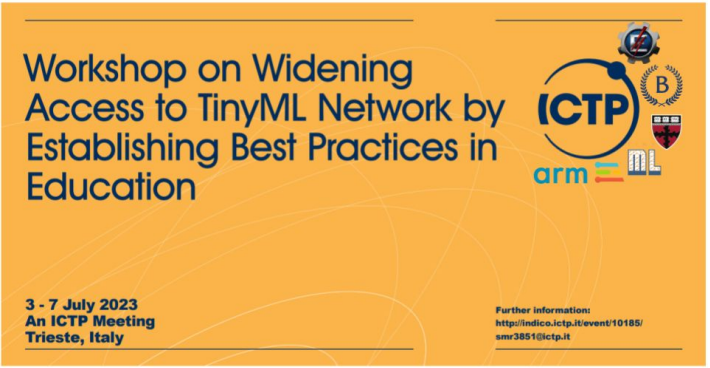
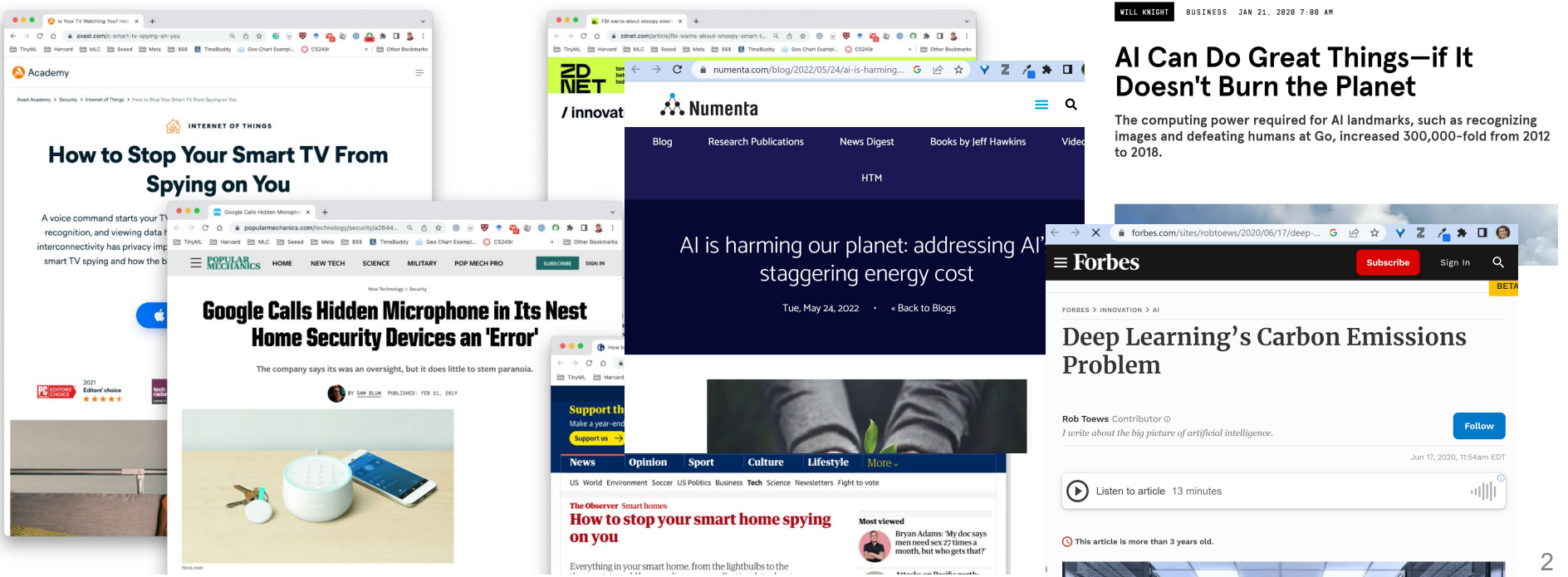


Responsible AI via Sustainable and Privacy Preserving EdgeML

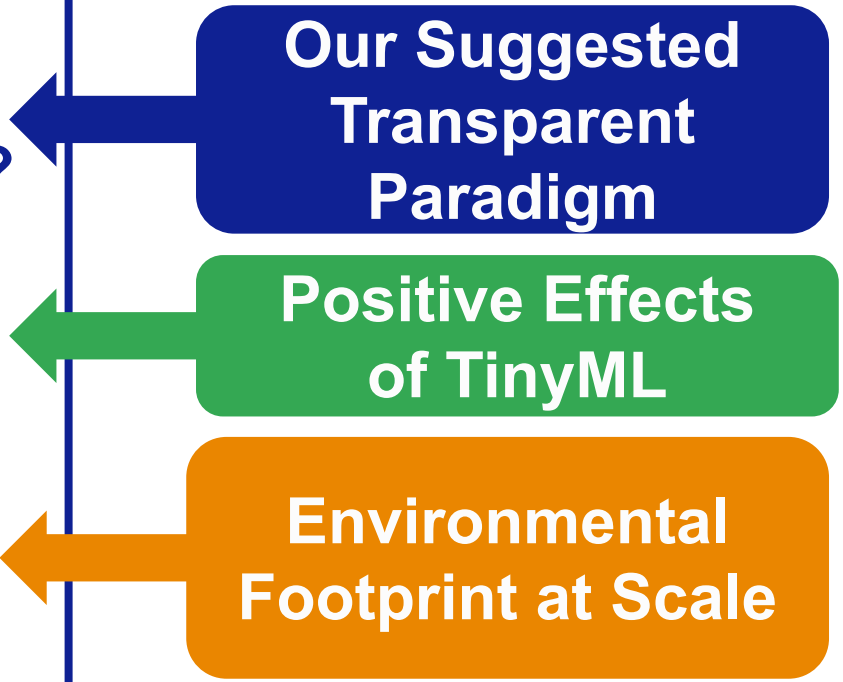
Brian Plancher
Barnard College, Columbia University
brianplancher.com

How can we adapt our approach to EdgeML to support **Responsible AI** future?



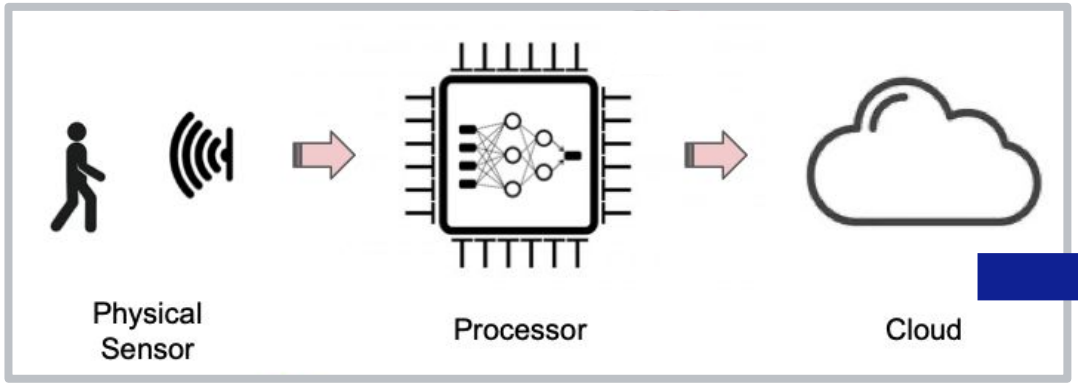
Responsible AI via Sustainable and Privacy Preserving EdgeML

1. What is a (**Datasheet** for a) **Machine Learning Sensor?**
2. **Applications** of TinyML for Sustainability
3. Environmental Footprint of **TinyML Systems at Deployed Scale**

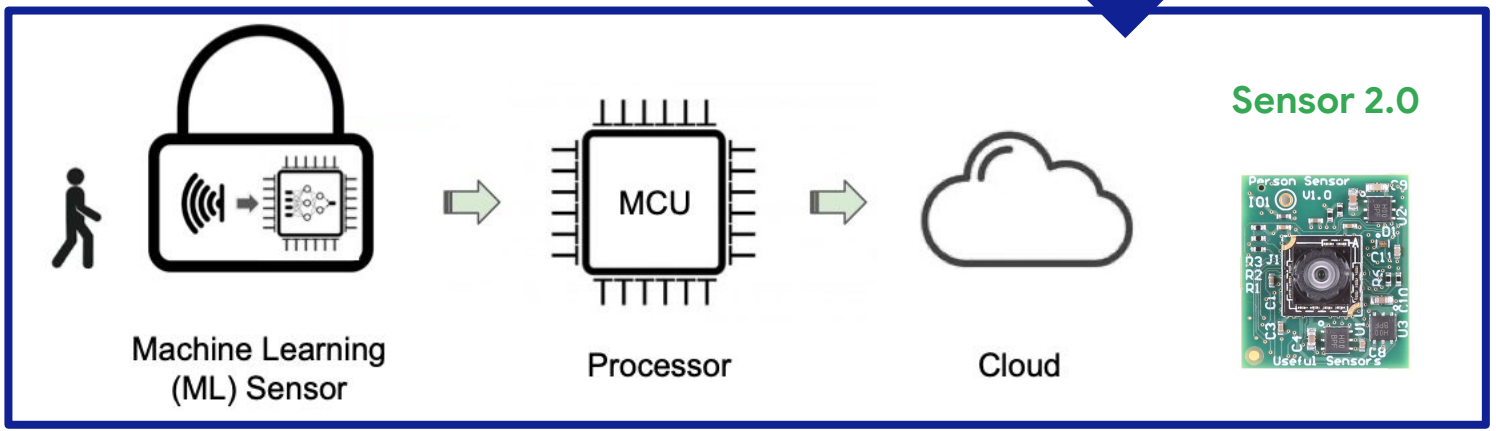


What is a (Datasheet for a) Machine Learning Sensor?

What is a Machine Learning Sensor?



Privacy by Design



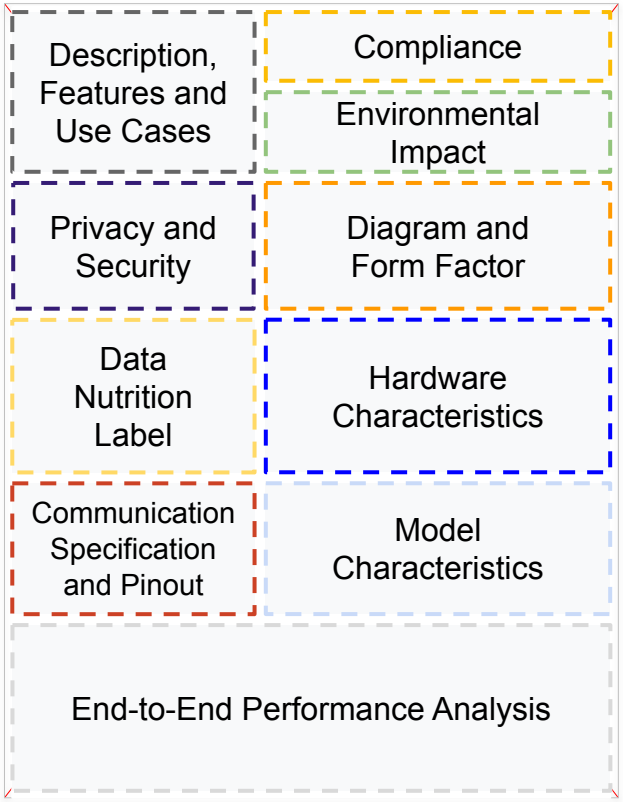
We suggest **transparency** as a core value to overcome these challenges.

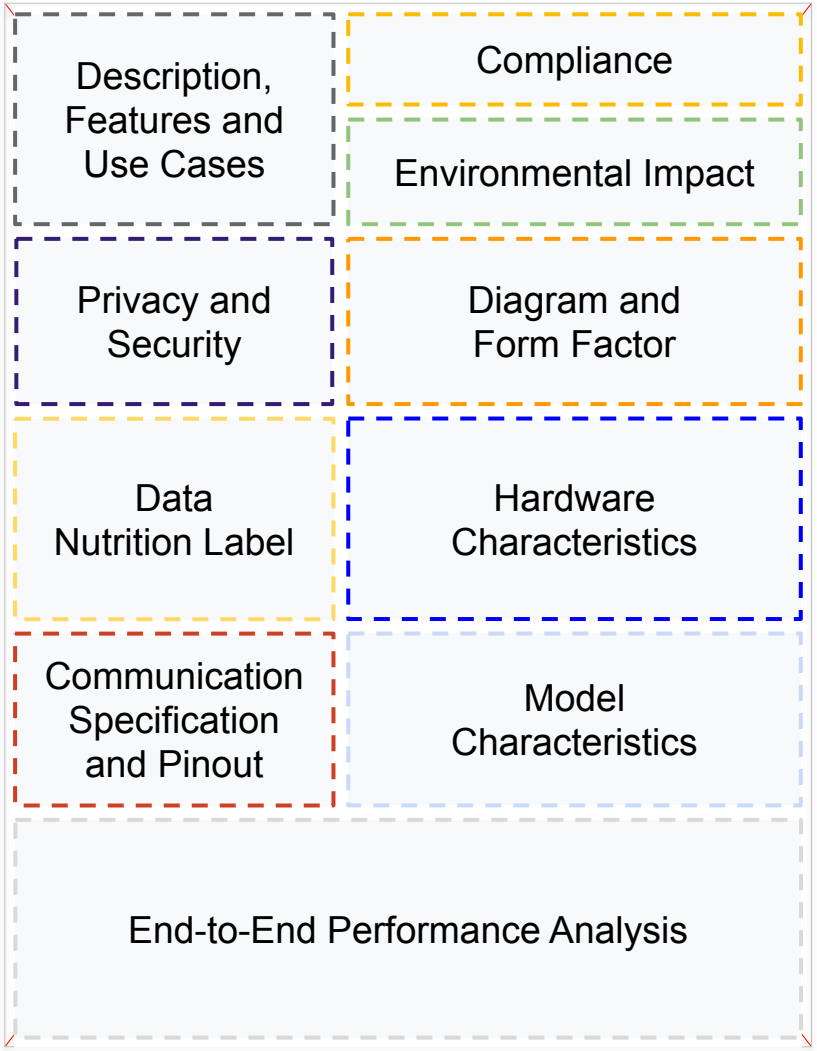
Datasheets for Machine Learning Sensors

Matthew Stewart[1*] Pete Warden[2,5] Yasmine Omri[1] Shvetank Prakash[1] Joao Santos[1]
Shawn Hymel[4] Benjamin Brown[1] Jim MacArthur[1] Nat Jeffries[5] Brian Plancher[3]
Vijay Janapa Reddi[1]

[1]Harvard University [2]Stanford University [3]Barnard College, Columbia University
[4]Edge Impulse [5]Useful Sensors

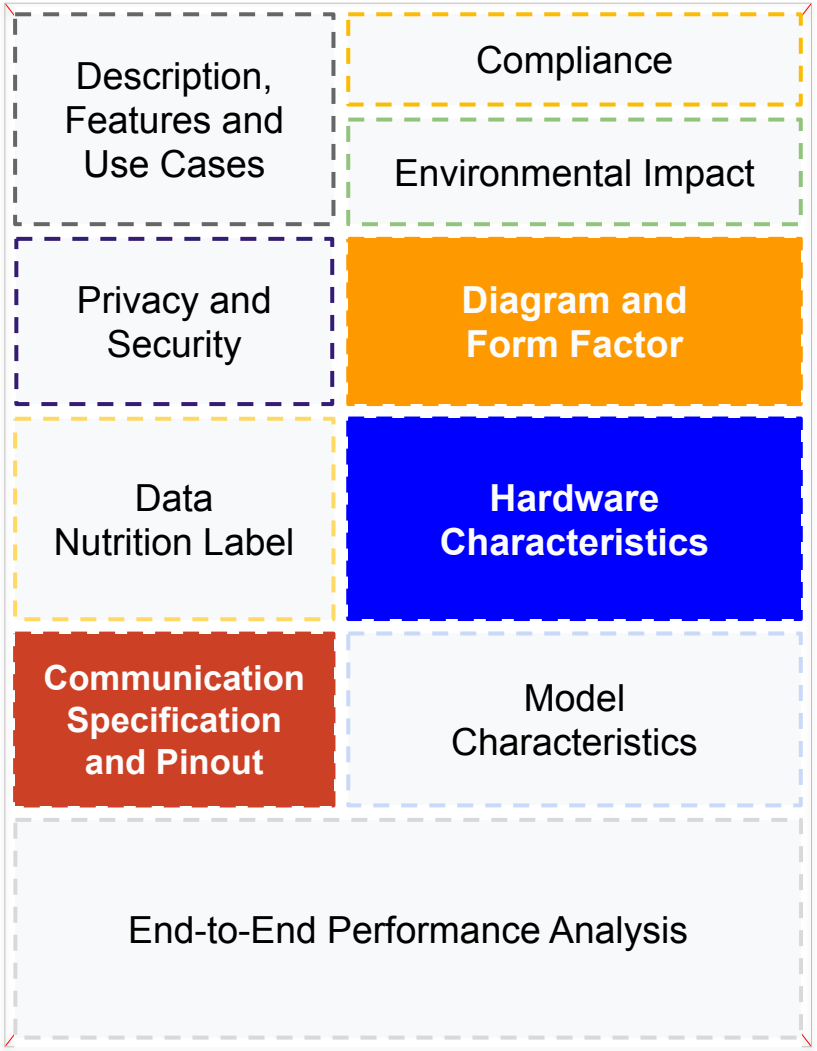
arxiv.org/abs/2306.08848





ML Sensor Datasheets Have 3 Goals:

1. Raise the level of **abstraction**
2. Transparent at the **hardware, data, model, and end-to-end layers**
3. Support **Responsible** Use



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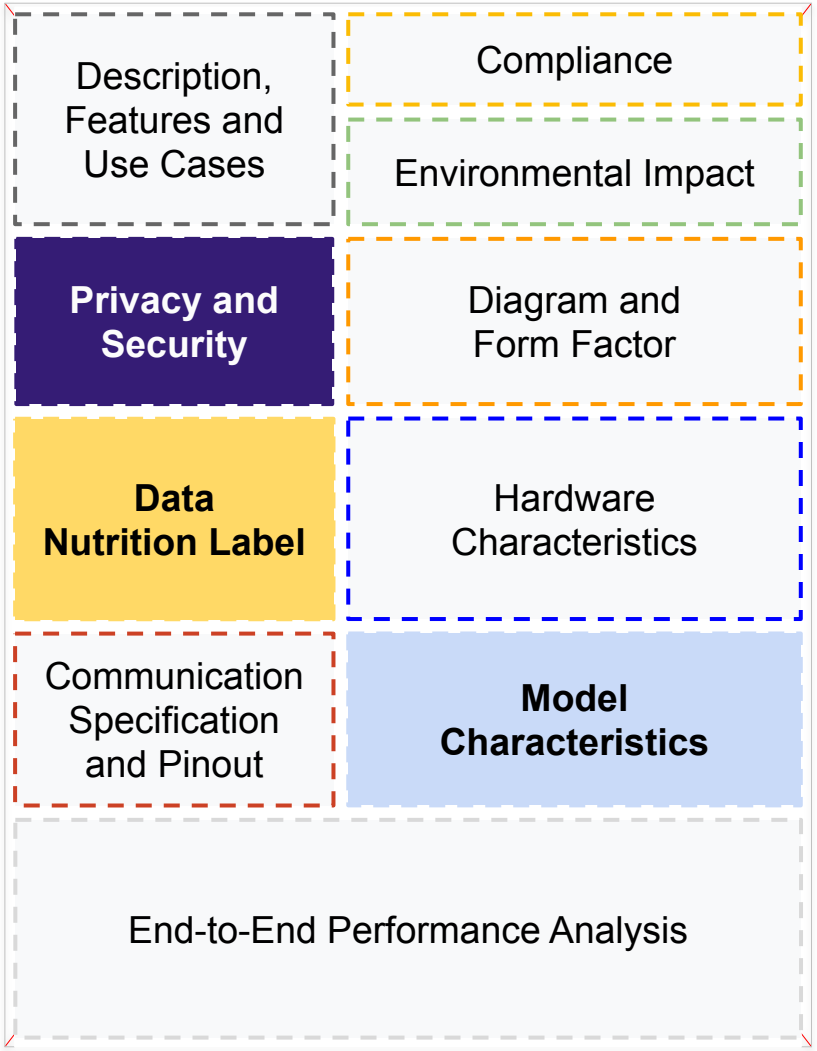
Standard Sensor Datasheet



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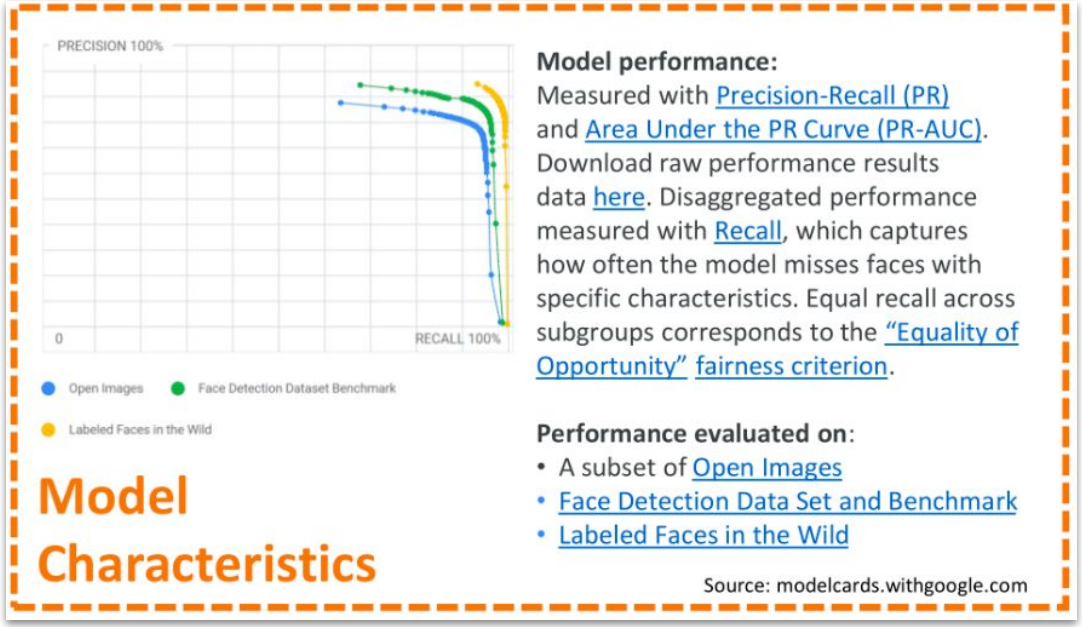
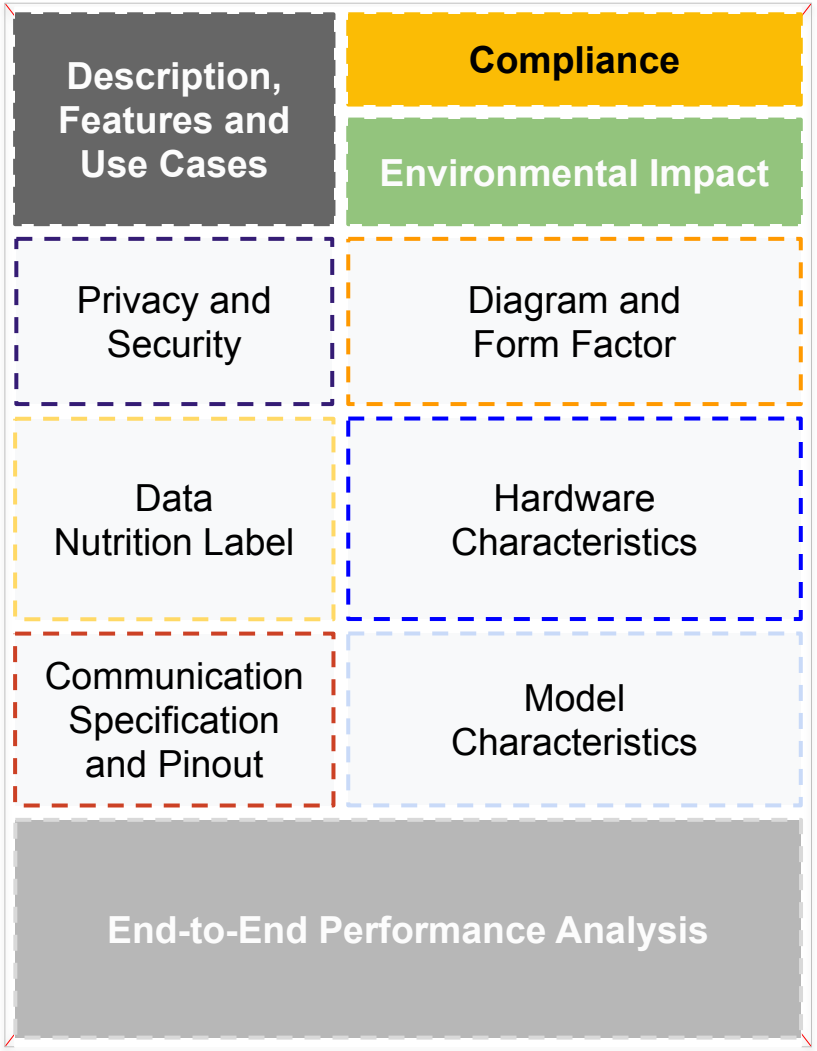
Responsible Machine Learning Analysis

Responsible Machine Learning Analysis





ML Sensor Datasheets Have 3 Goals:

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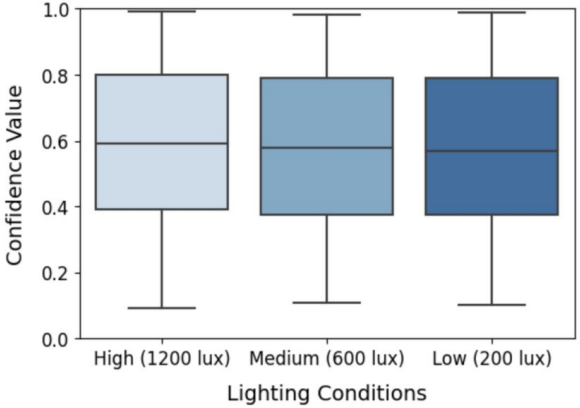
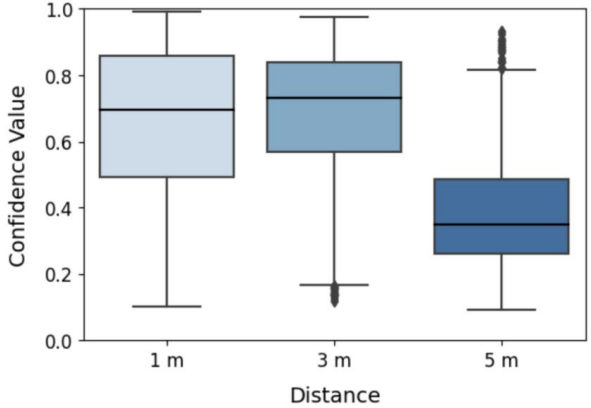
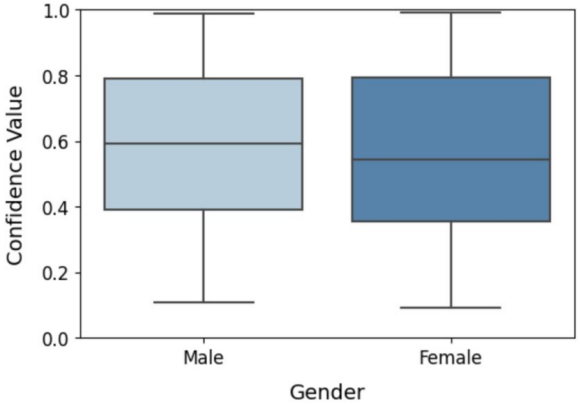
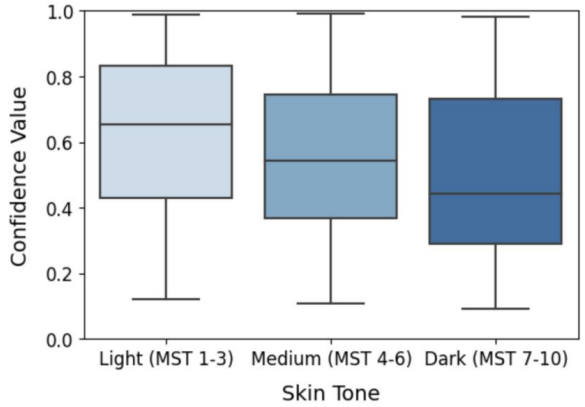
Overall System Analysis



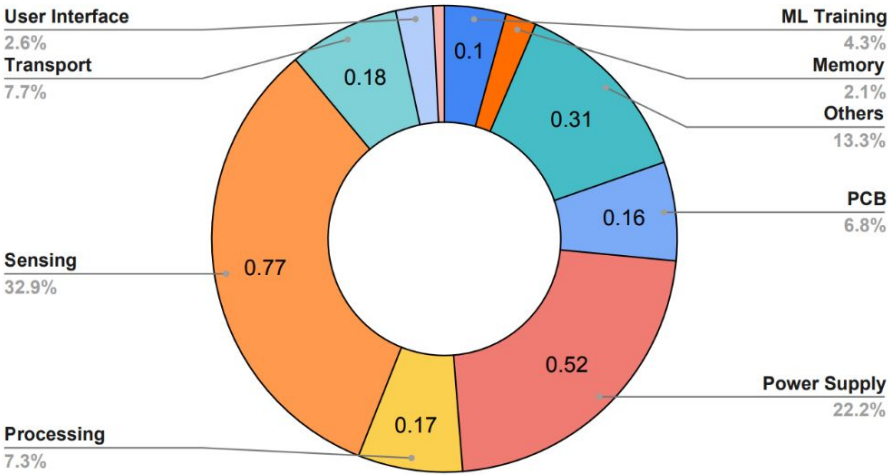


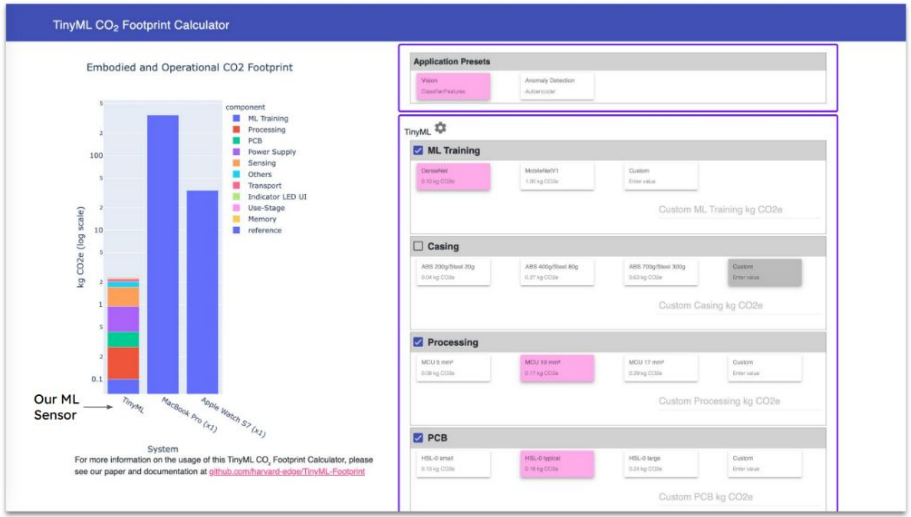




End-to-End
Responsible
Performance
Analysis

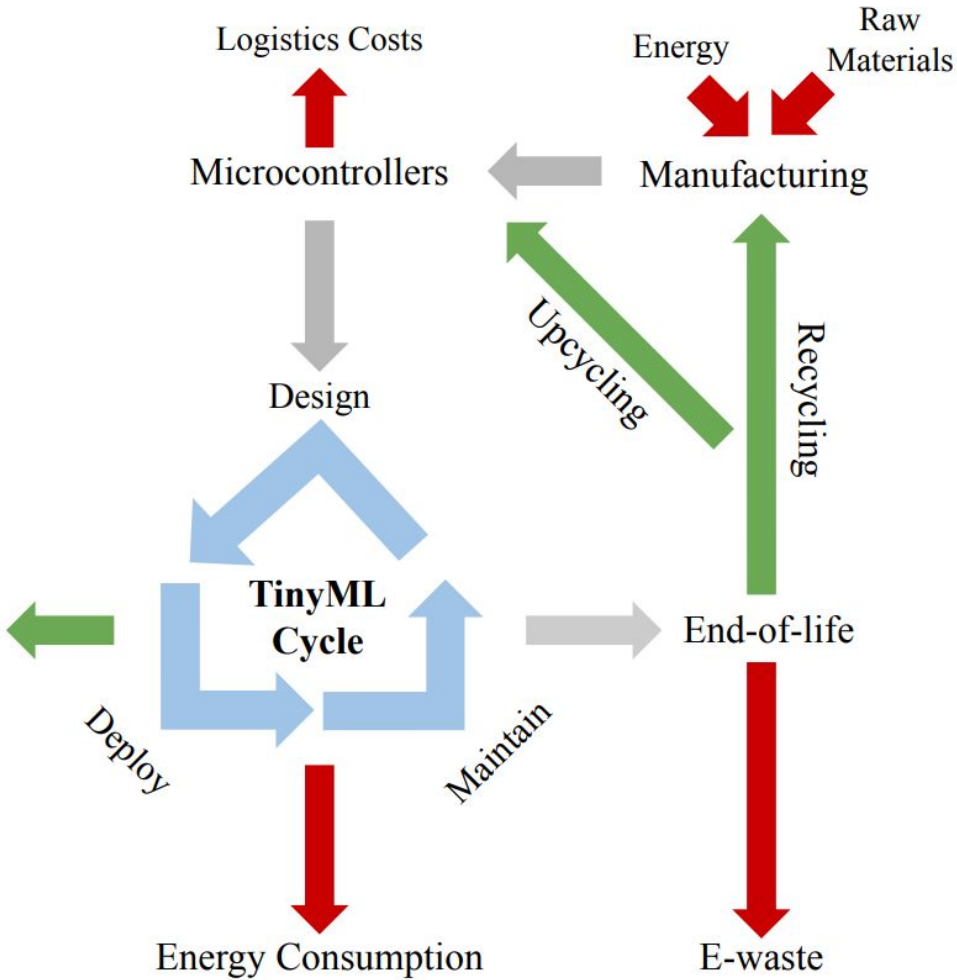
Environmental Impact





Lets Explore this Impact in More Detail

Sustainable Development Goals



TinyML can support the SDGs but comes with costs. **What is the net impact?**

Applications of TinyML for Sustainability

Zero Hunger & Good Health and Well-Being
(SDG #2 & #3)

Credit: PlantVillage Nuru

Nuru, an ML app more accurate than humans at detecting plant diseases. Increased a farmer's sales by 55% & **yields by 146%**.

Credit: Crop Angel Ltd

Tiny drones can provide targeted pesticide applications that **reduce use to 0.1%** of conventional blanket spraying.

Credit: Sinhyu/Getty Images

Using Edge Impulse, a system was prototyped to identify mosquitoes by wing beats sounds with **88.3% accuracy**.

Life on Land & Below Water

(SDG #14 & #15)

Credit: Rainforest Connection

Rainforest Connection uses **recycled smartphones** for **solar-powered** listening devices to warn of **deforestation** efforts

Credit: RESOLVE and Bivash Pandav

RESOLVE's AI camera transmits notifications of elephant detection and can **run for more than 1.5 years** on a single battery.

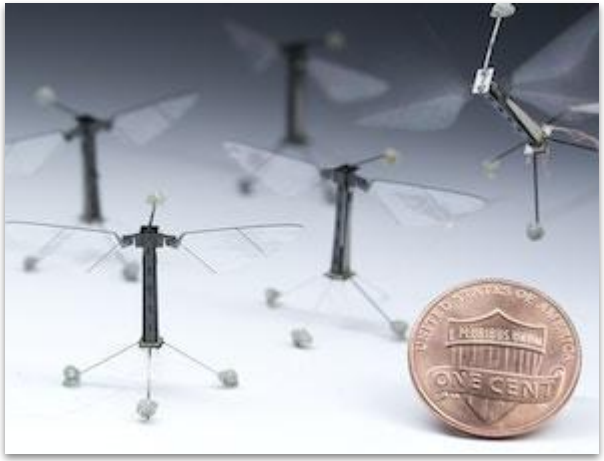
Credit: Tim Cole

To prevent collisions with whales in busy waterways, Google deployed a TinyML model on hydrophones to alert ships.

Climate Action
(SDG #13)

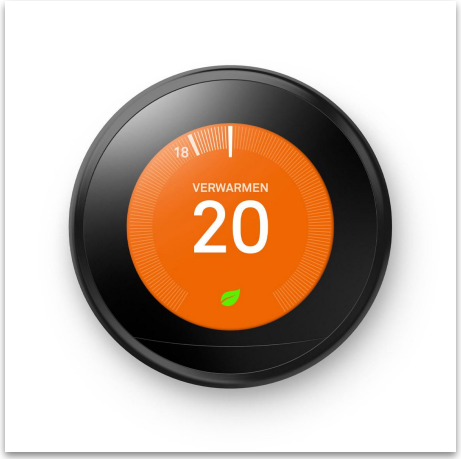
Credit: Ribbit Network

Ribbit Network is **crowdsourcing world's largest greenhouse gas emissions dataset** through distributed intelligent sensors



Credit: Wyss Institute at Harvard University

TinyML can help provide intelligence to **tiny robots like the Robobee** that can be used as artificial pollinators.

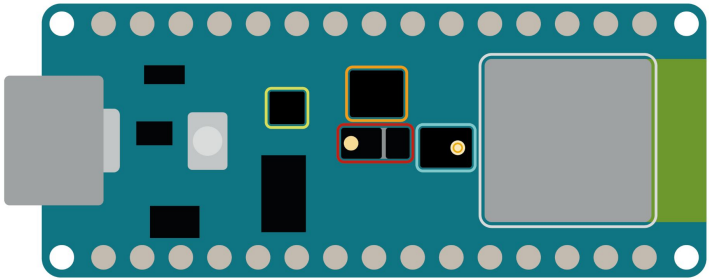


Credit: Google Nest

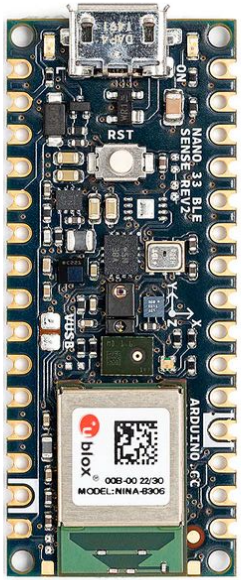
Smart HVAC systems show a **20-40% reduction in building energy** usage.

Environmental Footprint of TinyML Systems

Real TinyML Systems are more than just an MCU!

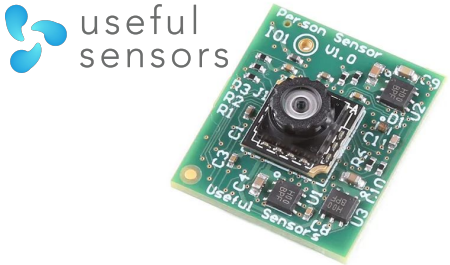


- Color, brightness, proximity and gesture sensor
- Digital microphone
- Motion, vibration and orientation sensor
- Temperature, humidity and pressure sensor
- Arm Cortex-M4 microcontroller and BLE module

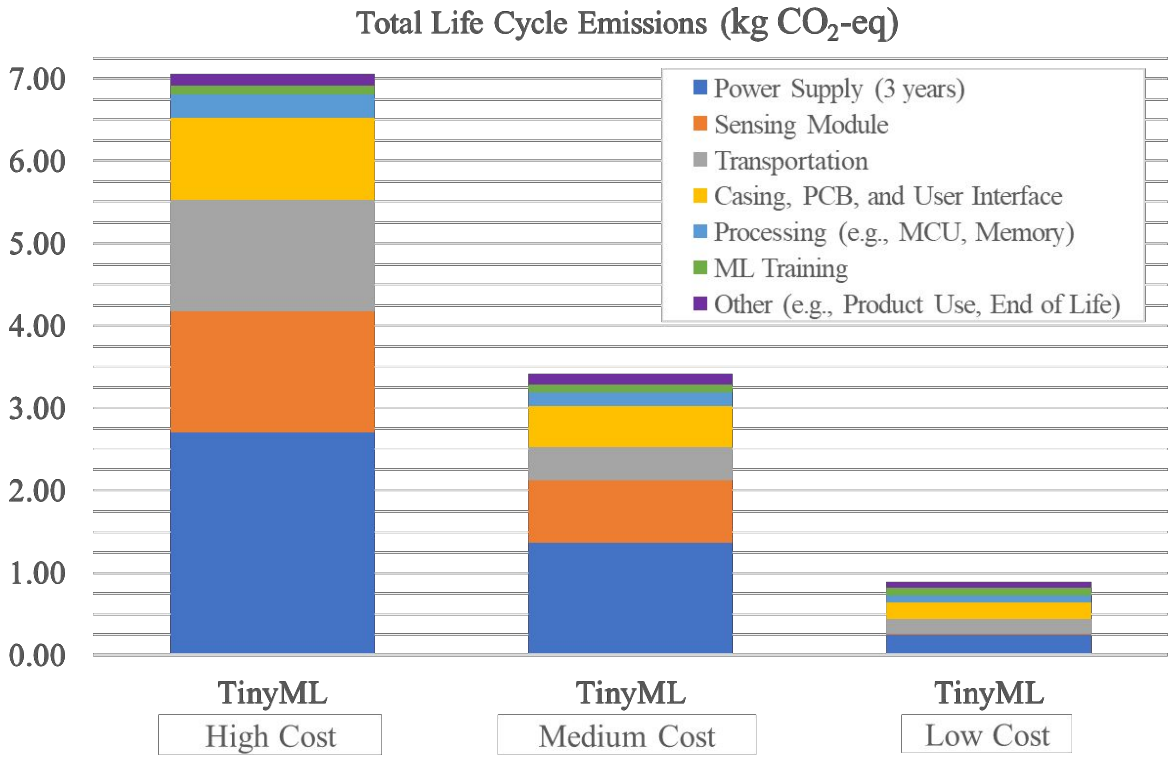


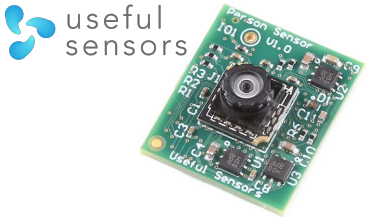
Building Representative Systems

Cost Level	High Cost	Medium Cost	Low Cost
Application	Image Classification		Keyword Spotting
Size	Large	Compact	Compact



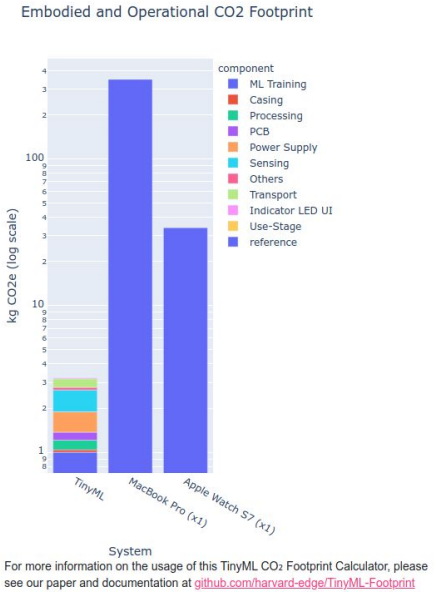
Building Representative Systems

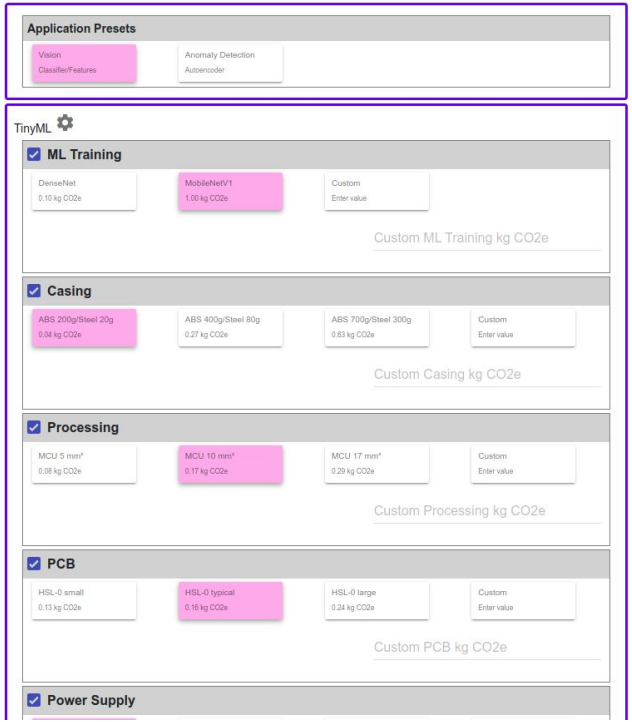




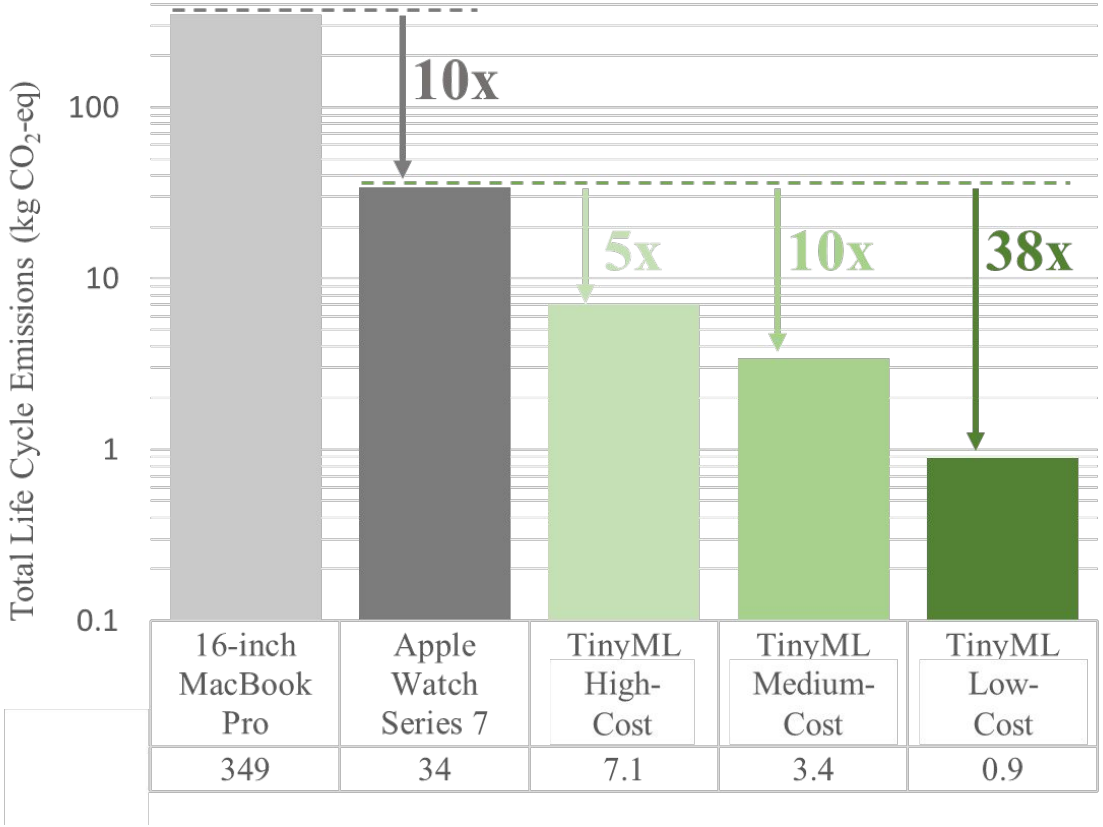
harvard-edge.github.io/TinyML-Footprint/

TinyML CO_2 Footprint Calculator





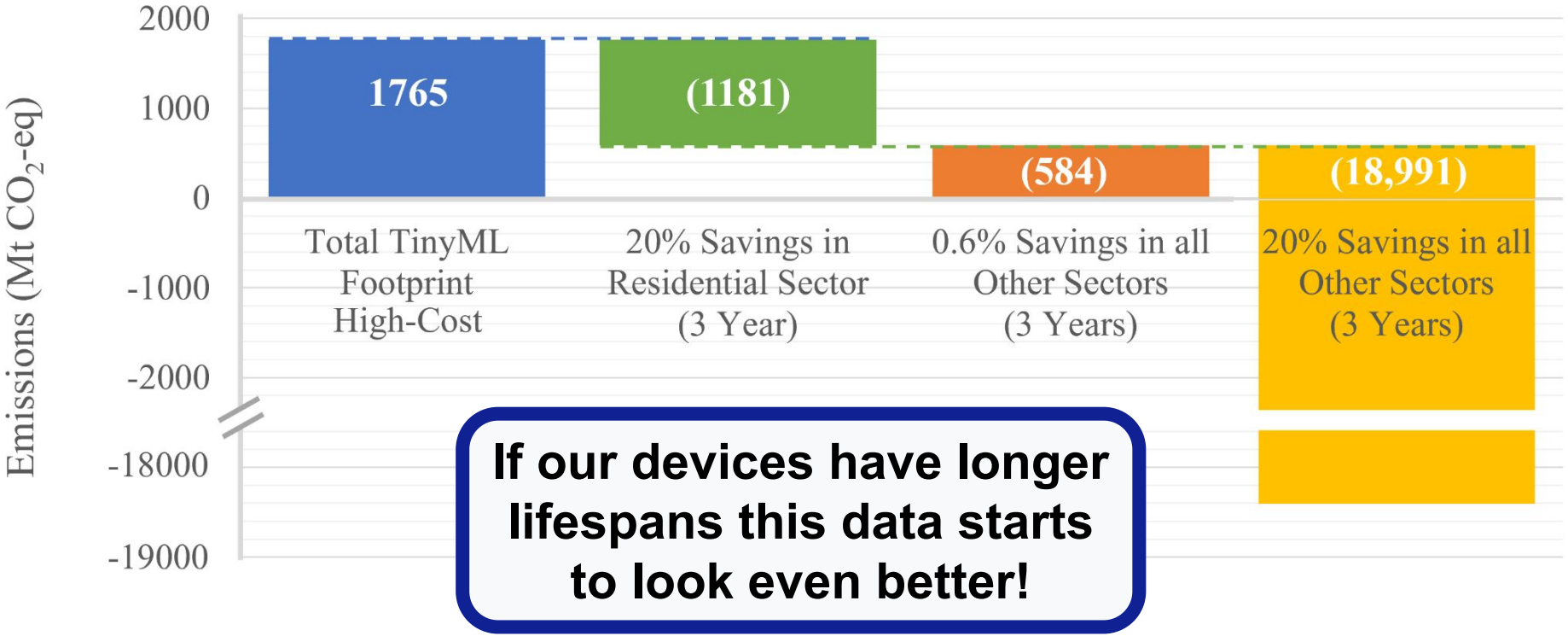
TinyML Systems in Context



5x to 38x Savings over a 3-year lifespan!

Environmental Footprint of TinyML Systems **at Deployed Scale**

What if we scale to 250bn devices?



If our devices have longer lifespans this data starts to look even better!

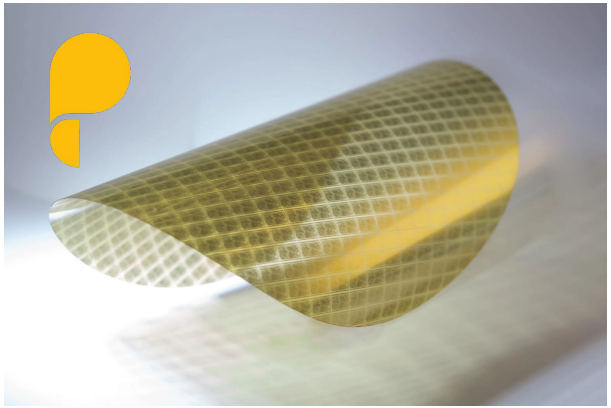
Limitations and Areas for Future Study

What about the net impact of factors **beyond carbon**?

What about **Jevons' Paradox**?

What about the **human costs**?

How can **emerging technologies** help?



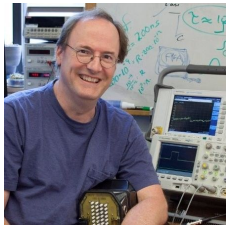
Responsible AI via Sustainable and Privacy Preserving EdgeML









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