Design For Sustainability (DFS)
Green Hardware & Software

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Member – IEEE (Region 6)

Contents

Let's understand Sustainability

What is the need for Sustainability ?

Role of SW / HW Engineer in Making Product Sustainable

Design For Sustainability (DFS)

Green Hardware & Software

Conclusion

Contents

Setting Expectations for this Lecture !

- Understand Sustainability
- Concept of Design for Sustainability
- A few examples of sustainable products in network field

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Let's Understand Sustainability

United	10:50 PM – 7:00 AM⁺²	15 hr 10 min SFO–SYD	Nonstop	1,248 kg CO_2 Avg emissions ⓘ	$1,349 round trip	⌄
United	7:00 PM – 6:55 AM⁺²	18 hr 55 min SFO–SYD	1 stop 2 hr 8 min LAX	1,117 kg CO_2 -10% emissions ⓘ	$1,353 round trip	⌄
Air Canada · Operated by Air Canada Express - Jazz	7:45 PM – 7:45 AM⁺²	19 hr SFO–SYD	1 stop 1 hr 8 min YVR	1,454 kg CO_2 +16% emissions ⓘ	$1,378 round trip	⌄

This flight	1,117 kg CO_2
Typical for this route	1,248 kg CO_2
10% lower	-131 kg CO_2

Emissions are calculated for 1 passenger in your selected seating class. Learn more

European Environment Agency

Google uses the European Environmental Agency (EEA) emission estimates with the most up-to-date algorithmic model from 2019

1.A.3.a Aviation 2019

Let's Understand Sustainability

easyJet easyJet	**7:15 AM – 7:25 AM** 	1 hr 10 min CDG–LGW	Nonstop	54 kg CO_2 -12% emissions ⓘ	**$188** round trip
British Airways	**6:40 AM – 7:00 AM**	1 hr 20 min CDG–LHR	Nonstop	70 kg CO_2 +13% emissions ⓘ	**$199** round trip
British Airways	**7:10 AM – 7:30 AM**	1 hr 20 min CDG–LHR	Nonstop	50 kg CO_2 -19% emissions ⓘ	**$212** round trip

Other departing trains

Eurostar	**9:03 AM – 10:30 AM**	2 hr 27 min Train service	Direct	17 kg CO_2 -72% emissions ⓘ	**$275** round trip
Eurostar	**10:03 AM – 11:30 AM**	2 hr 27 min Train service	Direct	17 kg CO_2 -72% emissions ⓘ	**$275** round trip
Eurostar	**11:03 AM – 12:30 PM**	2 hr 27 min Train service	Direct	17 kg CO_2 -72% emissions ⓘ	**$275** round trip

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This train	17 kg CO_2
Typical for this route	62 kg CO_2
72% lower	-45 kg CO_2

Emissions are compared with a typical economy class flight and are calculated for 1 passenger. Learn more

Even Google Maps shows CO_2 Emission for selected routes !

Let's Understand Sustainability

Did you see these kind of ads on consumer products recently ?

Photo Courtesy: Horizon

Greenhouse Gas

- In simple terms, Greenhouse Gases (GHGs) are the gases in the earth's atmosphere that trap heat !

- During the day, due to sunshine, earth's surface gets warmer

- At night, the earth's surface gets cooled and releases heat back into the air

- Some of this heat is trapped in the atmosphere by the greenhouse gases

- The primary GHGs are water vapor, carbon dioxide, methane, nitrous oxide and ozone

- GHGs cause climate change by trapping heat, and they also contribute to respiratory disease from smog and air pollution

Courtesy: https://energyeducation.ca/encyclopedia/Greenhouse_effect

- Carbon dioxide (CO2) is the primary GHG emitted through human activities
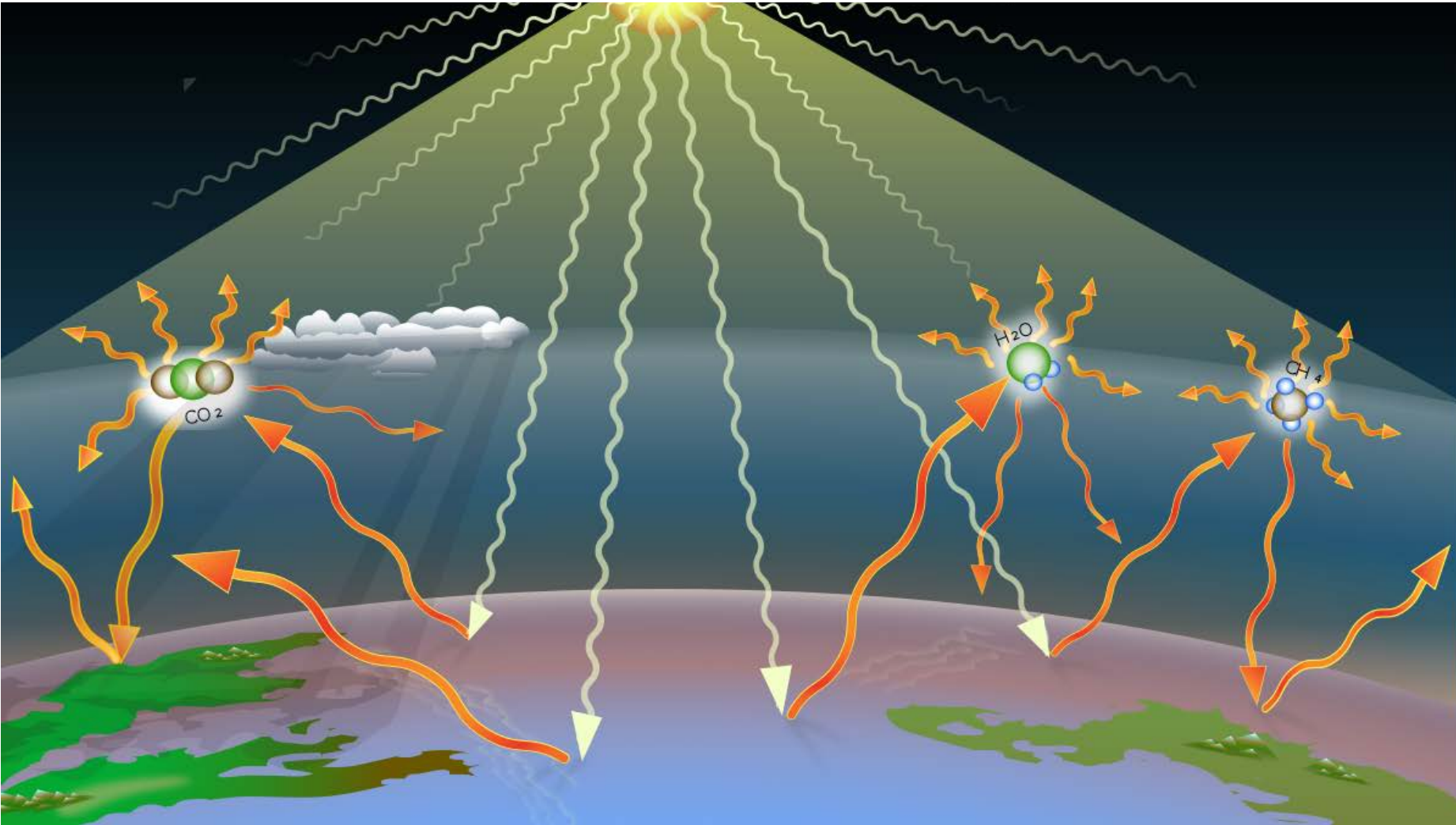
Figure Courtesy: Internet / Google – Thanks to the unknown owner

- In 2020, total U.S. electricity generation by the electric power industry of 4.01 trillion kilowatthours (kWh) from all energy sources resulted in the emission of 1.55 billion metric tons—1.71 billion short tons—of carbon dioxide (CO_2).

  Short ton (st): A unit of weight equal to 2,000 pounds

- This equaled about 0.85 pounds of CO_2 emissions per kWh.

  More energy consumption → More CO_2 → More GHG → Destroy Nature

What is Sustainability

- As per UCLA, Sustainability is the balance between the environment, equity, and economy

- The most often quoted definition comes from the UN World Commission on Environment and Development: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

- Natural resources are finite… and should be used conservatively

- Any product designed following the above principle is said to be a sustainable product

- In other words, the sustainable product must limit the CO_2 or GHG Emission !!!

Contents

Digital Transformation – IoT

Any object can be turned into a Data Acquisition Point with Wireless Sensor Network !

What are the implications of this connectivity ?

- According to Prof. Francois Gemenne, Professor of Environmental Geopolitics, Sciences Po Free University of Brussels, Belgium, if the internet were a country, it would be the fifth largest consumer of electricity in the world.

- The United States Environmental Protection Agency (EPA) estimates that 25% of GHG emissions arise from the production of electricity.

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2019

Agriculture 10%
Commercial & Residential 13%
Transportation 29%
Industry 23%
Electricity 25%
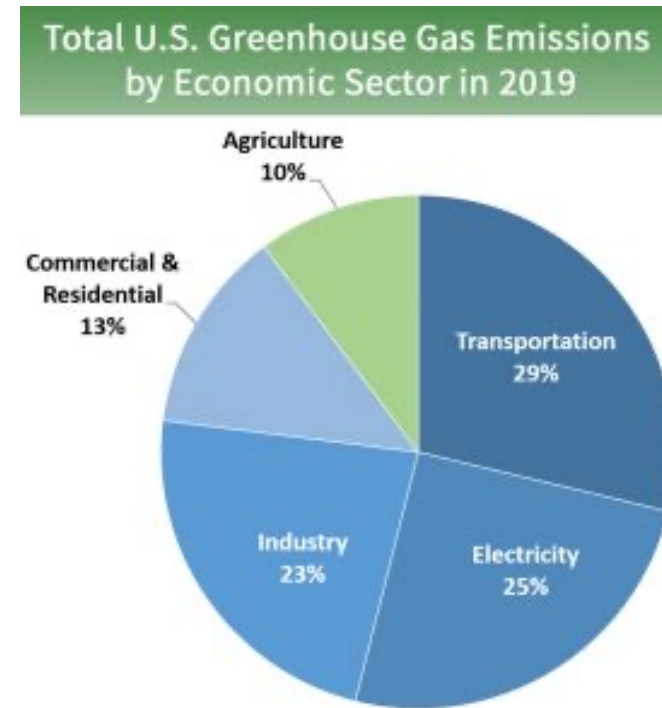
- ▶ Natural resources aren't infinite

- ▶ All the electrical / electronics systems produce Greenhouse Gases

- ▶ Watt-by-Watt can spoil the planet in finite time ahead !
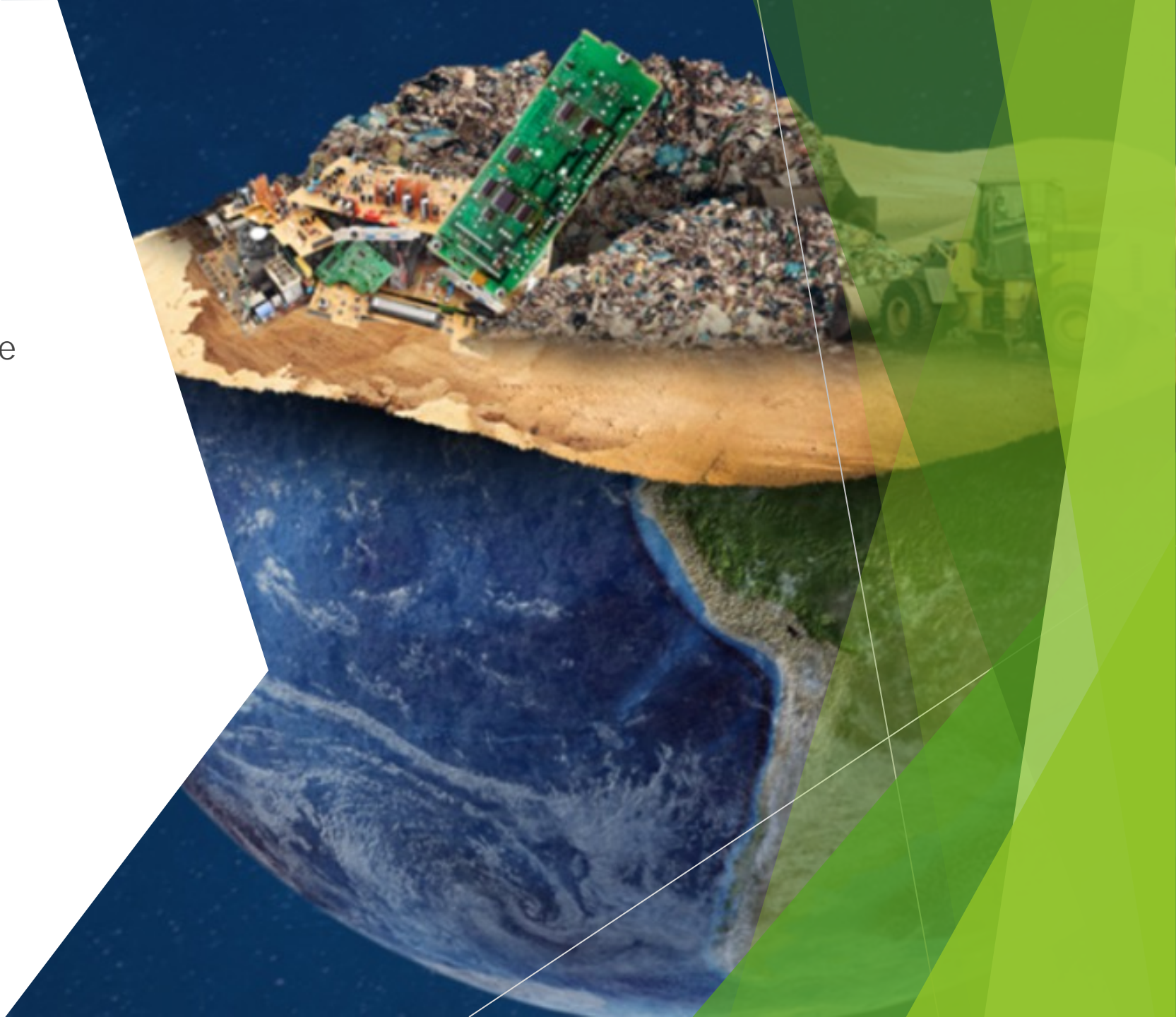
Net Zero !

- Net Zero means Carbon Neutral !

- As per Oxford Dictionary:

  - Net Zero is a target of completely negating the amount of greenhouse gases produced by human activity, to be achieved by reducing emissions and implementing methods of absorbing carbon dioxide from the atmosphere.

- Many Technology Companies have signed a pledge at WEF meeting promising to achieve Net Zero by 2050 !

- In order to achieve Net Zero by 2050, technology companies must change the way products are designed …. Make them sustainable !

- Not just new products are sustainable, make existing / shipping products also sustainable

Meet the way
we will get there:

A Circular Economy.

TRANSFORMING TO THE **CIRCULAR ECONOMY**

- Input Materials (Recycled or Virgin)
- Transportation
- Owens Corning Manufacturing
- Transportation
- Use
- End of Life
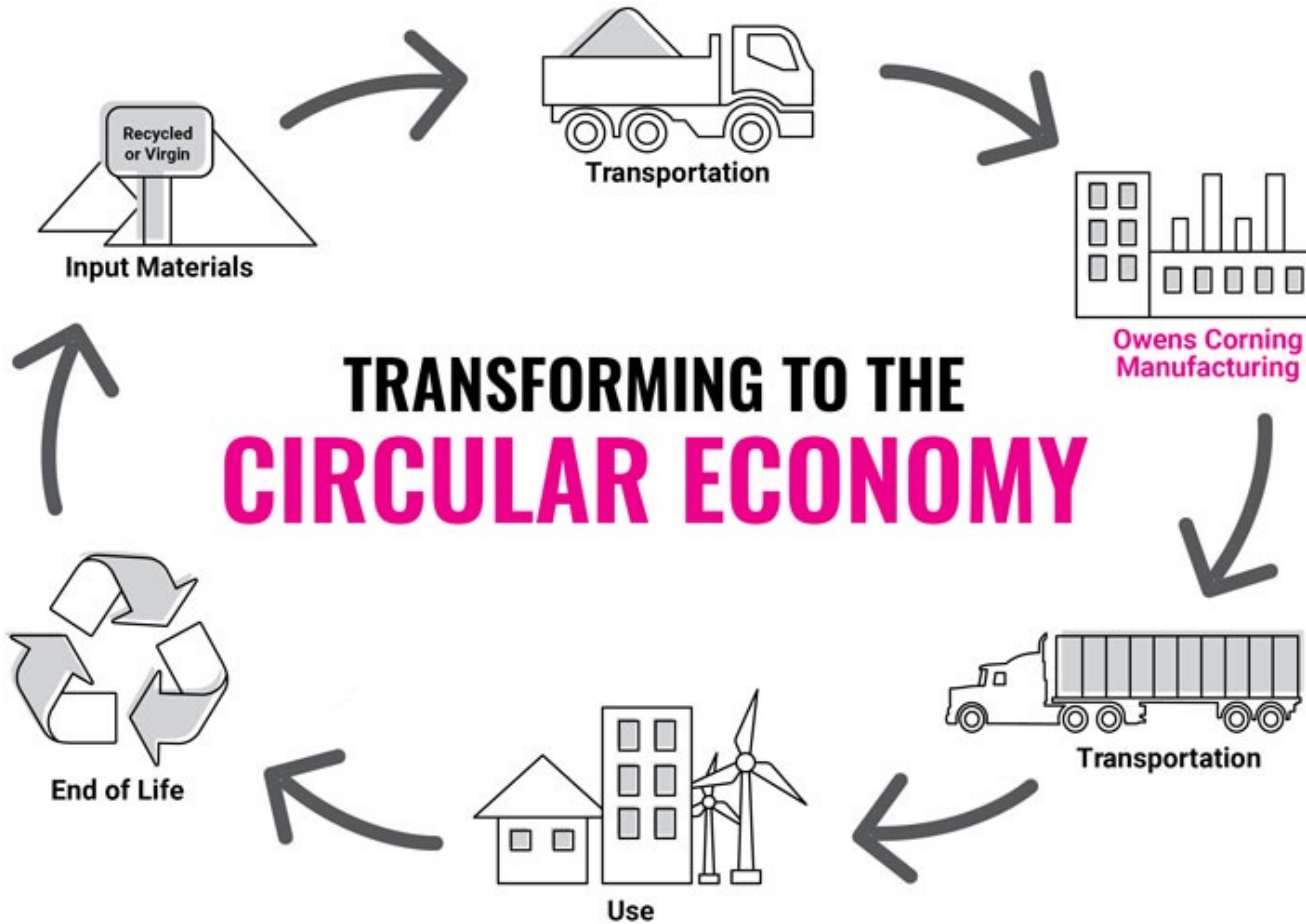
Picture Courtesy: From Internet ... thanks to the original developer

What is a Circular Economy?

The concept of a circular economy is based on the following principles:

- ✓ Design out waste and pollution from the beginning.

- ✓ Extend the lifetime of products and materials.

- ✓ Regenerate natural systems.

In other words, a circular economy attempts to close the loop on waste by finding ways to give a new life to existing resources through durability, renewability, and reuse.

Make every product sustainable !

Contents

What should SW / HW Engineer Consider ?
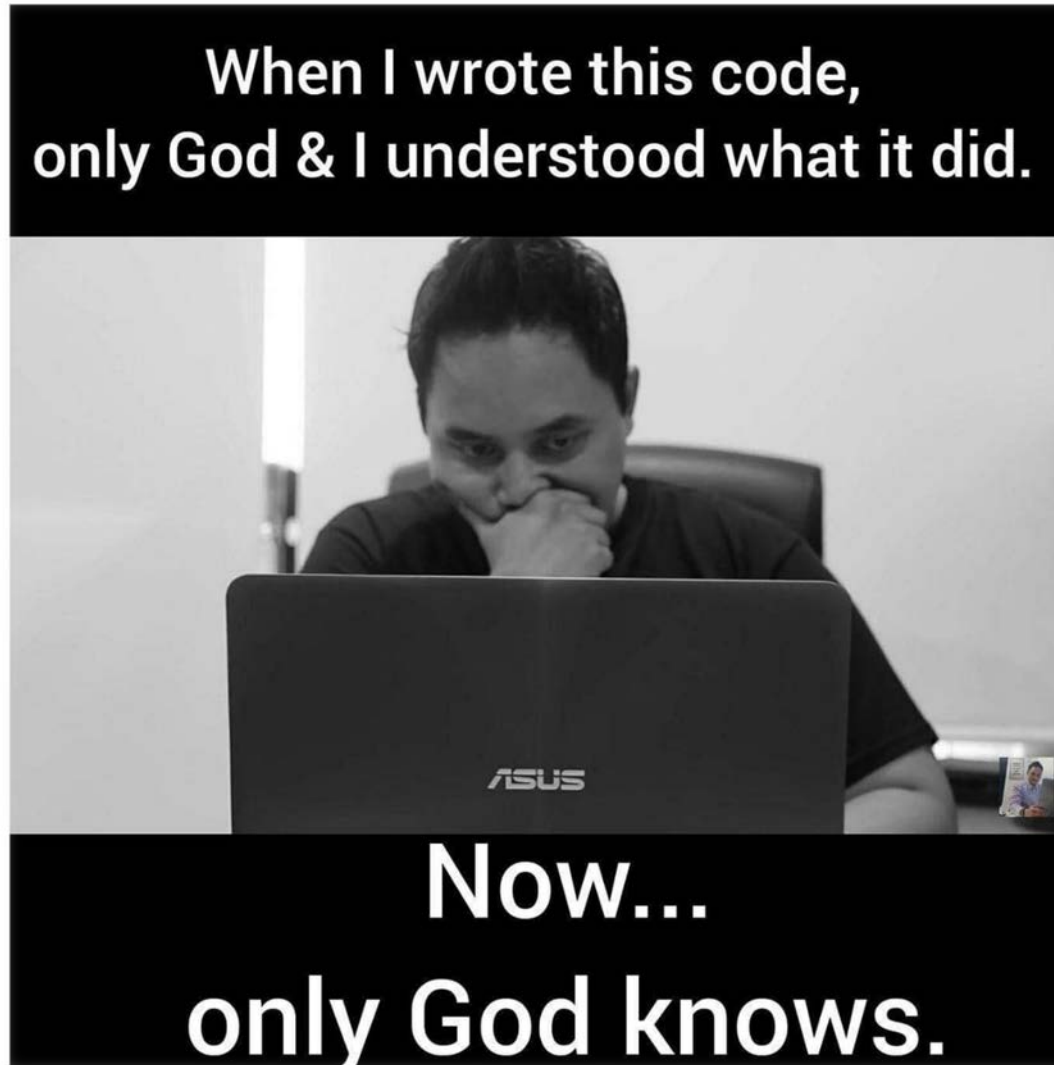
Role of SW & HW Engineer in Making Product Sustainable

SW Engineer

- Have a clear SFS Document
- Include Monitoring Dashboards
- Include Debuggability
- Don't maintain the old code !
- Automate Testing
- Use Simulators instead of HW
- Use reliable CI / CD Tool
- Built-in-Self-Test (BIST)

HW Engineer

- Have a clear HFS Document
- Include Visible / Audible Alarms
- Include Testability (DFT)
- Consider Shelf Life of a product
- Use Test Fixtures / Avoid Re-solder
- Use Debugging Tools (JTAG)
- Avoid RMA with Local Repair
- Use Built-in-Self-Test (BIST)

What should product design consider ?

DESIGN FOR TESTABILITY (DFT)

DESIGN FOR MANUFACTURABILITY (DFM)

DESIGN FOR SUSTAINABILITY (DFS)

Contents

Design For Sustainability

- Biggest Consideration for any Electrical Product Design is Power Consumption !

- Less Power Consumption results in less CO_2 emission there by lowering GHG Emission

- Lower GHG Emission Makes Product more Sustainable !

- Both Software and Hardware Engineer Need to Contribute to achieve this !

- Automation Layer Plays an important role in Software !

Design For Sustainability

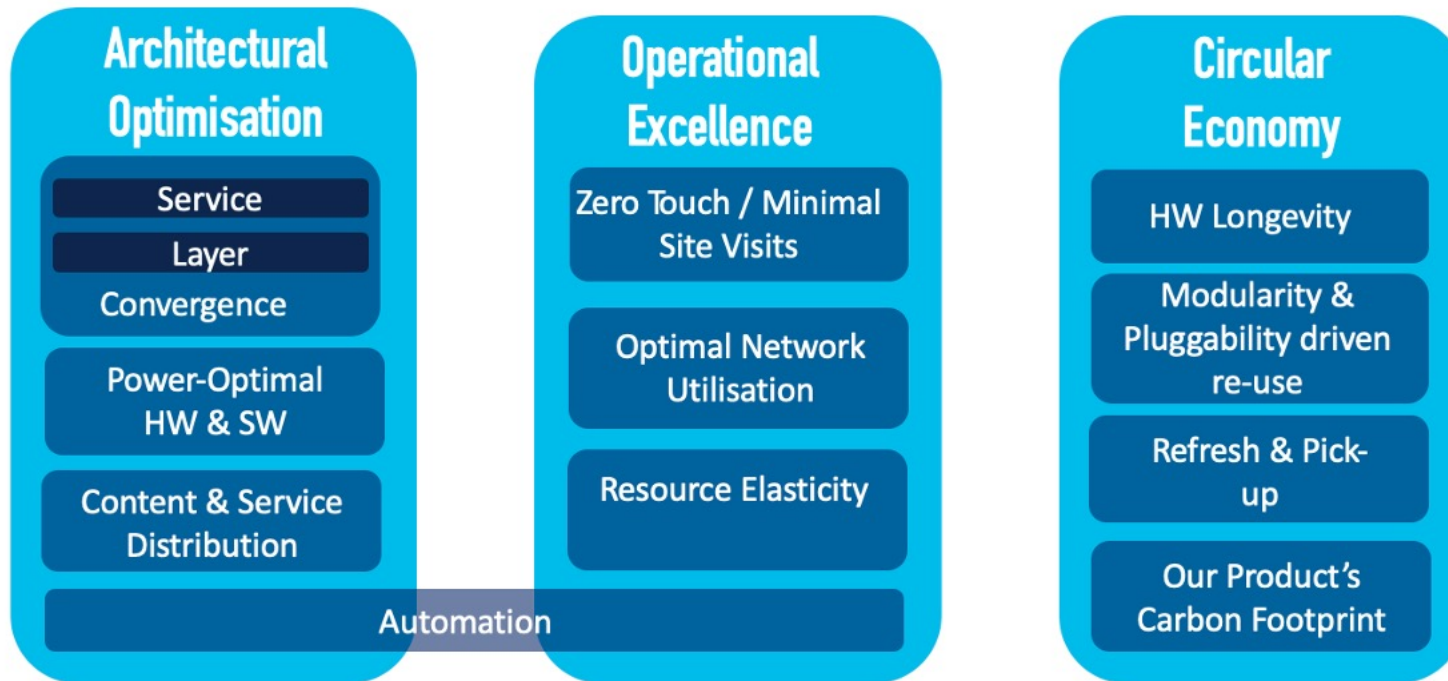- Design Economy Class Product → No overkills
  - Less no. of Cores
  - Smaller Capacity SSD
  - Make ISSU (In System Software Upgrade) Faster / Easier
  - Use Scaling Only if necessary (Graceful Reduction of Scale)
  - Reduce SMUs (Software Maintenance Upgrades) – Software Patches
  - Common Re-usable Hardware Across Products
  - Use Common Test Beds / Automation Packages (APs)
  - Use Simulators in place of protos

Design For Sustainability

- Use Automation / Cloudification
  - Consider Cloud Computation (in place of Edge Computation)
  - Turn off the HA (High Availability) When Network Traffic is considerably low
  - Turn off the Radio from 1AM to 4AM
  - Consider Turning off the ports when traffic is loow
  - Reuse the Protos
  - Use Software Modular Design
  - Hardwire the commonest Software Routines (using programmable chip sets, CPLD/FPGA)
  - Use the Smart Fan Algorithms
  - Consider power efficient Optics

Design For Sustainability

Key Pillars

Architectural Optimisation
- Service Layer Convergence
- Power-Optimal HW & SW
- Content & Service Distribution

Operational Excellence
- Zero Touch / Minimal Site Visits
- Optimal Network Utilisation
- Resource Elasticity

Automation

Circular Economy
- HW Longevity
- Modularity & Pluggability driven re-use
- Refresh & Pick-up
- Our Product's Carbon Footprint

Contents

Green Hardware & Software

- The term Green Hardware refers to the hardware system which is designed to be sustainable

    - Power Efficient

    - Produces less CO_2 Emission

    - More Longevity compared to its predecessors

Sustainability Resources

https://sustainableict.ieee.org/

Many Universities provide certificate / graduation programs in Sustainability

Recently, Microsoft has initiated the Green Software Foundation, together with the Linux Foundation. The goal is to build an ecosystem of people, standards, tooling, and practices to reduce carbon emissions caused by software development.

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Recap !

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- Concept of Design for Sustainability
- A few examples of sustainable products in network field

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