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# Sustainability and the Future of Moore's Law

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# Intel's Sustainability Vision

Help build a sustainable technology industry

#1

2022 America's Most Sustainable Company<sup>1</sup>

BARRON'S

#2

2023 America's Most Sustainable Company<sup>1</sup>

BARRON'S

Reducing our Footprint with sustainable suppliers, manufacturing, and distribution

Continuous Accountability

Sustainability by Design for Products, platforms, software and services

Driving Open Innovation that enables others to meet sustainability goals



# History of Taking Action Against Climate Change

**1994**

Intel begins voluntary environmental reporting

**1996**

Intel leads agreement to reduce use of perfluorocarbons (PFCs) in our industry

**2006**

Intel joins the US EPA Climate Leaders program and the EU Commission's Sustainable Energy Europe Campaign

**2008**

Intel becomes the largest voluntary corporate purchaser of green power under the US EPA Green Power Partner Program

**2012**

Intel reduces absolute GHG emissions more than 60% below 2007 levels, exceeding a 20% reduction goal

**2013**

Intel achieves 100% renewable electricity in the United States

**2017**

Intel achieves 100% renewable electricity in Europe

**2020**

Intel commits to new operational, industry, and global challenge climate goals for 2030

**2022 +**

Intel announces goal to achieve net zero Scope 1 + 2 GHG emissions by 2040

# Sustainability Goals in Intel Operations

## Climate & Energy

- Achieve net zero greenhouse gas (GHG) emissions across our global operations by 2040.
- By 2030, achieve 100% renewable electricity use across global operations; conserve 4 billion kWh of electricity; drive a 10% reduction in our absolute Scope 1 and 2 GHG emissions as we grow, informed by climate science.
- Build new factories and facilities to US Green Building Council LEED standards

**In 2021: Achieved 80% renewable electricity use**

## Water

By 2030, achieve net positive water use by conserving 60 billion gallons of water and funding external water restoration projects.

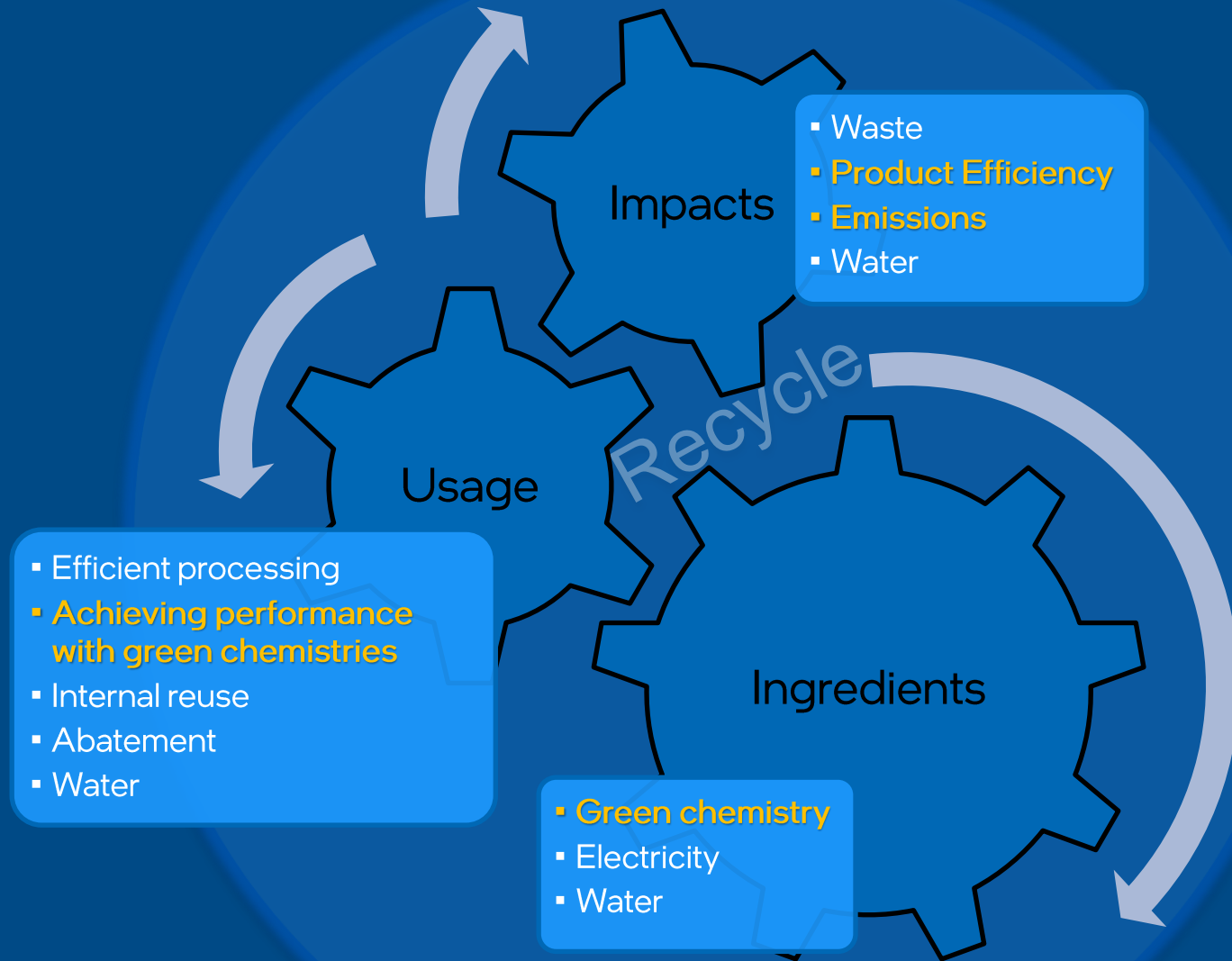
**In 2021: 9.3 billion gallons conserved and net positive in US, Costa Rica and India**

## Waste

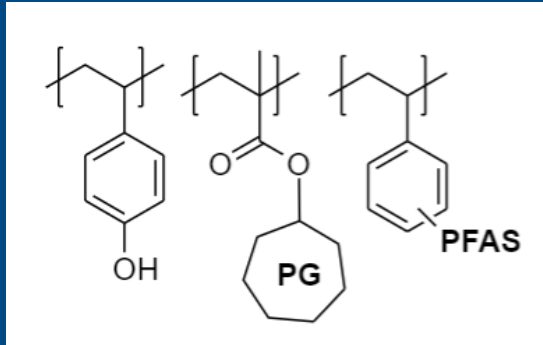
By 2030, achieve zero total waste to landfill and implement circular economy strategies for 60% of our manufacturing waste streams in partnership with suppliers.

**In 2021: 5% total waste to landfill**

# Opportunities for a Greener Fab

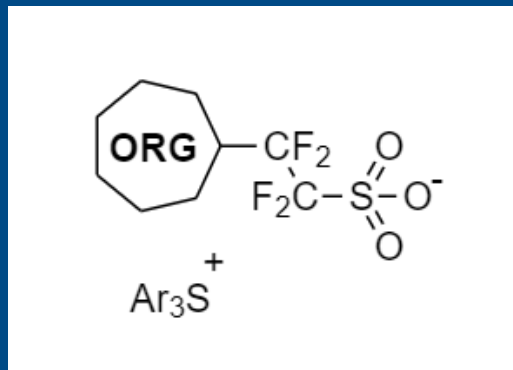


# Green Chemistry Focus: PFAS in Photoresists

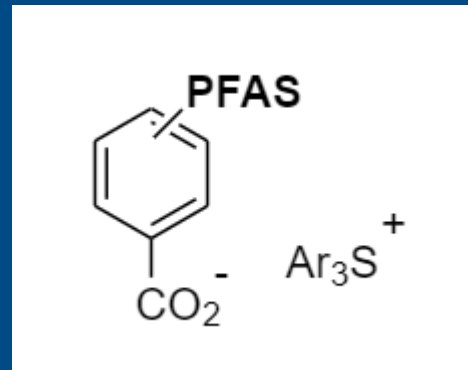


Polymer

Generally found as isolated  $\text{CF}_2$  or  $\text{CF}_3$  groups



PAG



Quencher

## Roles of PFAS in EUV Resists (CAR's)

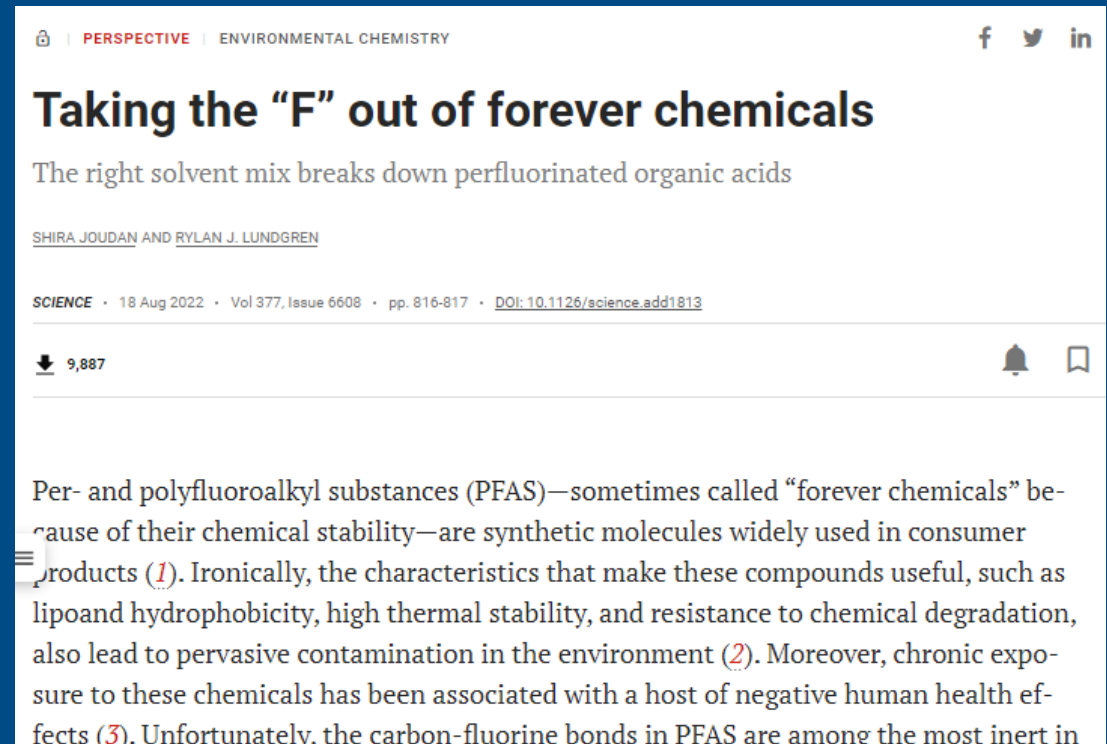
- 1) Superacidity of photoacid
- 2) Increase EUV absorbance
- 3) Quencher basicity tuning
- 4) Distribution of components
- 5) Rinses (ancillary material)

*Efforts already in progress to move to PFAS-free rinses*



# PFAS-Free Resists: Research Focus Areas

- **Replace** incumbent organic CAR's with Inorganic F-free resists
- **Remediate** PFAS in resist waste streams via chemical digestion
- **Redesign** CARs with no PFAS components



The screenshot shows a news article from Science magazine. The title is "Taking the 'F' out of forever chemicals" and the subtitle is "The right solvent mix breaks down perfluorinated organic acids". The authors are Shira Joudan and Rylan J. Lundgren. The article is dated 18 Aug 2022, Vol 377, Issue 6608, pp. 816-817, with a DOI of 10.1126/science.add1813. It has 9,887 downloads. The article text begins with: "Per- and polyfluoroalkyl substances (PFAS)—sometimes called 'forever chemicals' because of their chemical stability—are synthetic molecules widely used in consumer products (1). Ironically, the characteristics that make these compounds useful, such as lipophilicity and hydrophobicity, high thermal stability, and resistance to chemical degradation, also lead to pervasive contamination in the environment (2). Moreover, chronic exposure to these chemicals has been associated with a host of negative human health effects (3). Unfortunately, the carbon-fluorine bonds in PFAS are among the most inert in

# Green Chemistry and Emissions: Global Warming Potential



## Chemicals of Concern:

**Table 1.** The GWP and lifetime of major greenhouse gases.

Type of greenhouse gas	Lifetime (year)	GWP
CO <sub>2</sub>	50–200	1
CF <sub>4</sub>	50 000	6500
CHF <sub>3</sub>	250–390	11 700
C <sub>2</sub> F <sub>6</sub>	10 000	9200
C <sub>3</sub> F <sub>8</sub>	2600–7000	7000
C <sub>4</sub> F <sub>8</sub>	3200	8700
SF <sub>6</sub>	3200	23 900
NF <sub>3</sub>	50–740	8000
CH <sub>4</sub>	12	21
N <sub>2</sub> O	120	310

Source: Plasma Sci. Technol. 2020, 22, 105505.

## Problem Statement:

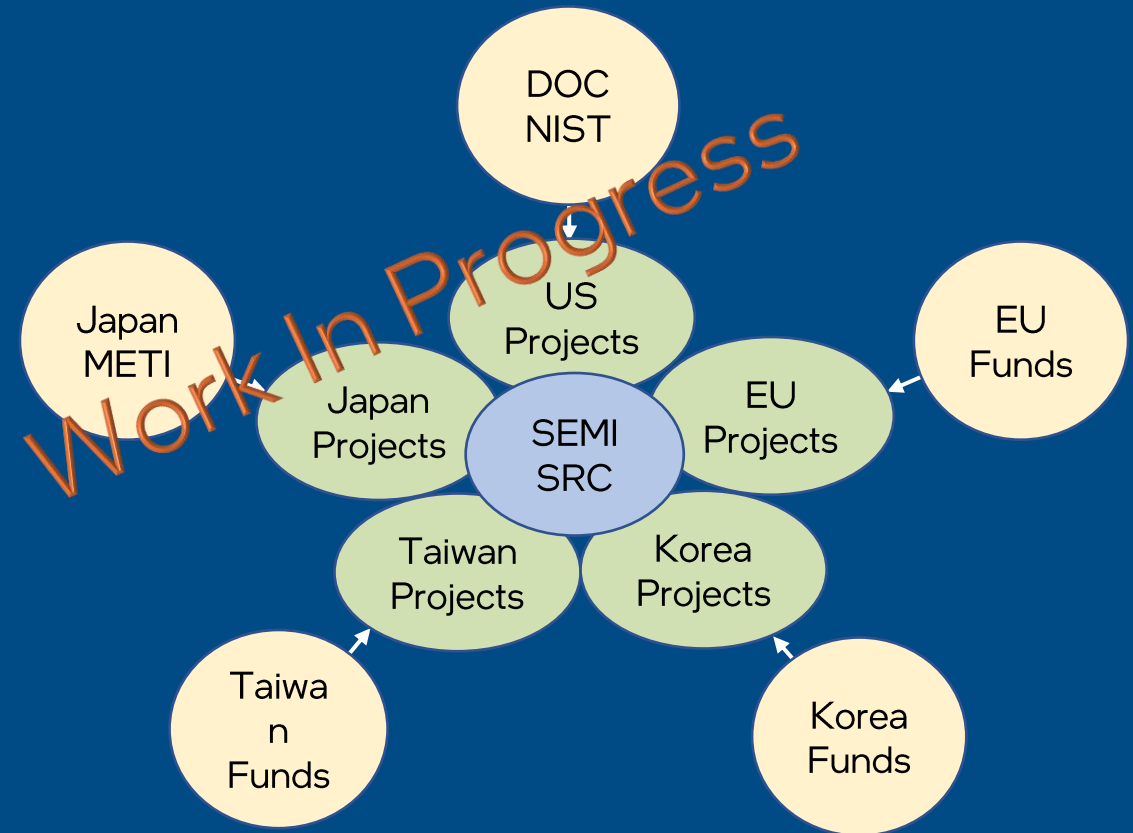
- For each Greenhouse Gas (GHG), a Global Warming Potential (GWP) was developed to quantify warming relative to CO<sub>2</sub>. Gases with high GWP absorb more energy thus contribute more to warming Earth. Fluorocarbon's have high GWP
- Dry etch & chamber clean gases, many of which are fluorocarbon's, are high priority for (GHG) emissions reduction
- Many standard etch gases have high GWP (i.e., CF<sub>4</sub>, CHF<sub>3</sub>, C<sub>2</sub>F<sub>6</sub>, C<sub>4</sub>F<sub>8</sub>, SF<sub>6</sub>, NF<sub>3</sub>, and other HFCs)



# Opportunity: Sustainable Semiconductor Manufacturing

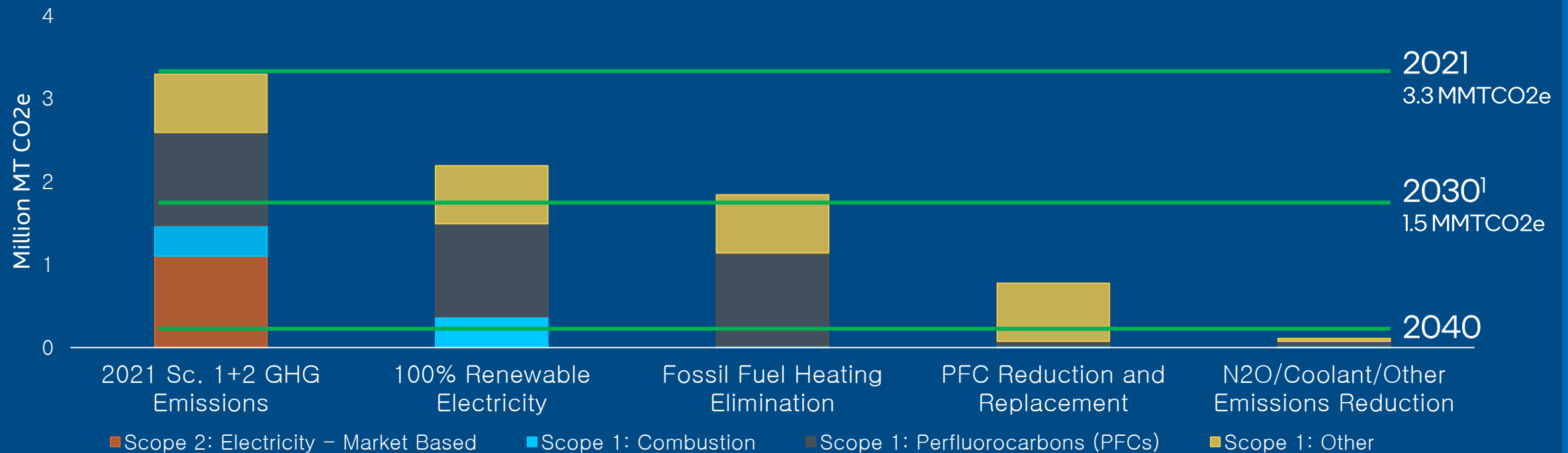
## Proposed Organization

- Regional governments provide funds for companies and universities in their region to explore semiconductor manufacturing R&D projects to improve sustainability
- Projects are contracted through SEMI and the Semiconductor Research Corporation (SRC), which provide a central coordination and data sharing role
- This alliance also helps with eliminating redundancies and leveraging learnings between regions
- Intel is willing to partner with companies developing new chemicals to assess their usefulness in semiconductor manufacturing



# Emissions: 2040 GHG Reduction Roadmap

Intel Goal: Achieve net zero greenhouse gas (GHG) emissions across our operations by 2040 and >50% reduction by 2030. Use credible offsets to achieve this goal only if other options are exhausted.



**Note:** Baseline emissions (and the corresponding 10% reduction target) may change as a result of new reporting requirements, changes to site ownership, etc.

**Note:** All efforts to reduce GHG emissions are being worked in parallel. The timescale in this chart does not represent the implementation timeline for individual projects in this chart.

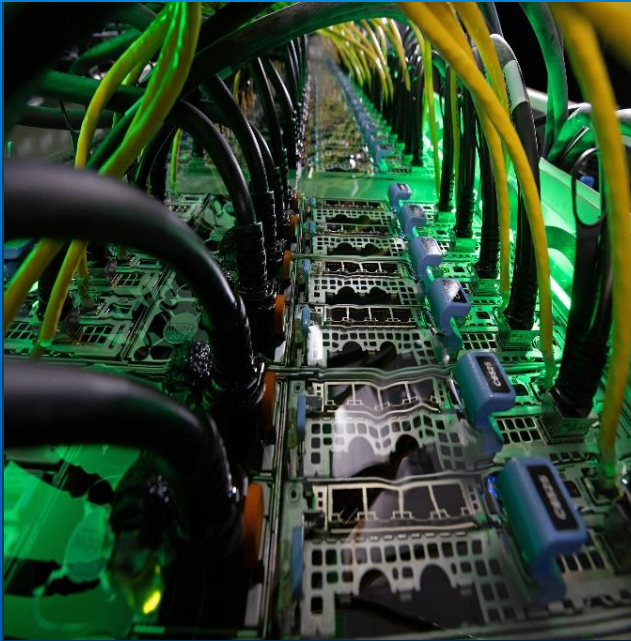
**Note:** Statements in this document that refer to future plans or expectations are forward-looking statements. These statements are based on current expectations and involve many risks and uncertainties that could cause actual results to differ materially from those expressed or implied in such statements. For more information on the factors that could cause actual results to differ materially, see our most recent earnings release and SEC filings at [www.intc.com](http://www.intc.com).

<sup>1</sup>Part of this emissions reduction is Intel's divestiture of the Dalian fab.

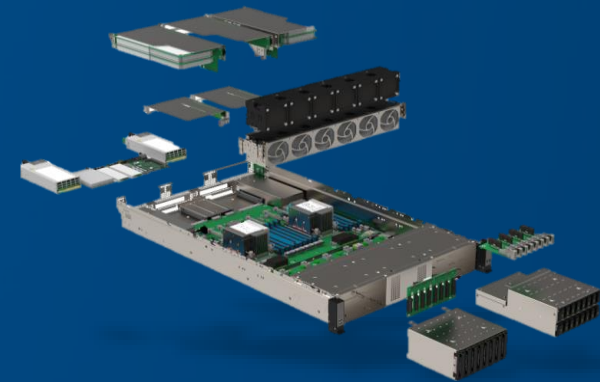
# Product Efficiency: Innovations in Data Center

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Design and  
Manufacturing



Liquid Cooling



Modularity





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