



# COLLABORATION - THE CHALLENGE TO REDUCE EMISSIONS DURING A PERIOD OF GROWTH

SEMICON Europa  
Chris Jones  
November 2022

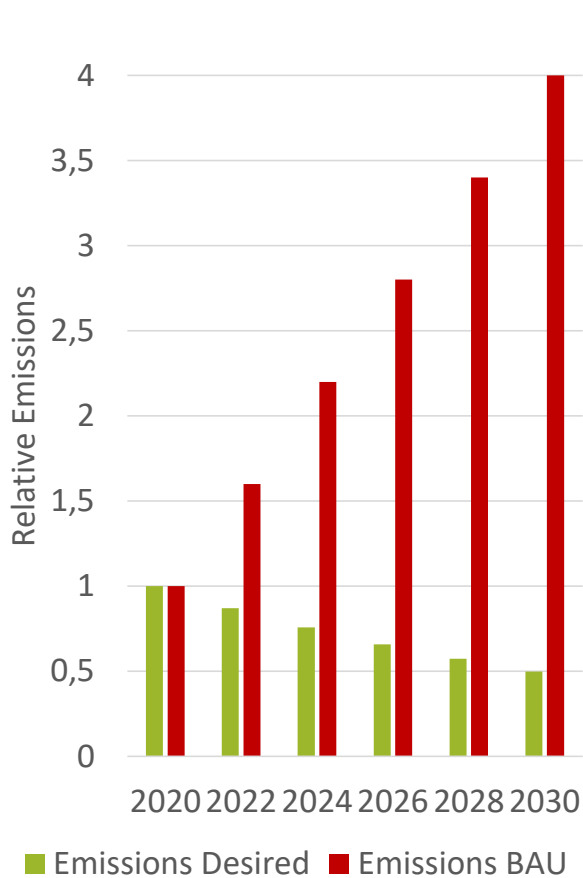


## Sustainability Is A Broad Topic

- Topics are taken from the materiality matrices of leading semiconductor companies.
- Areas of interest include environmental, human, regulatory, and business practice focusses.



## Sustainability Challenge – *GHG Emissions is one of many.*



- The industry faces many challenges:
  - GHG emissions, global warming and climate change.
  - Use of critical materials and water.
  - Energy costs.
  - Air pollution.
- The semiconductor industry could increase GHG (scope 1 and 2) emissions by a factor of four by 2030 when the 1.5°C pathway needs a 50% reduction.
- How do we move forward?

# The challenge for the industry – the greenhouse gas protocol scopes.



**Power reduction of equipment and the use of renewable electricity can have major impacts on scope 2.**



**Abatement is used to treat hazardous and greenhouse gases. Reduce their scope 1 emissions.**

**Scope 2**  
*Indirect*

Emissions from generating electricity, steam, and cooling for own use.

← Upstream Activities

**Scope 1**  
*Direct*

CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, PFC, HFC, SF<sub>6</sub>, NF<sub>3</sub>

Company facilities

Company vehicles

Reporting Company

**Scope 3**  
*Indirect*

Use of sold products

Transport and distribution

Leased assets

Franchises

End of life processing

Investments

Processing of sold products

Downstream Activities →

**Scope 3**  
*Indirect*

Purchased goods and services

Transport and distribution

Capital Goods

Waste from operations

Fuel and energy-related

Employee commuting

Leased assets

Business travel

← Upstream Activities

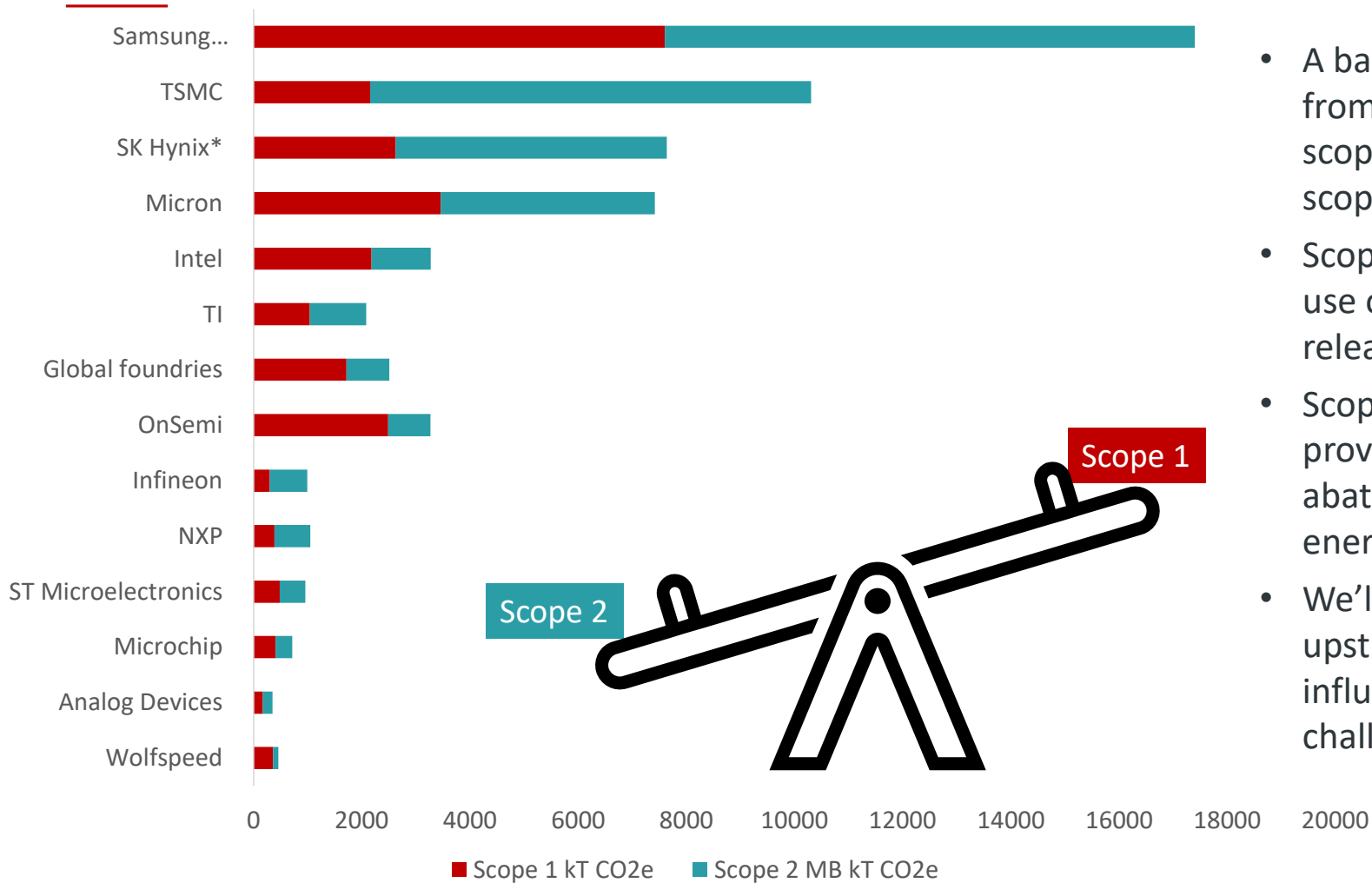
Your emissions

Your energy

What you buy

What you sell

## Major Manufacturers Scope 1 and 2 *(Public CSR/CDP information)*

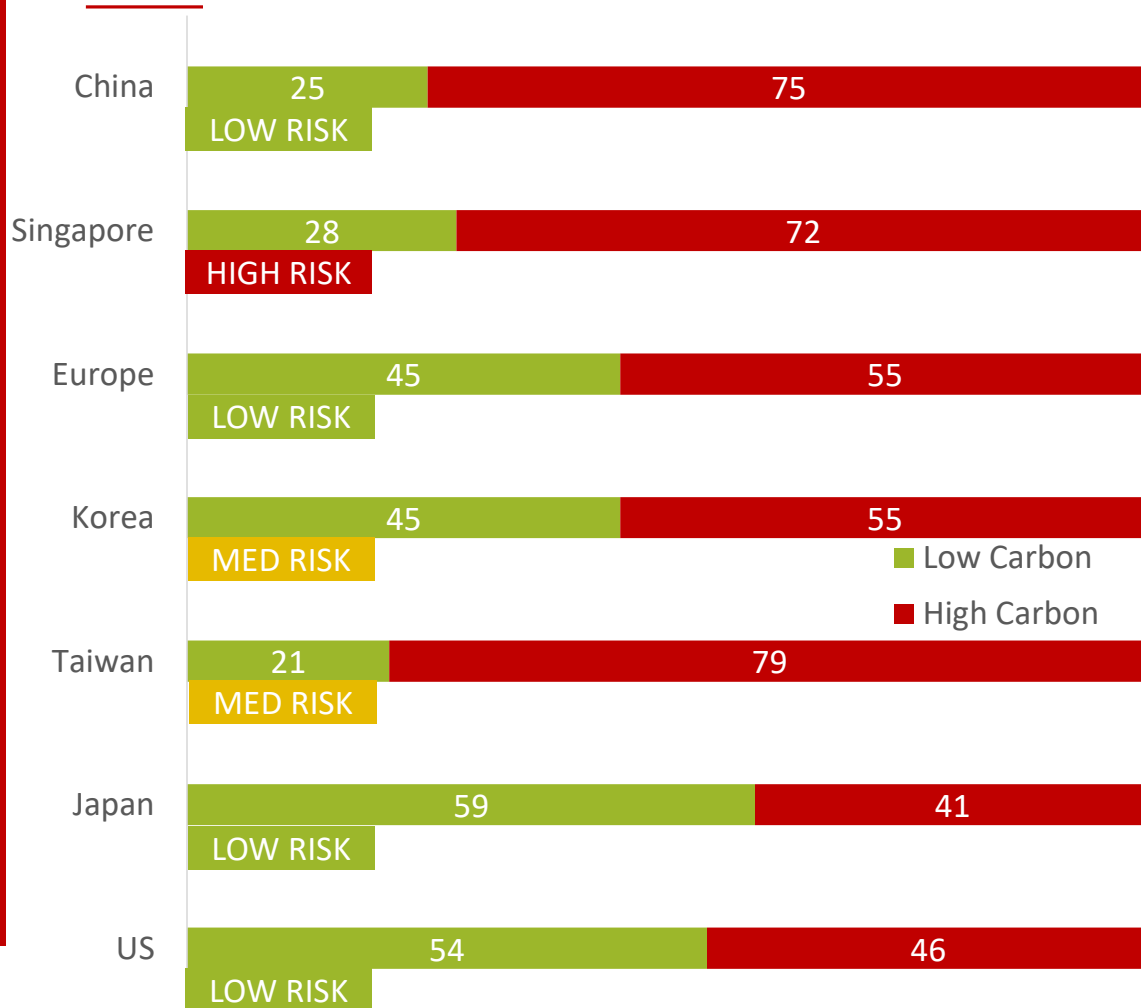


- A balance between emissions from direct emissions of GHG scope 1 and energy provision scope 2.
- Scope 1 mainly relates to the use of, abatement, and release of GHG.
- Scope 2 is largely electricity provision – our vacuum and abatement products influence energy consumption.
- We'll discuss both since the upstream vacuum strongly influences the abatement challenge.

## Emissions sustainability commitments – *Many steps forward*

Company	RE100 or Renewable	Net-Zero or Neutrality
Analog Devices	2025 100%	Scope 1&2 2050
Global foundries	No statement	Scope 1&2 2050
Infineon	2050 100%	Carbon Neutral 2030
Intel	2030 100% RE	Scope 1&2 2040
Microchip	2040 100%	Scope 1&2 2040
Micron	2025 100% US	Scope 1&2 2050
NXP	50% 2027	Carbon Neutral 2035
OnSemi	2040 100%	Scope 1&2 2040
Samsung Electronics	2050 100%	Scope 1&2 2050
SK Hynix*	2050 100%	Scope 1&2 2040
ST Microelectronics	2027 100%	Carbon Neutral 2027
TSMC	2050 100%	Scope 1&2 2050
Wolfspeed	No statement	50% 2030 2019 Scope 1&2 2050

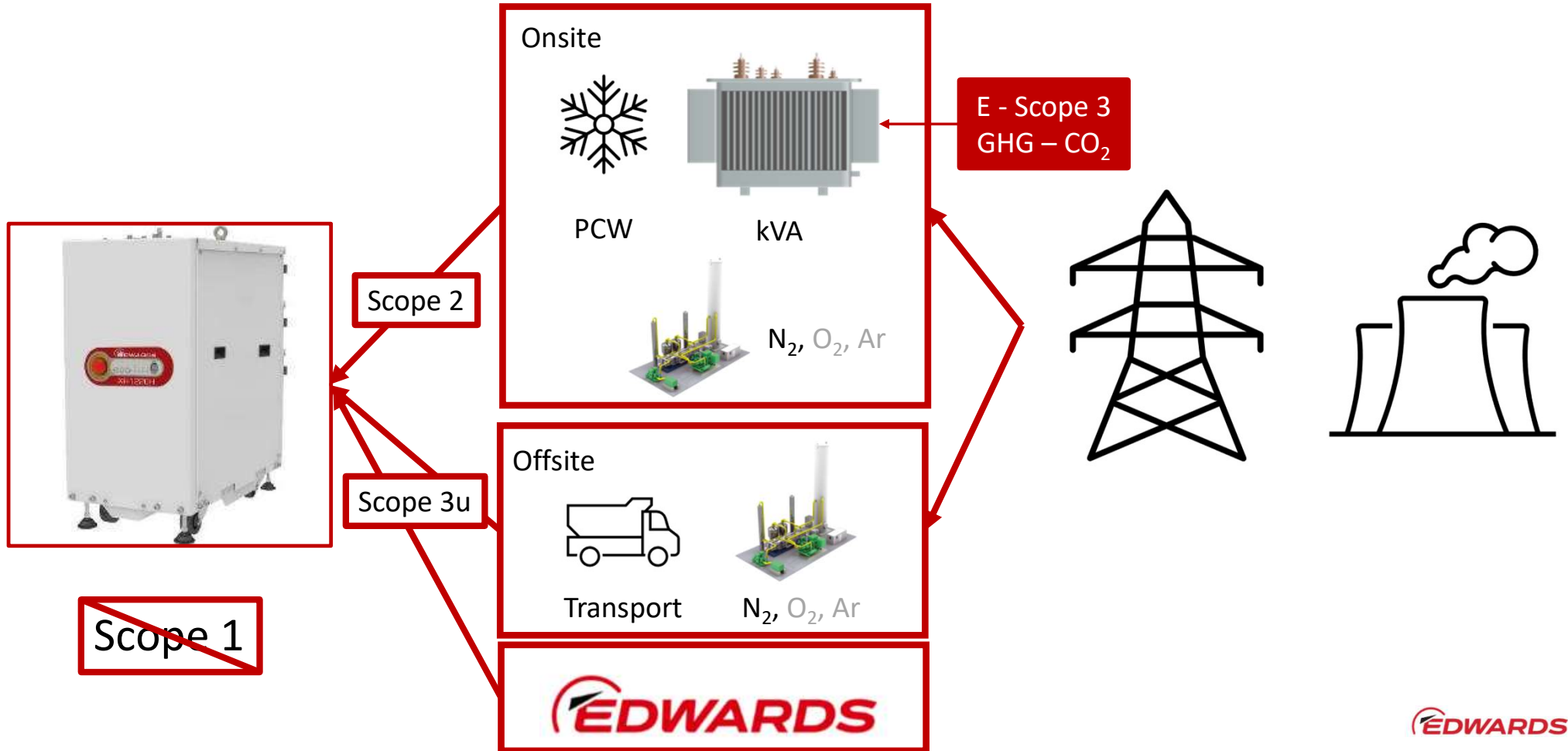
## Renewable energy challenge 2030 – *Regional Sensitivity*



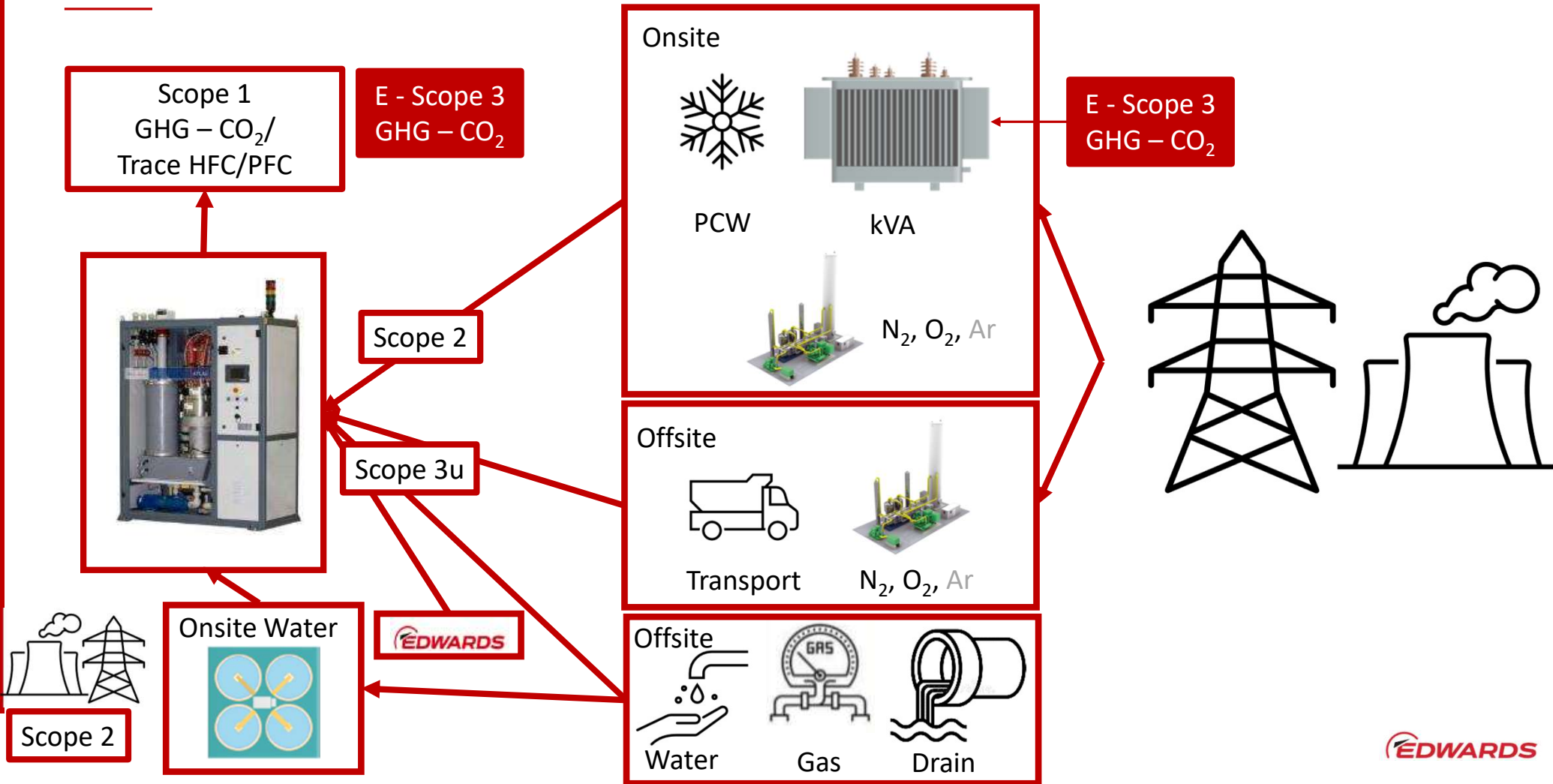
- By 2030, the proposed plans deliver between 21% and 59% low-carbon energy to the countries where major installations of EUV will be installed.
- The delivered geographic availability of low-carbon energy may delay achieving neutrality goals for some operators.
- We should expect more information ahead and during COP27 in November.
- LC-Energy is important when considering using electrical abatement (HW/PW) or alternative fuels such as hydrogen.



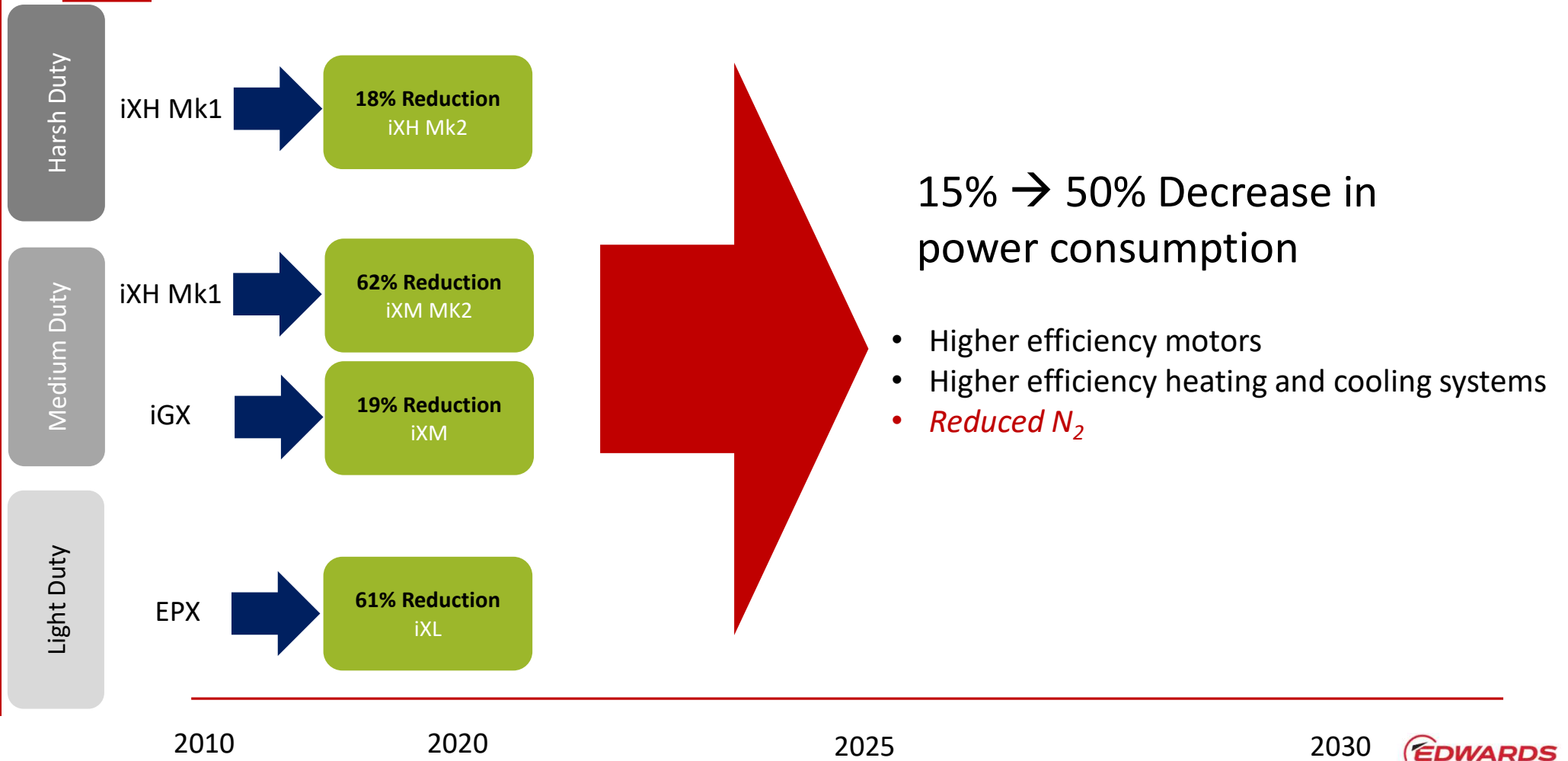
# Pump on a customer site – Their Scope 1, Scope 2, Scope 3 emissions



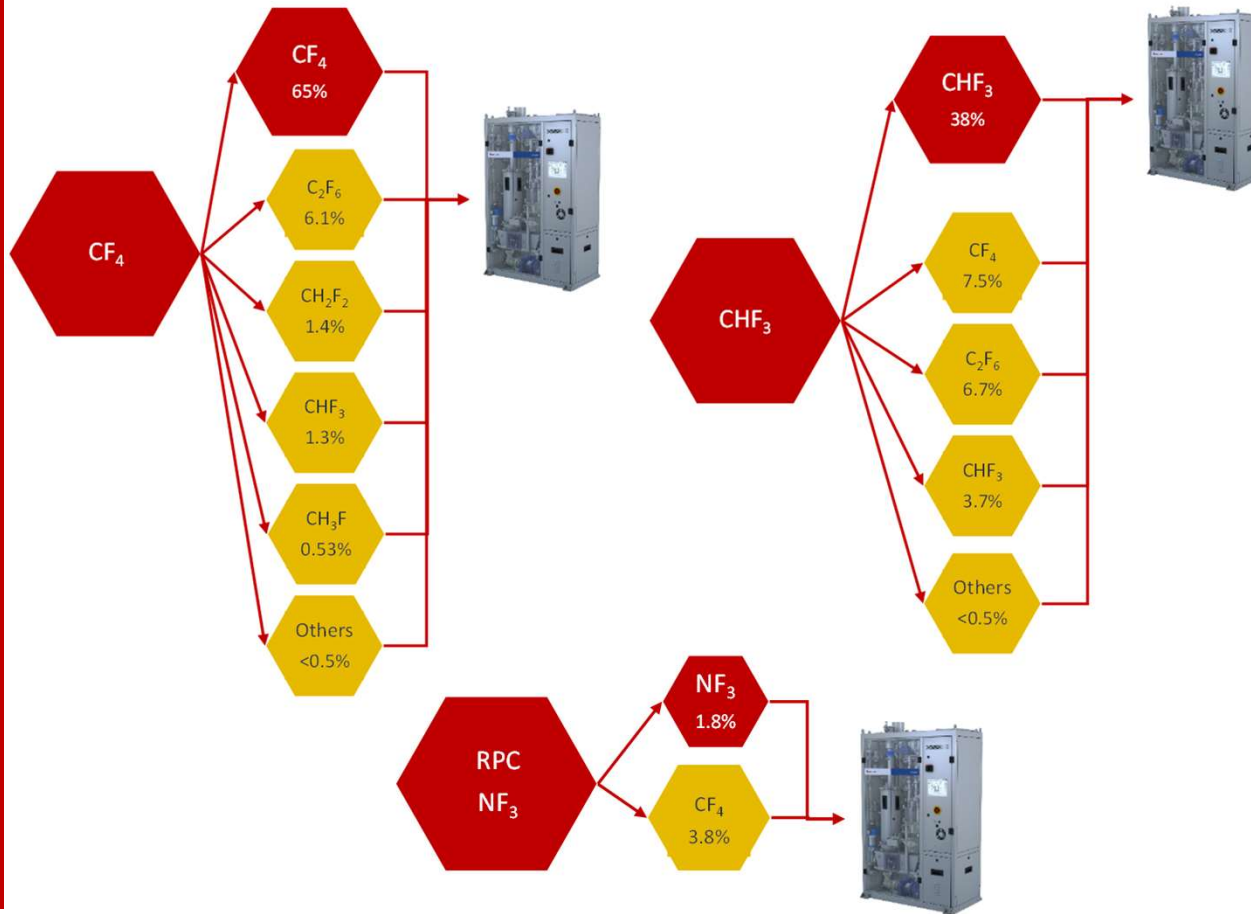
# Abatement on a customer site – Scope 1, Scope 2, Scope 3 in use emissions



## Dry Pump Power-down Roadmap



Process gases are converted to other PFCs, the Abatement should not generate  $\text{CF}_4$ .



- We treat the gases from the chamber.
- The energy used needs to reflect the abatement challenge.
- IPCC Rev 2019 and from 2023 EPA 40CFR Subpart I of Part 98 require confirmation of  $\text{CF}_4$  production rate in fossil-fuel driven abatement; we are <0.1% threshold level.
- Collaboration with process F-gas suppliers, tool owners, IDM and abatement providers is an important move to gases that are more effectively used in the chamber, easier to abate and have a lower GWP.

## IPCC/EPA Certification

- Edwards can provide EPA / IPCC certificates for our systems upon request.
  - Certificate now includes gas flow ranges for which DREs are valid.
  - IPCC cert includes additional note regarding F<sub>2</sub>/NF<sub>3</sub> conversion to CF<sub>4</sub>.
  - Revised EPA certificate required for NF<sub>3</sub>/F<sub>2</sub> revision and changes to default DREs.
- For the certificate to be valid, the customer must meet the stated requirements.
  - The abatement system is installed, commissioned, operated and maintained in accordance with Edwards Final Test and Commissioning documentation, the Instruction Manual and Service Operating Procedures.
  - Within the abatement system, all components on the process exhaust line, the fuel and oxygen inject lines up to and including the combustor must be Edwards' original parts.
  - Gas types and flows and utility supplies must all be within Edwards' recommendations as documented in the relevant product instruction manual.
  - Total gas flows per quadrant of the abatement system must not exceed Edwards stated maximum as documented in the relevant product instruction manual.

**EDWARDS** YA0003094 - Certificate of Regulatory Compliance for the 2019 Refinements to the 2006 IPCC Guidelines for Greenhouse Gas Inventories Abatement System Design Certificate





Table 1. Expected DRE Values for Edwards Abatement Systems





Process Gas	SRI Reference Table 2	1,2,4,6,10	1,2,4,6,10	1,2,4,6,10	Abatement System Type			
					Atlas Series (SRI)	Atlas Series (SRI)	Atlas Series (SRI)	Atlas Series (SRI)
Formic Acid								
Compound Name								
CO <sub>2</sub>		0.25	0.25	NV	NV	NV	NV	NV
CH <sub>4</sub>		0.27	0.25	0.25	NV	NV	NV	NV
C <sub>2</sub> H <sub>6</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>2</sub> H <sub>4</sub>		0.04	0.05	0.05	NV	NV	NV	NV
C <sub>2</sub> H <sub>2</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>2</sub> F <sub>6</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>2</sub> F <sub>4</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>3</sub> F <sub>8</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>3</sub> F <sub>6</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>3</sub> F <sub>4</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>3</sub> H <sub>8</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>3</sub> H <sub>6</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>3</sub> H <sub>4</sub>		0.05	0.05	0.05	NV	NV	NV	NV
C <sub>3</sub> H <sub>2</sub>		0.05	0.05	0.05	NV	NV	NV	NV
HCN		0.05	0.05	0.05	NV	NV	NV	NV
H <sub>2</sub>		0.05	0.05	0.05	NV	NV	NV	NV
H <sub>2</sub> O		0.05	0.05	0.05	NV	NV	NV	NV
N <sub>2</sub>		0.05	0.05	0.05	NV	NV	NV	NV
N <sub>2</sub> O		0.05	0.05	0.05	NV	NV	NV	NV
HF		0.05	0.05	0.05	NV	NV	NV	NV
SO <sub>2</sub>		0.05	0.05	0.05	NV	NV	NV	NV

NV = No DRE value defined.  
 Numbers in parentheses refer to the abatement system and product model specified in table 2.

© Edwards (2019) 1002 - 001  
 All rights reserved.  
 Page 1 of 4

## Many tasks - *Improved collaboration – More trust required – Break down walls*

Scope	Signals/Monitoring (optimisation)  ISO50001 Energy ↓	Purges/Dilution N <sub>2</sub> ↓ DRE ↑ Energy ↓	CIP Vacuum Energy ↓ Size ↓  Vac	CIP Abatement DRE ↑ Energy ↓  Abate.	Electrical Abatement 
Scope 1	✓	✓	✓	✓	✓
Scope 2	✓	✓	✓	✓	✓ (low C energy)

Scope	New fuels hydro- methane/hydrogen H <sub>2</sub> /CH <sub>4</sub> – H <sub>2</sub> (GBP Y)	Pre-concentration DRE ↑ Energy ↓ 	GHG Capture/Recycle Energy ↓ 	CIP Process Gases DRE ↑ Energy ↓  Gas	LC Energy Collaboration 
Scope 1	✓	✓	✓	✓	✓
Scope 2	✓	✓	✓	✓	✓

Scope	Cluster V&A DRE ↑ Energy ↓
Scope 1	✓
Scope 2	✓

Achieving sustainability goals requires many parties to come together in collaboration

V&A	OEM	IDM	Gas Supp.	Infrastruc.	Finance	Local Govt	Nat. Govt	Regulators	Glob. Gov.	Sensors	Data
-----	-----	-----	-----------	-------------	---------	------------	-----------	------------	------------	---------	------

## Swept Inlet – reduction of energy or improvement in DRE

### Goal

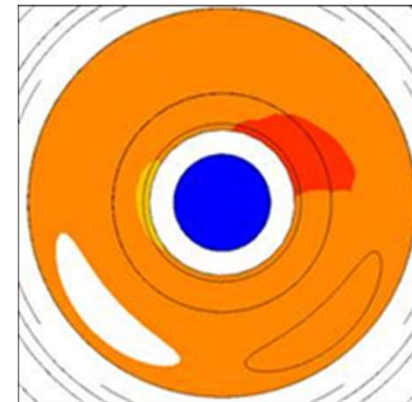
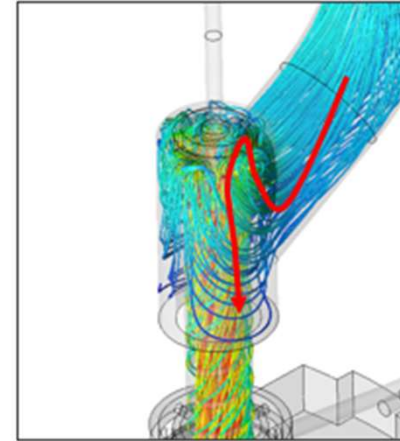
- Reduce fuel and oxygen usage for Etch.
- Maintain current DRE performance.
- Lower PCW usage.

### Technology Implementation.

- New inlet design.
- PTFE or Viton o-ring head seal.
- Improved mixing of oxygen and fuel injects.

### Status.

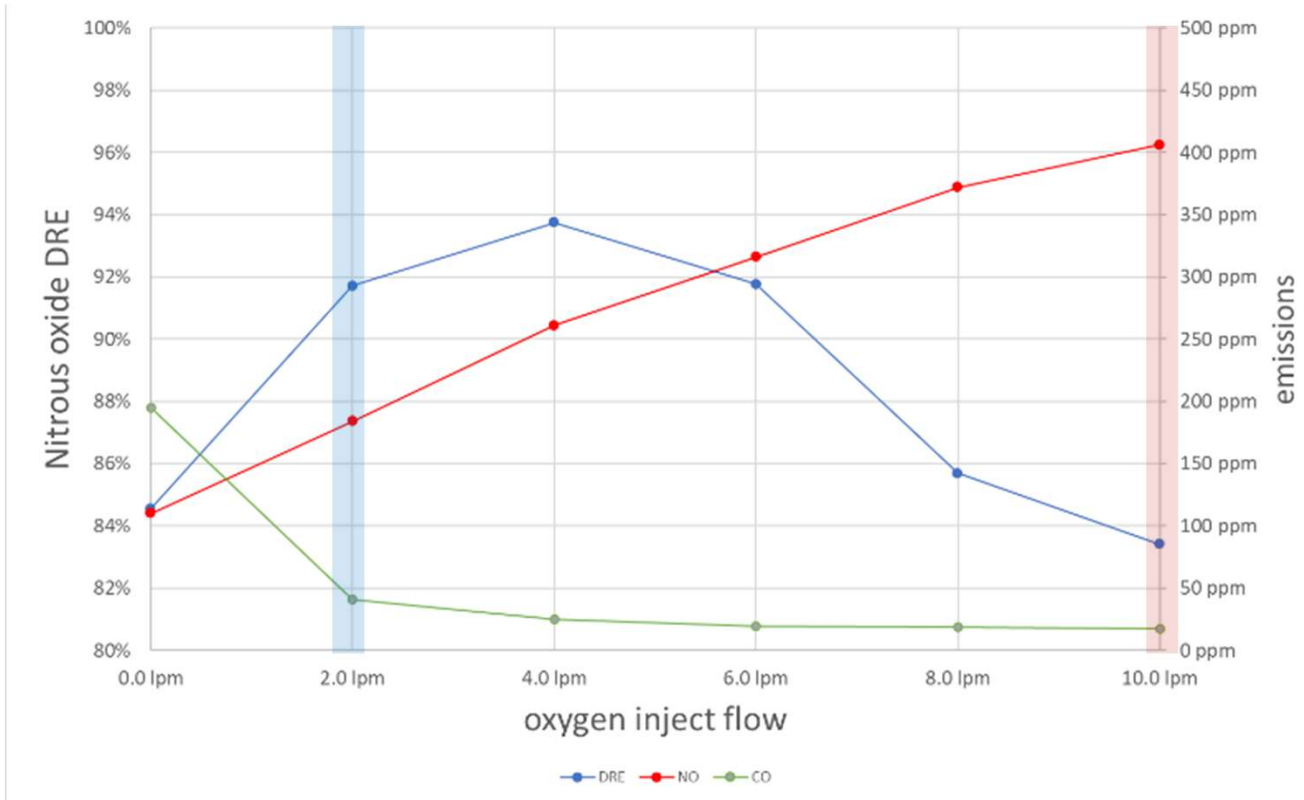
- Undergoing field evaluation as a technology demonstrator.
- 20% Reduction in fuel and oxygen usage.
- Signalling can result in a further 20% reduction in fuel and oxygen use.
- 95-98% Increase capacity with current fuel usage.
- 60% Lower NOx and CO emissions.



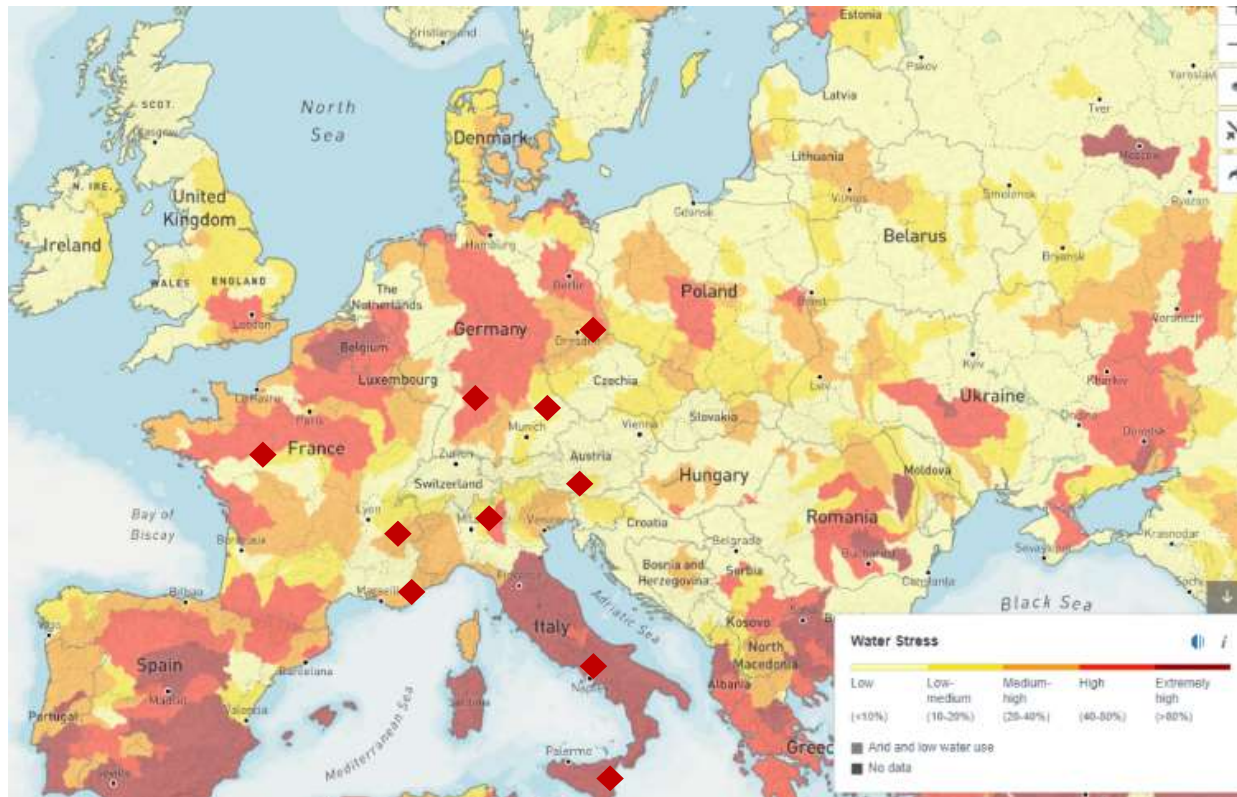
## Flame tuning – reduction of criteria pollutants.

### Lab data illustration

- Current conditions, high oxygen. ■
  - Clean combustion
  - ~ 400 ppm Nox
  - ~ 20 ppm CO
  - ~ 83% DRE N2O
- 
- Flame optimised, lower oxygen. ■
  - Optimum combustion
  - Balanced CO and Nox
  - ~ 200 ppm Nox
  - ~ 40 ppm CO
  - ~ 92% DRE N2O



## Europe – Fabs locations on a water stress map

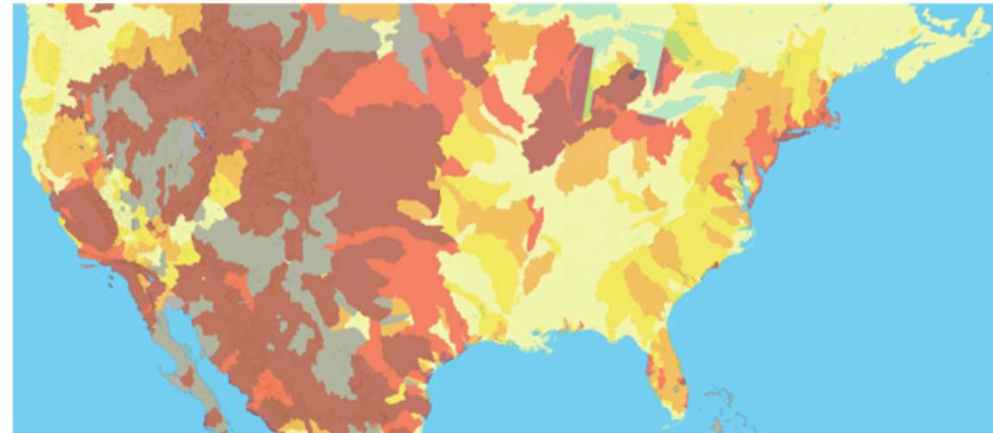


- A large fab may withdraw 13 million cubic metres of water in a year. This is equivalent to 31,000 US homes.
- Fabs are investing in water recycling/reuse/treatment facilities to maximise the use of water
- Optimisation targets 2-4% acid concentration – routinely 1.5 - 2.5 lpm – ideal for WWTP.
- Un-dosed packed tower scrubber operates well even with these low water flows.

## USA - Many fabs are operating in water stress areas.



2040 BAU



- A large fab may withdraw 13 million cubic metres of water annually. This is equivalent to 31,000 US homes.
- Fabs are investing in water recycling/reuse/treatment facilities to maximise the use of water

## Moving forward

- The industry is looking to grow strongly in the next decade.
- Sustainability challenges mean we have to achieve more with less.
- Collaboration and trust are critical.
- Success must be measured, verified, and publicly shared to ensure public credibility.
- We are proud to be members of the newly formed Semiconductor Climate Consortium – it will be a long and worthy journey for us all.

*Advantest*  
*Google*  
*Pfeiffer Vacuum*  
*AICELLO*  
*Hermes-Epitek*  
*Plexus Corp.*  
*AMD*  
*Hitachi High-Tech*  
*Samsung Electronics*  
*ams OSRAM Group*  
*imec*  
*Schneider Electric*  
*Analog Devices*  
*Intel Corporation*  
*SCREEN*  
*Applied Materials*  
*JSR*  
*Showa Denko Materials*  
*Arkema*  
*KLA*  
*onsemi*  
*GlobalWafers*

*SK Hynix*  
*ASE*  
*KOKUSAI ELECTRIC*  
*SkyWater*  
*ASM*  
*Kulicke & Soffa*  
*Sphera*  
*ASML*  
*Lam Research*  
*STMicroelectronics*  
*ASMPT*  
*Lasertec*  
*Sumitomo Chemical*  
*Athinia™*  
*Longi*  
*Tokyo Electron Limited*  
*Axcelis*  
*Marvell*  
*Tokyo Ohka Kogyo*  
*Brewer Science*  
*Western Digital*  
*Ovivo*

*Micron*  
*Tokyo Seimitsu*  
*DAS Environmental Expert*  
*Microsoft*  
*Tri Chemical Laboratories*  
*Dongjin Semichem*  
*Monument Chemical*  
*TSMC*  
*DuPont*  
*MYCRONIC*  
*UCT*  
*EBARA*  
*Nanya Technology*  
*ULVAC*  
*Edwards*  
*Nikon*  
*UTAC*  
*Entegris*  
*NXP*  
*VAT Group*  
*GlobalFoundries*

## Abstract

---

A credible reduction in both direct and indirect, specifically energy-related, greenhouse gas emissions is needed to meet the global warming goals outlined by the Paris Agreement. This is one of the many environmental sustainability challenges the semiconductor industry must face. This reduction must be achieved during a period of substantial growth for our industry and must be met by innovation and unprecedented collaboration.

We will describe the scale of the challenge, the specific issues that need to be overcome, and outline some approaches to halve our emissions on a decadal basis, whilst the industry could quadruple emissions by 2030 compared with 2020.

We all must understand the magnitude of the challenge.

## Speaker details

Christopher Jones is a PhD-qualified chemist with more than 30 years of experience in the environmental protection arena. He has designed and implemented processes to manage wastes generated by the semiconductor, nuclear, military, and pharmaceutical industries and developed analytical methods for air and water quality monitoring. He is the Environmental Solutions Business Development Manager at Edwards. He aims to help owners of fabs better understand the local and broader environmental sustainability implications associated with the operation of their facilities.





[edwardsvacuum.com](http://edwardsvacuum.com)