyses transactional data to find out how bottlenecked is each toolset over time

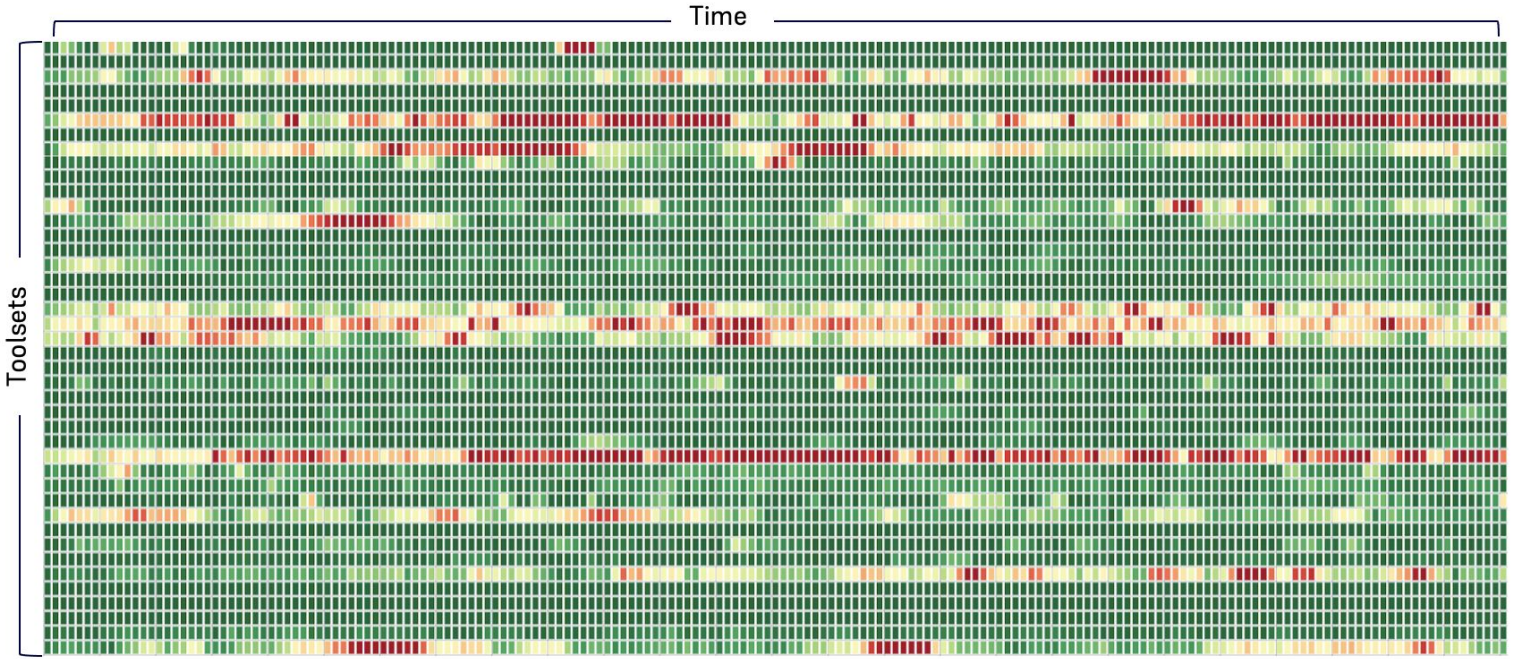


Flexciton

Energy efficiency opportunities with Flexciton

An overview of the fab status quo

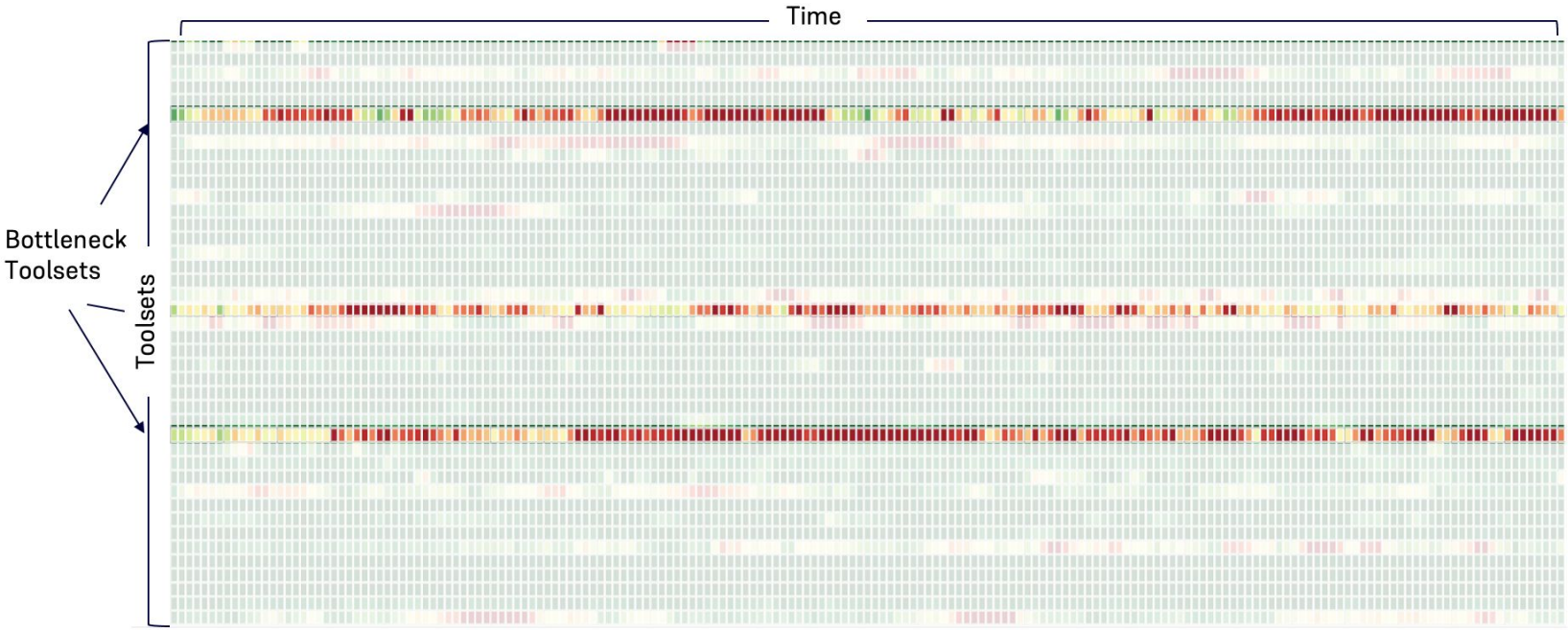
We map the current status quo of a fab and look at WIP patterns across the whole fab.



Energy efficiency opportunities with Flexciton

An overview of the fab status quo

Typically Photo, Clean and Furnace are the bottlenecks.



Energy efficiency opportunities with Flexciton

01 Optimising bottleneck tools to meet the fab's primary objectives

- Photolithography, Clean and Furnace are typically bottlenecks tools
- Optimising performance at these tools will ensure delivery of primary KPIs
- Optimising for the primary KPIs can also help energy efficiency

→ Case Studies

Case study #1: Gains at photolithography area

SEAGATE

Introduction

- Long and highly re-entrant process with 1,600 steps.
- The photolithography area sets the cadence of the Seagate facility and with the added complexity of reticle movement, it's critical to have an optimised schedule.
- The results are from one toolset (live production environment), with internal reticle library, where reticles can be moved individually between tools and cabinets.

Case study #1: Gains at photolithography area

Results

5.3% reduction in reticle moves with 9.4% increase in lot moves

Case study #2: Gains at clean and furnace

RENESAS
BIG IDEAS FOR EVERY SPACE

Introduction

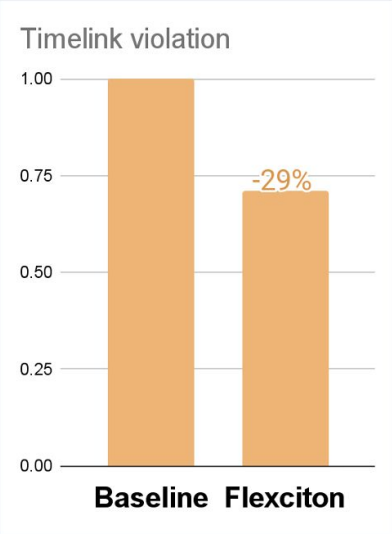
- Renesas challenged us to solve their scheduling problem at multi-step batch tools with timelinks constraints.
- We applied our advanced optimisation technology in a simulation environment encompassing the scheduler, a digital twin of the factory state, a schedule executor, and a real-time-dispatch simulator.

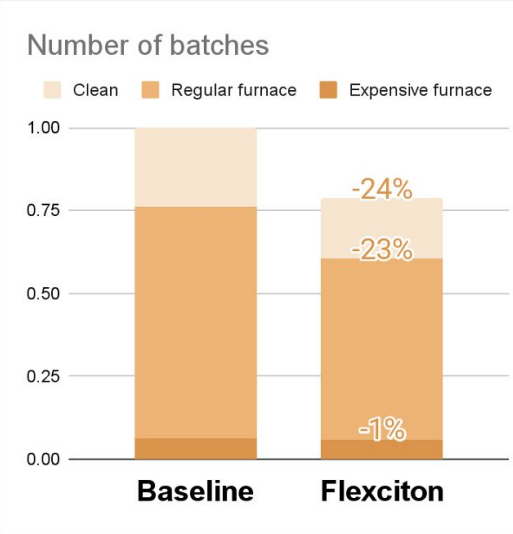
Case study #2: Gains at clean and furnace

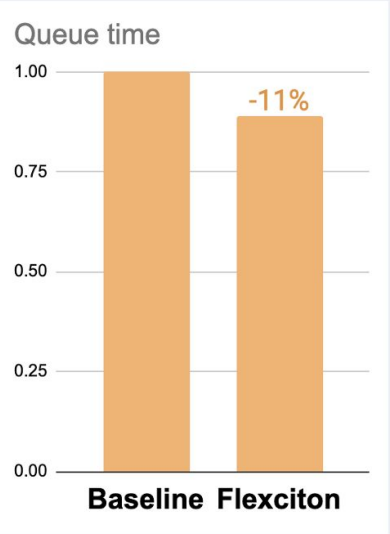
RENESAS
BIG IDEAS FOR EVERY SPACE

Results

29% reduction in timelink violations, **22%** reduction in number of batches and **11%** reduction in queue time







Flexciton

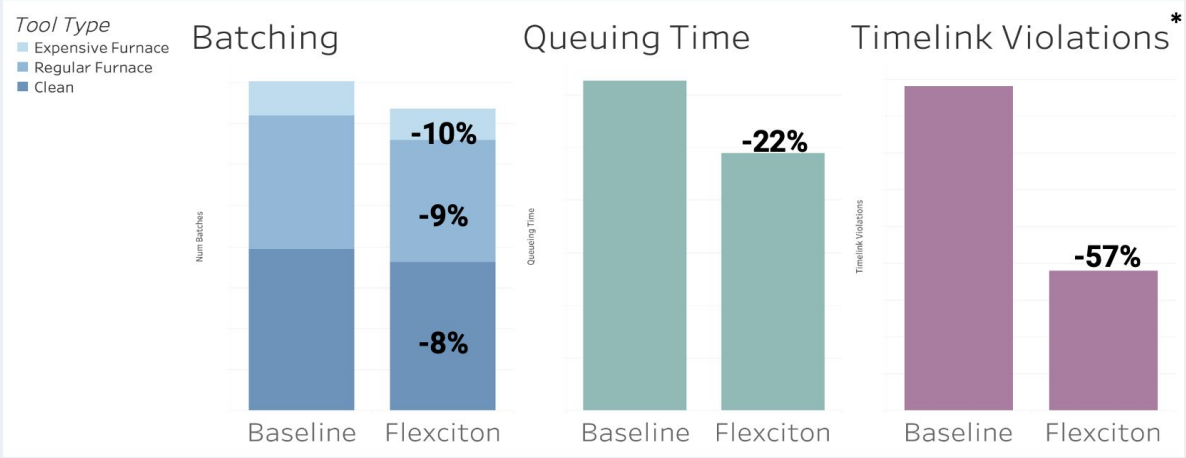
Case study #3: Improvements at clean and furnace

Introduction

- A fab in Europe supplying automotive manufacturers.
- The fab has been struggling to achieve expected efficiencies at clean and furnace due to complex timelink constraints.
- We took a similar approach to Renesas, where we built a simulation environment to apply our optimisation technology.
- The results from the offline simulation (next slide) led to live deployment of Flexciton optimiser in this fab.

Case study #3: Improvements at clean and furnace

Results



** Non-critical violations that cause rework*

Energy efficiency opportunities

Bottlenecks

➔ Doing more with less creates energy efficiency opportunities

➔ Photo - more moves with less tools means:
- Possible to idle tools -> reduce energy consumption
- Possible to avoid buying more tools -> reduce energy consumption

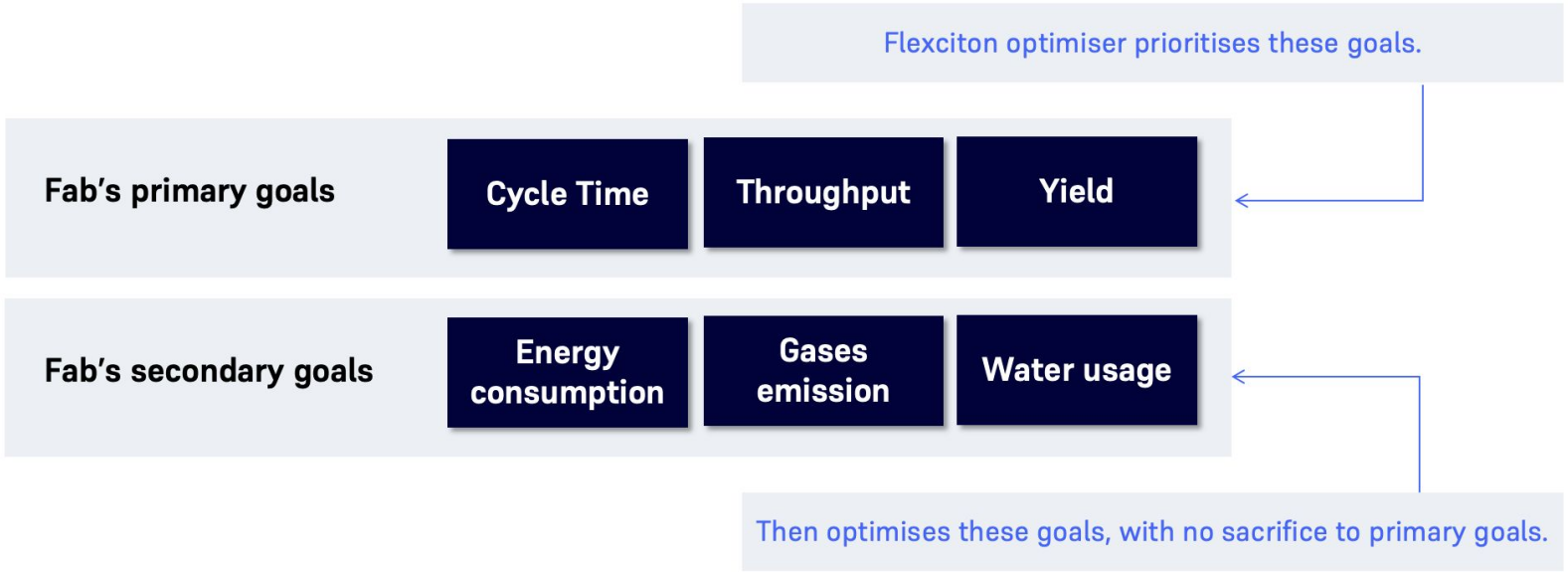
➔ Clean and Furnace – same moves, fewer batches:
- Fewer energy intensive furnace runs -> reduce energy consumption

Energy efficiency opportunities with Flexciton

02 Optimising energy consumption whilst delivering primary KPIs

- Flexciton optimiser is built to work with any constraints and objectives.
- We can optimise production schedules for energy efficiency without sacrificing fab's primary KPIs.

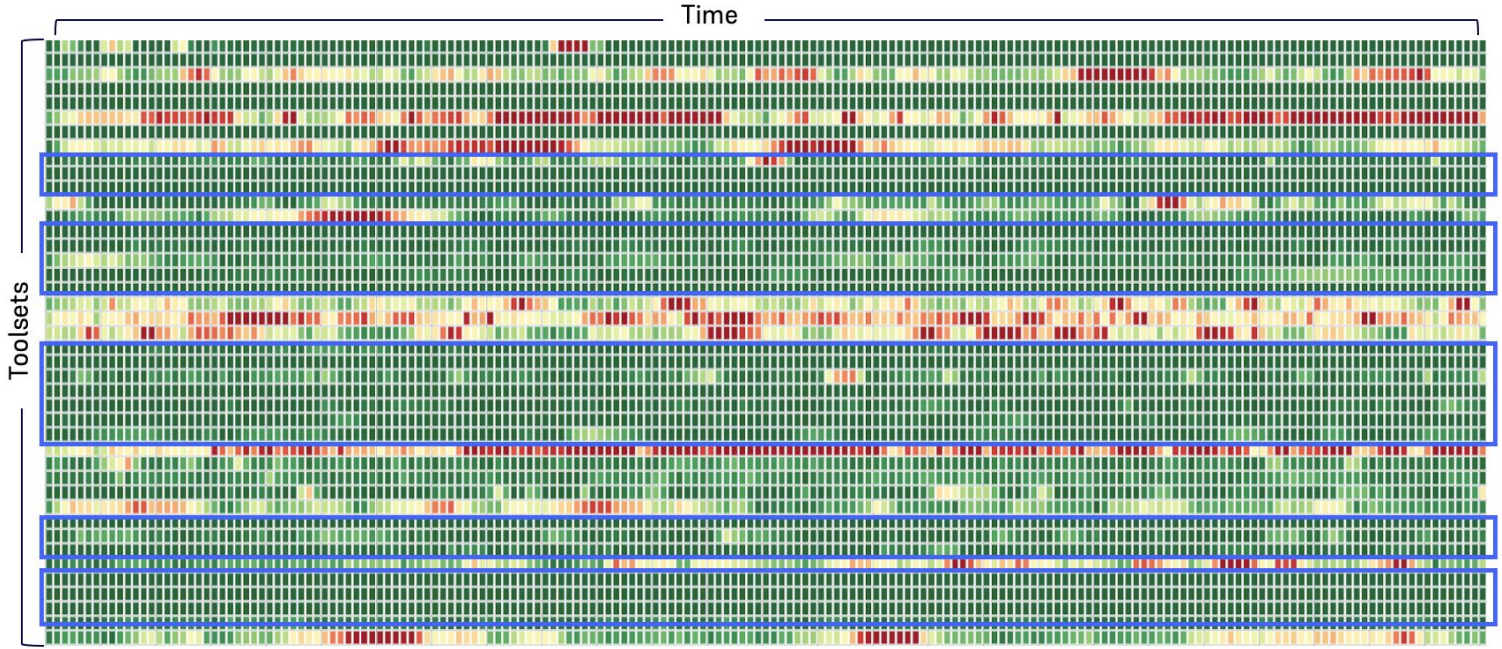
Energy efficiency opportunities with Flexciton



Energy efficiency opportunities with Flexciton

An overview of the fab status quo

We can optimise non-bottleneck toolsets for energy efficiency goals without jeopardising primary KPIs.



The Flexciton Optimisation Platform

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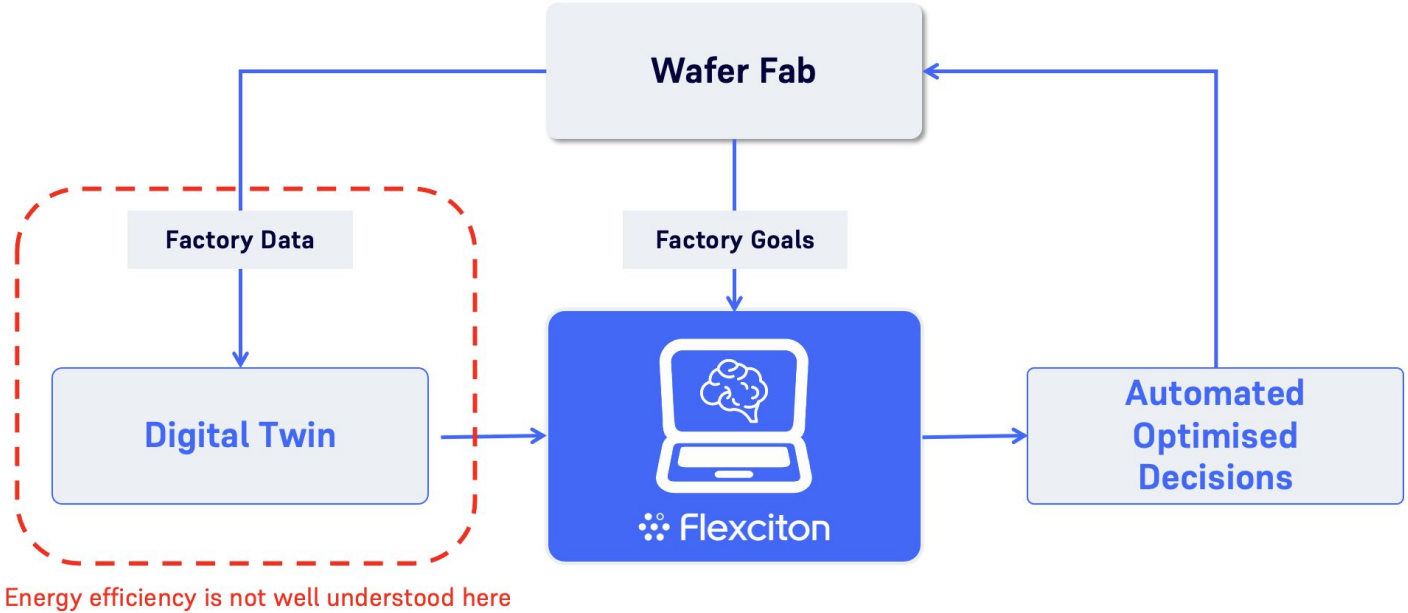

Energy efficiency opportunities with Flexciton

02 Optimising energy consumption whilst delivering primary KPIs

- Flexciton optimiser is built to work with any constraints and objectives.
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→ Energy Efficiency Study Project

Energy efficiency opportunities with Flexciton

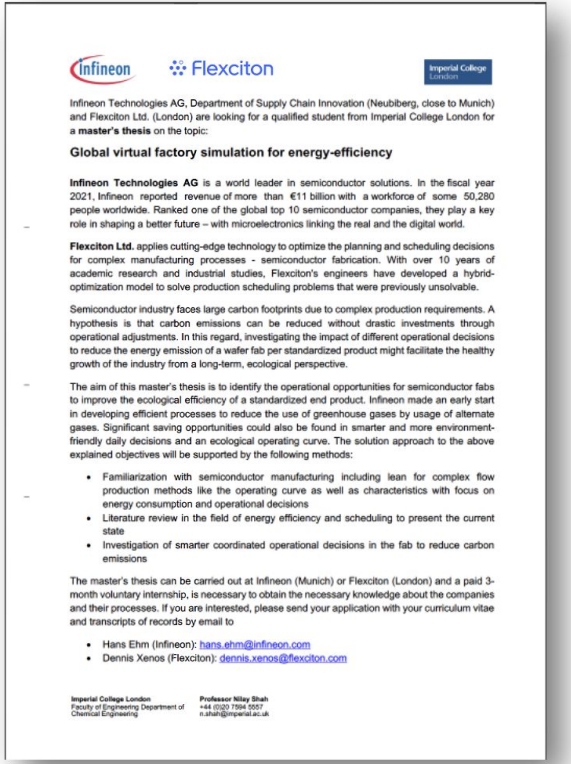
Global virtual simulation for energy efficiency

- We're working with:
  - Technical University of Munich
  - Imperial College London
  - Infineon Supply Chain Innovations

- Infineon want to optimise energy consumption in their attempt to achieve CO2 neutrality by 2030.

- Aim – better understand how smarter decisions can reduce carbon emissions.

- Future – Flexciton specifically optimises for energy consumption.



Infineon Flexciton Imperial College London

Infineon Technologies AG, Department of Supply Chain Innovation (Neubiberg, close to Munich) and Flexciton Ltd. (London) are looking for a qualified student from Imperial College London for a **master's thesis** on the topic:

Global virtual factory simulation for energy-efficiency

Infineon Technologies AG is a world leader in semiconductor solutions. In the fiscal year 2021, Infineon reported revenue of more than €11 billion with a workforce of some 50,280 people worldwide. Ranked one of the global top 10 semiconductor companies, they play a key role in shaping a better future – with microelectronics linking the real and the digital world.

Flexciton Ltd. applies cutting-edge technology to optimize the planning and scheduling decisions for complex manufacturing processes - semiconductor fabrication. With over 10 years of academic research and industrial studies, Flexciton's engineers have developed a hybrid-optimization model to solve production scheduling problems that were previously unsolvable.

Semiconductor industry faces large carbon footprints due to complex production requirements. A hypothesis is that carbon emissions can be reduced without drastic investments through operational adjustments. In this regard, investigating the impact of different operational decisions to reduce the energy emission of a wafer fab per standardized product might facilitate the healthy growth of the industry from a long-term, ecological perspective.

The aim of this master's thesis is to identify the operational opportunities for semiconductor fabs to improve the ecological efficiency of a standardized end product. Infineon made an early start in developing efficient processes to reduce the use of greenhouse gases by usage of alternate gases. Significant saving opportunities could also be found in smarter and more environment-friendly daily decisions and an ecological operating curve. The solution approach to the above explained objectives will be supported by the following methods:

- Familiarization with semiconductor manufacturing including lean for complex flow production methods like the operating curve as well as characteristics with focus on energy consumption and operational decisions
- Literature review in the field of energy efficiency and scheduling to present the current state
- Investigation of smarter coordinated operational decisions in the fab to reduce carbon emissions

The master's thesis can be carried out at Infineon (Munich) or Flexciton (London) and a paid 3-month voluntary internship, is necessary to obtain the necessary knowledge about the companies and their processes. If you are interested, please send your application with your curriculum vitae and transcripts of records by email to

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