

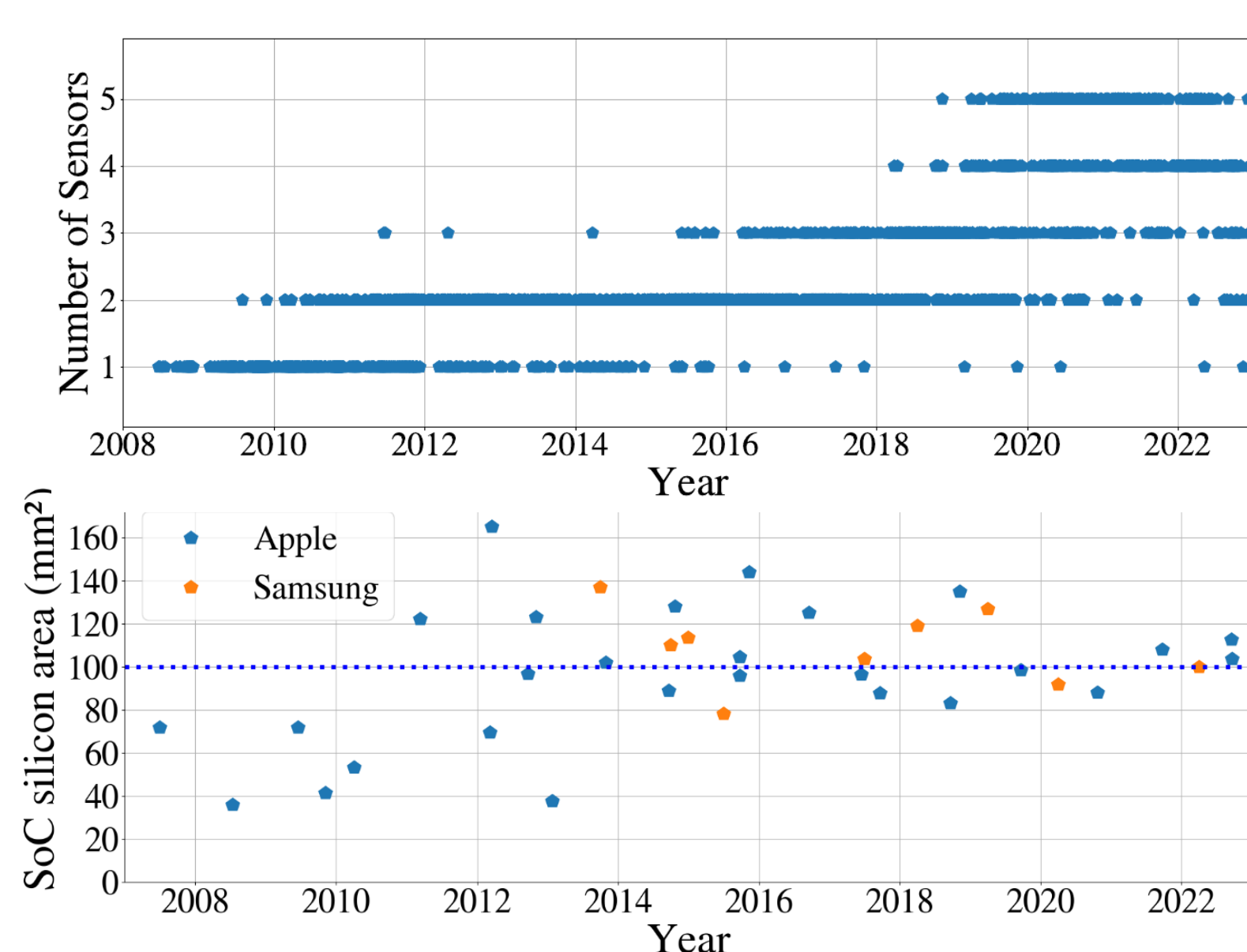
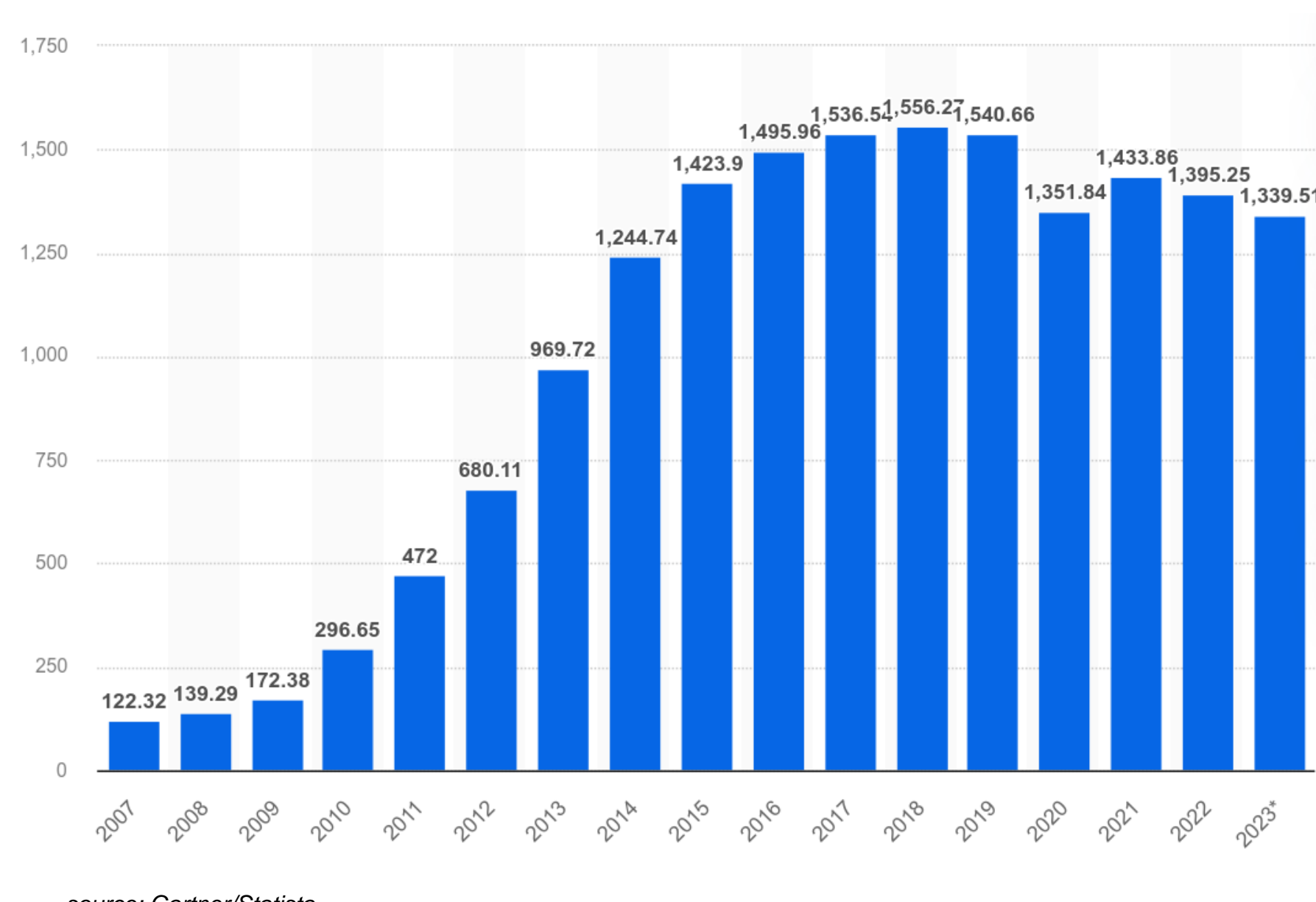
ICs and sustainability: Image sensors case study

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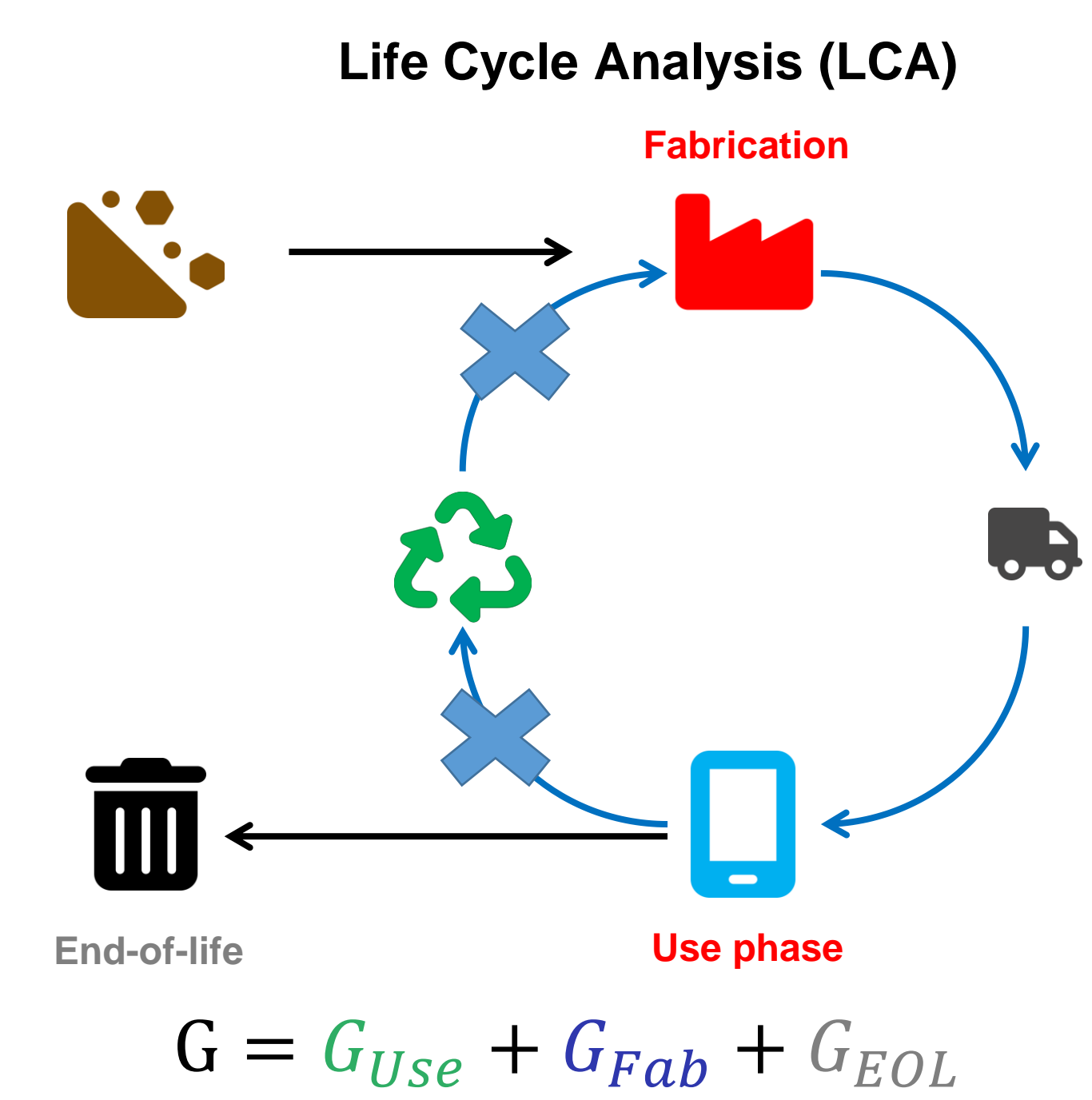


Growing impact of smartphone image sensors

Around 1.4 billions smartphones produced each year



Increased number of sensors → more silicon surface
In the meantime, silicon area of SoC remains stable



Model for use phase

Use phase accounts for the electrical energy used during image capture (**Use power**) and when the device is powered up but not in use (**Idle power**).

The GWP is determined by the total energy consumption of the device, which is then weighted according to the energy mix specific to the location where the device is used.

$$G_{Use} = T_{loc}(P_{Use}t_{Use} + P_{Idle}t_{Idle})$$

Electric carbon intensity at the use location (kgCO₂e/kWh)

Table 17 Current consumption and standby current (NOK = 18MHz, V_{DD} = 2.8V, V_{DDQ} = 1.05 V, V_P = 1.8 V, T_J = 60 °C)

Item	Symbol	Min.	Typ.	Max.	Unit
Current consumption (analog)	I _{DDA}	low	62.8	65.5	mA
Current consumption (digital)	I _{DDQ}		257.8	356.0	mA
Current consumption (IF)	I _{DD}		2.2	2.7	mA
Standby current (analog)	I _{DDSA}			2	µA
Standby current (digital)	I _{DDSQ}			158	µA
Standby current (IF)	I _{DDSF}			1	µA

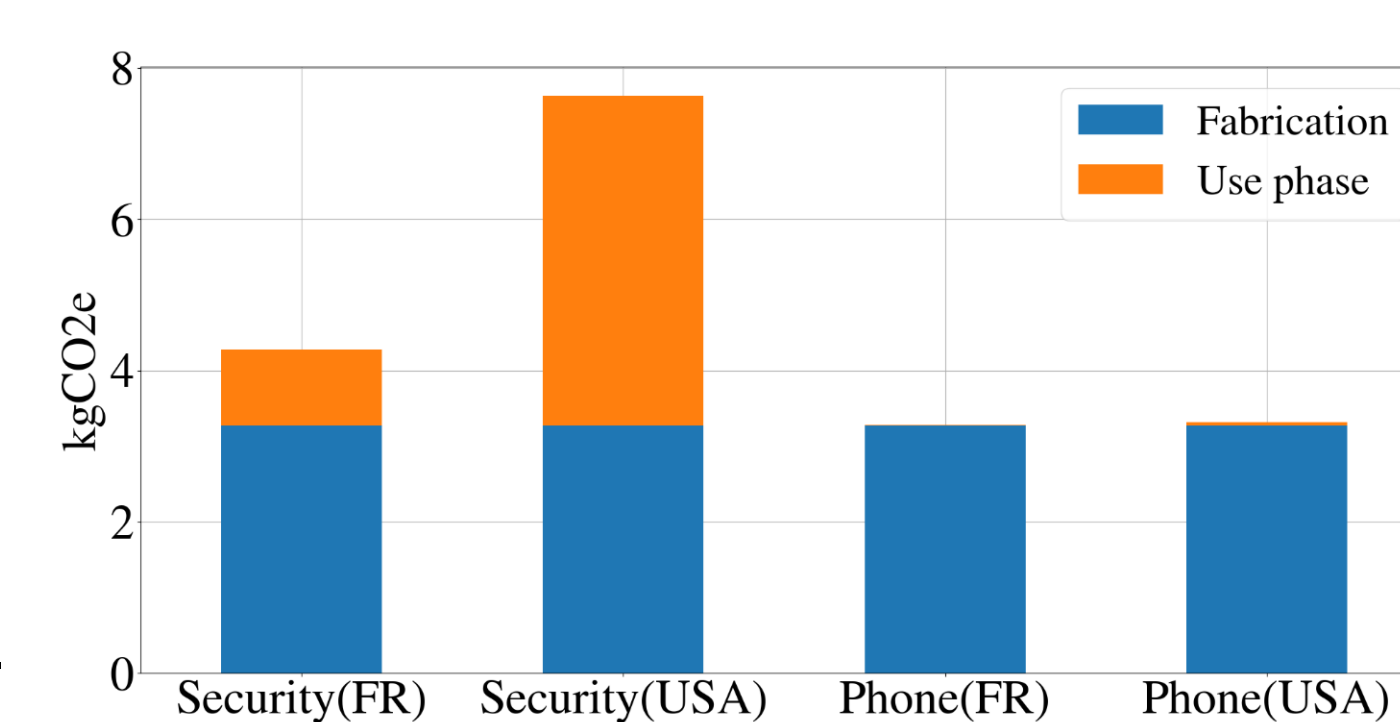
Excerpt from IMX576 datasheet

Results

- Total GWP for scenarios with the same sensor:
- security camera active 24/7
 - smartphone camera active 15min/day

→ G_{Use} is negligible for smartphones sensors.

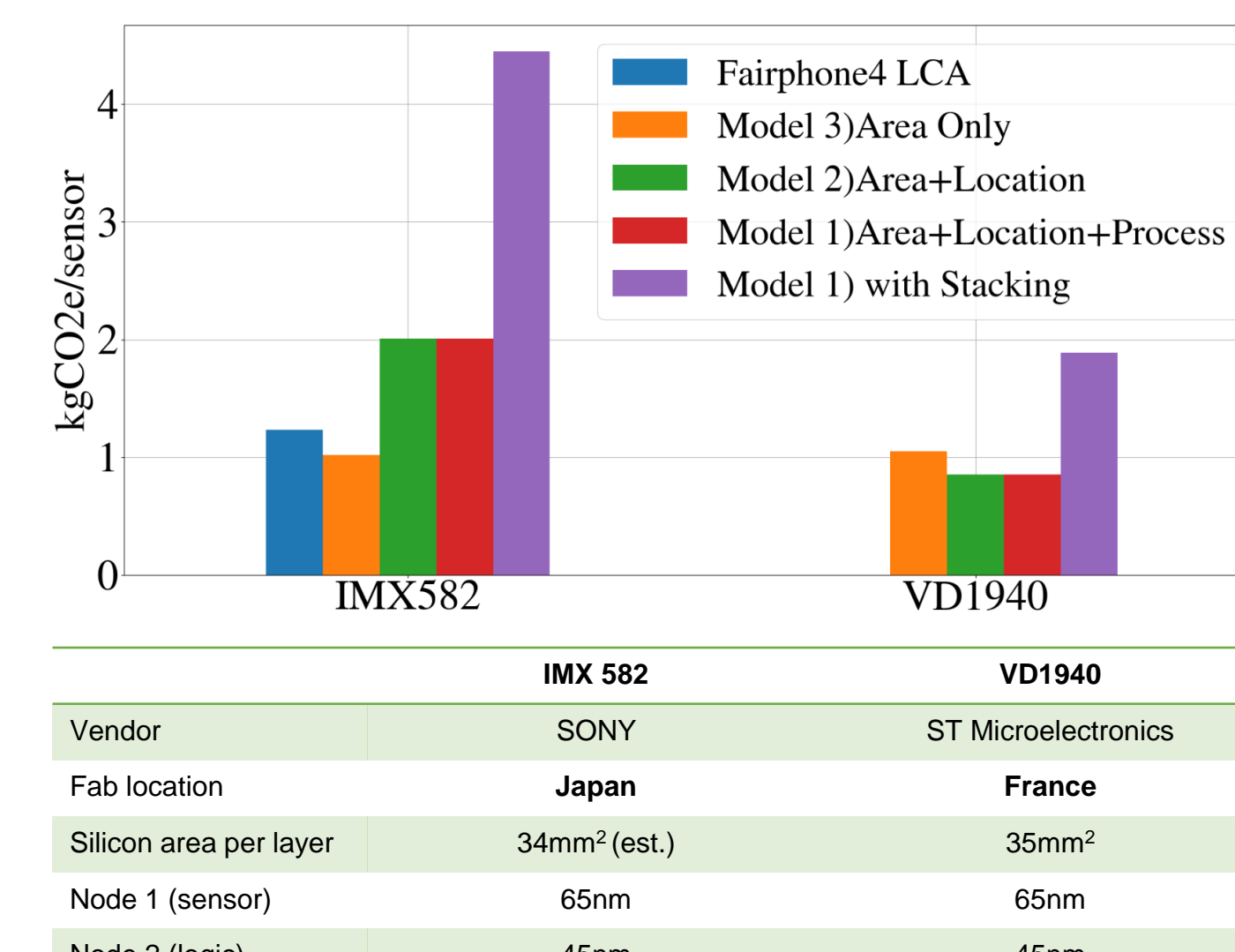
For devices that remain continuously active:
→ the local energy mix has a significant impact.



Fabrication impact of sensors with similar characteristics, constructed in different locations
→ influence of the energy mix at the factory.

The incorporation of 3D stacking technology amplifies GWP of the device by more than double.

For context, the estimation from Fairphone 4 LCA is 3.6 times lower for the same sensor.

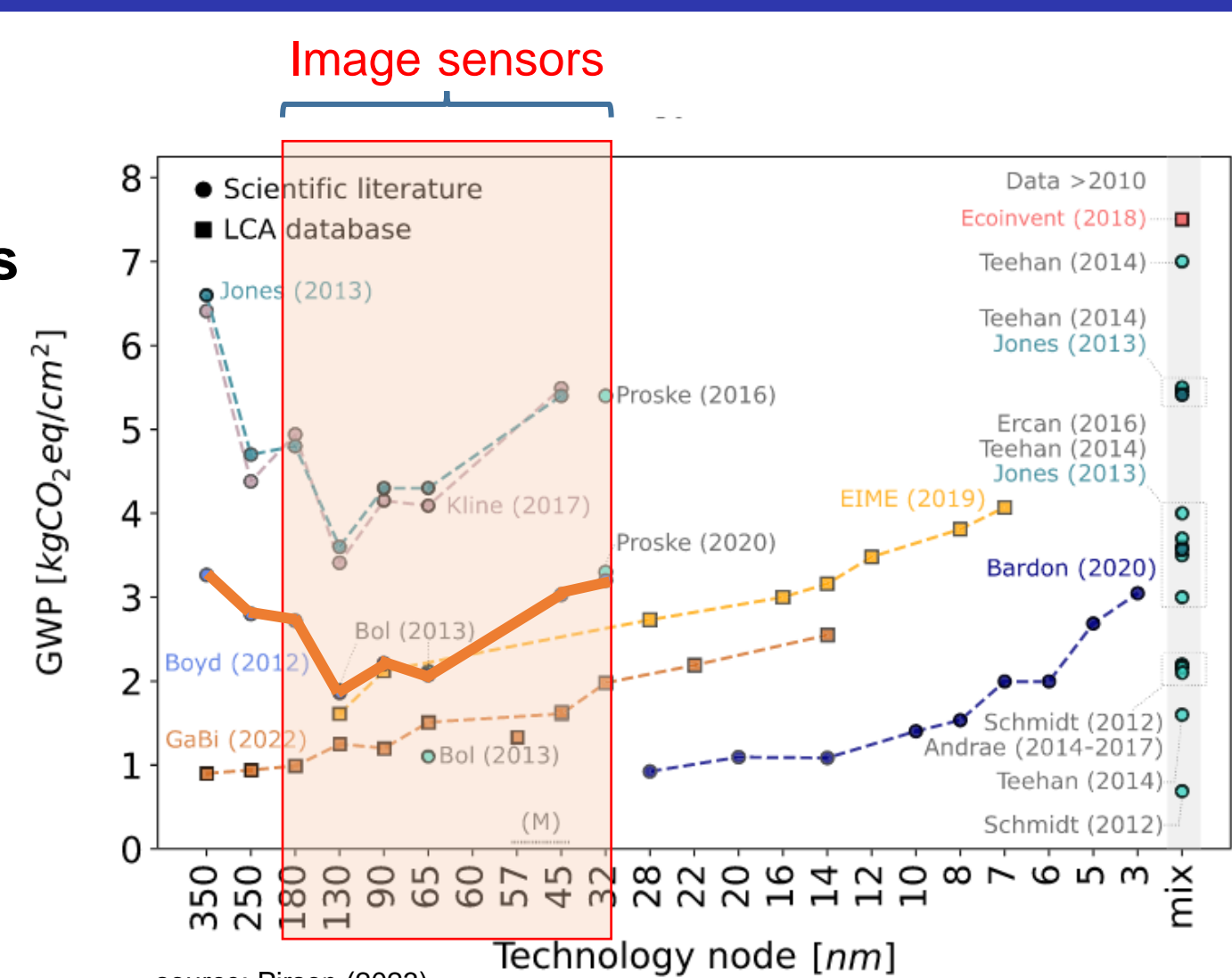


Model for fabrication phase

Scarce data from semiconductor manufacturers

Public information in databases and publications:

- Large discrepancies in results (up to 7x)
- Technology dependent: increase of carbon impact with more advanced technologies.



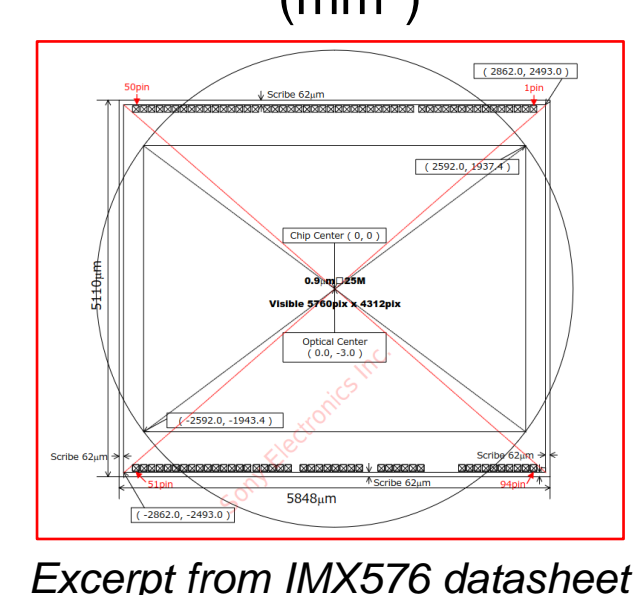
Proposed model for fabrication

- Proportional to silicon area
- Localize electrical power consumption
- Can adapt to available information
- Suited also for other types of ICs

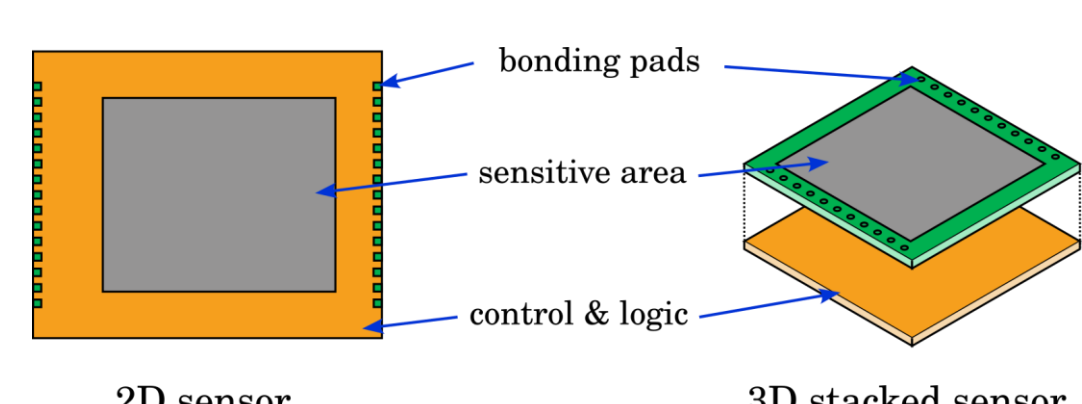
$$G_{Fab} = S \cdot (K_{nm} + E_{nm} \cdot T_{loc})$$

Ancillary Carbon Impact
Blank silicon wafer
Chemicals and materials
Gas emissions (kgCO₂e/mm²)

Manufacturing process electricity (kWh/mm²)



Excerpt from IMX576 datasheet



Advanced sensors use stacking of 2 dies:

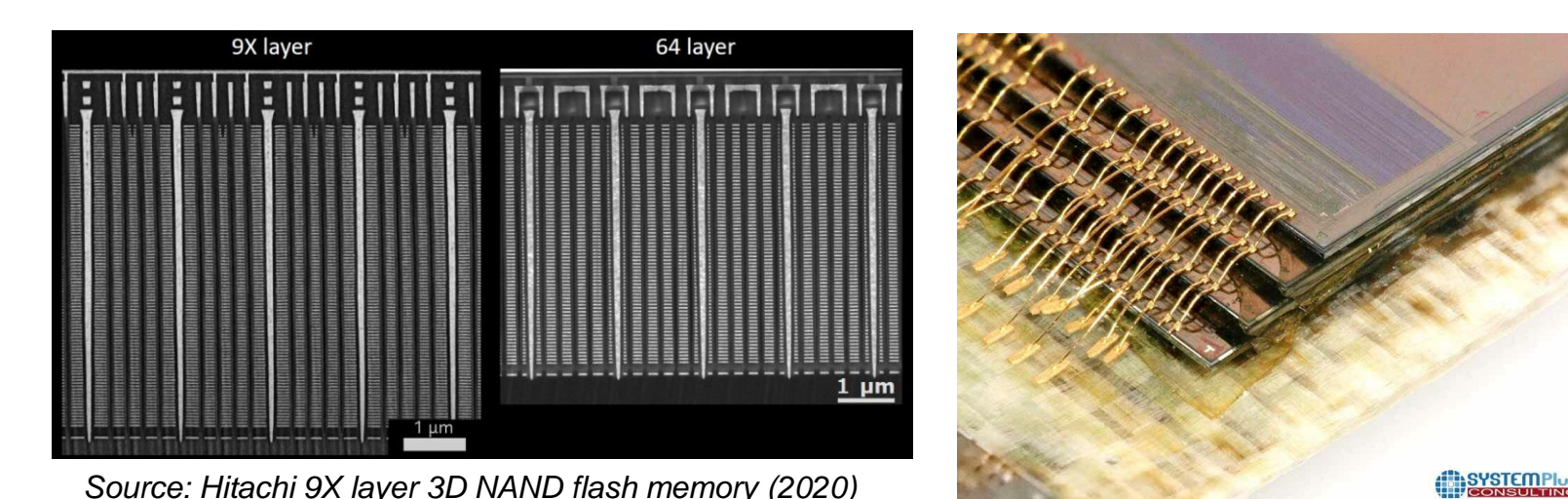
- Sensitive surface (pixels) on the top
- Control and processing below

→ Twice the carbon footprint per surface unit

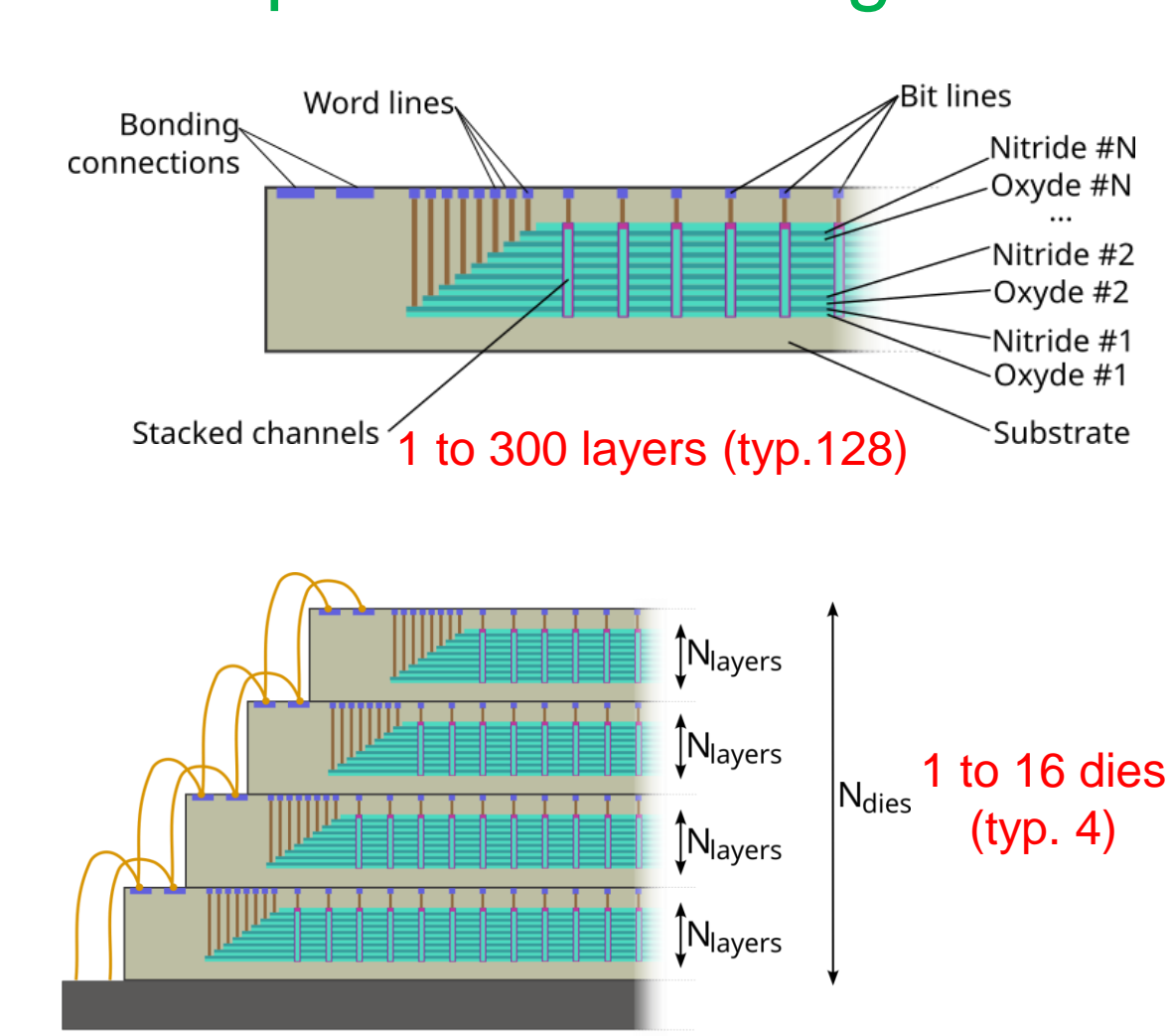
Rise of 3D technologies and global warming

3D stacking technologies increase the total silicon area of an integrated circuit.

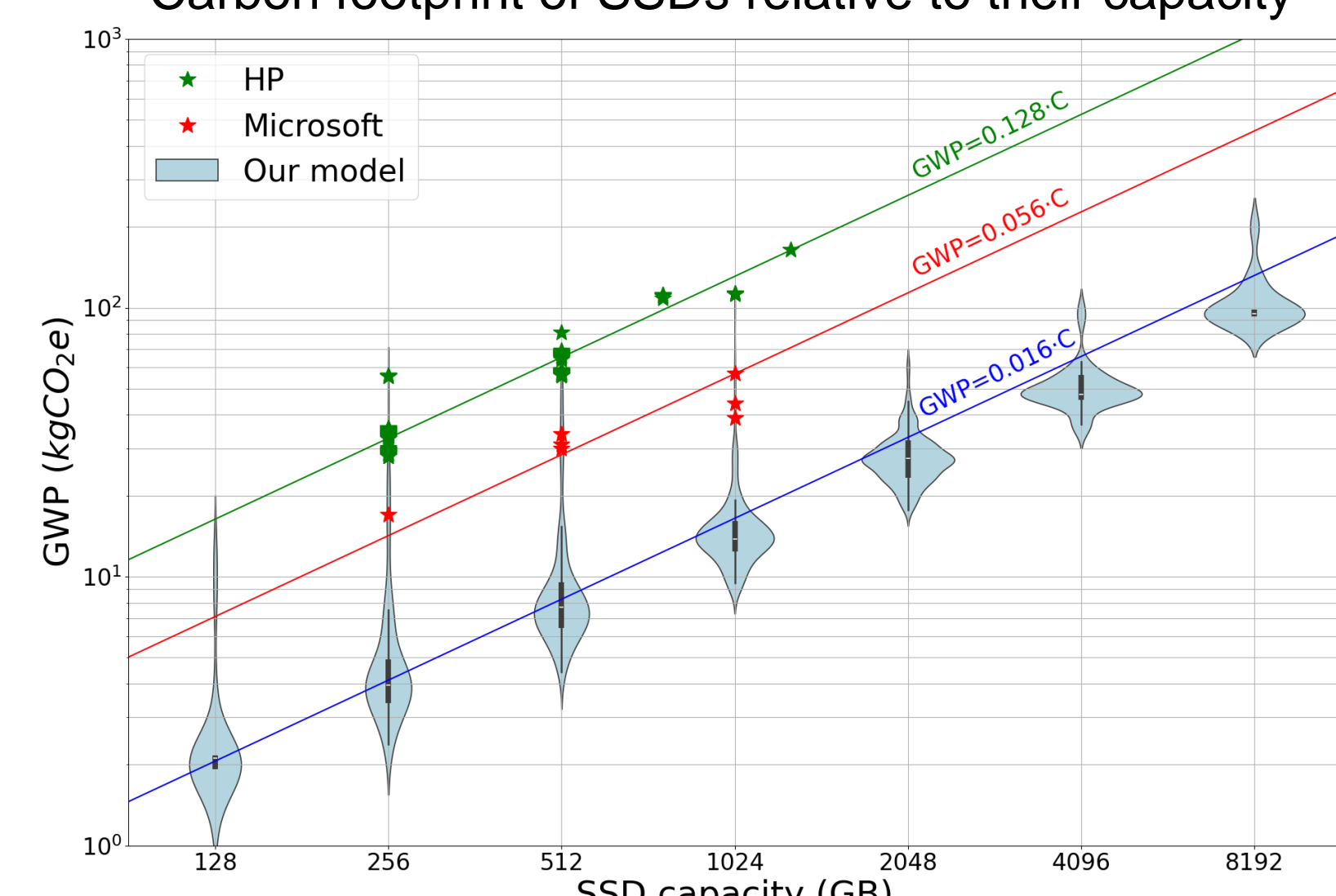
Same apparent package size, but multiple times the impact compared to 2D devices.



Example: Flash storage ICs:



Carbon footprint of SSDs relative to their capacity



Streamlined Models of CMOS Image Sensors Carbon Impacts
Olivier Weppe, Jérôme Chossat, Thibaut Marty, Jean-Christophe Prévotet, Maxime Pelcat
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