

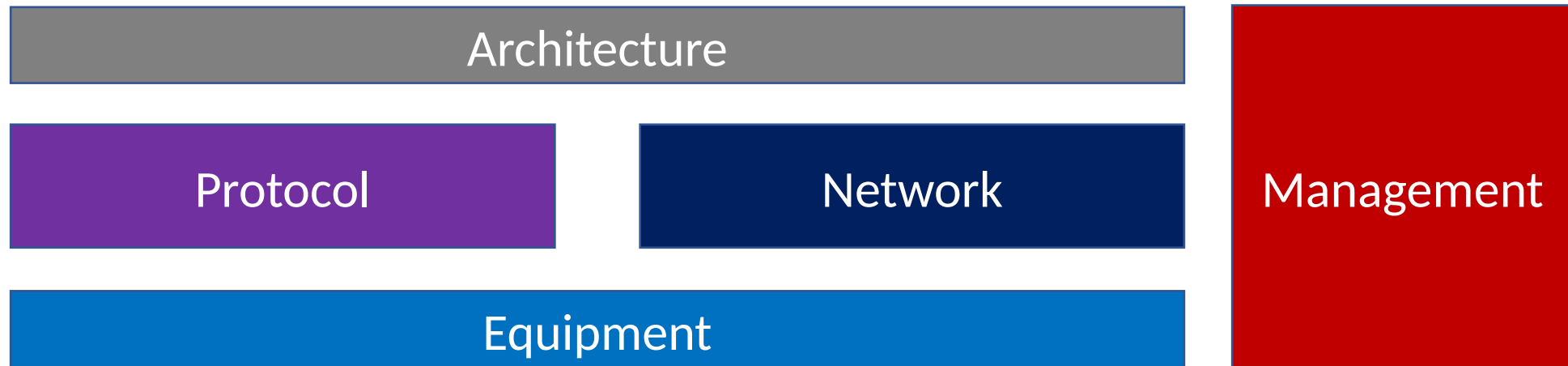
IETF 118, Prague, Czech Republic
November 2023

Network sustainability, green metrics, data models, and instrumentation

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Approaches to improve sustainability

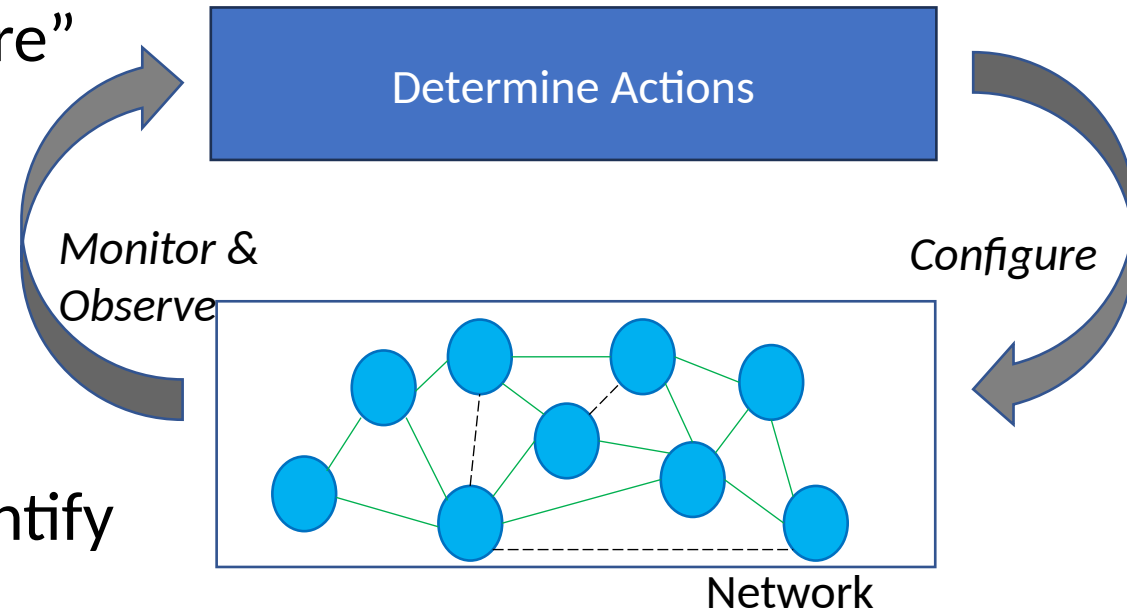
- Plenty of opportunities to explore: pollution-aware traffic steering, energy-aware VNF placement, schemes to retire idling resources, ...
- Structuring Challenges and Opportunities – [draft-irtf-nmrg-green-ps](#)



- What is actionable for us? Which areas promise the greatest impact?
What are the enablers?

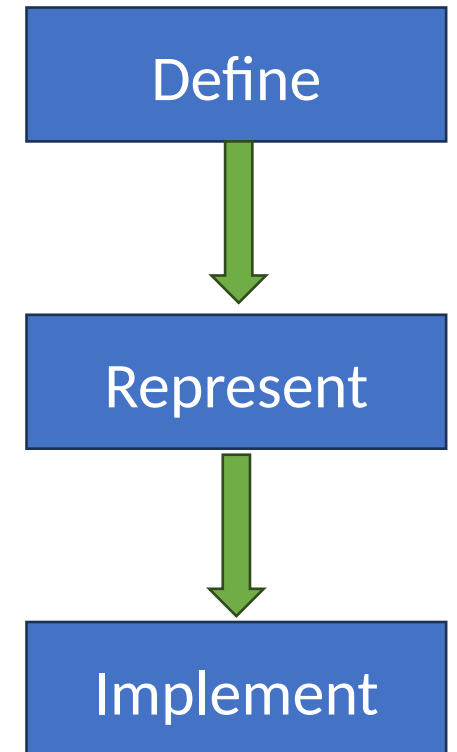
The relevance of data

- “You cannot manage what you cannot measure” (Peter Drucker)
 - Compare effectiveness of alternatives
 - Quantify impact (cost/benefit analysis)
 - Enable control loops
- Foundational requirement hence: data that can be used to observe, assess, quantify “environmental impact”
- This happens to also be actionable in IETF
 - Everybody will need this
 - Standardized data will facilitate solutions
 - Hence a priority for E-Impact (we hope)



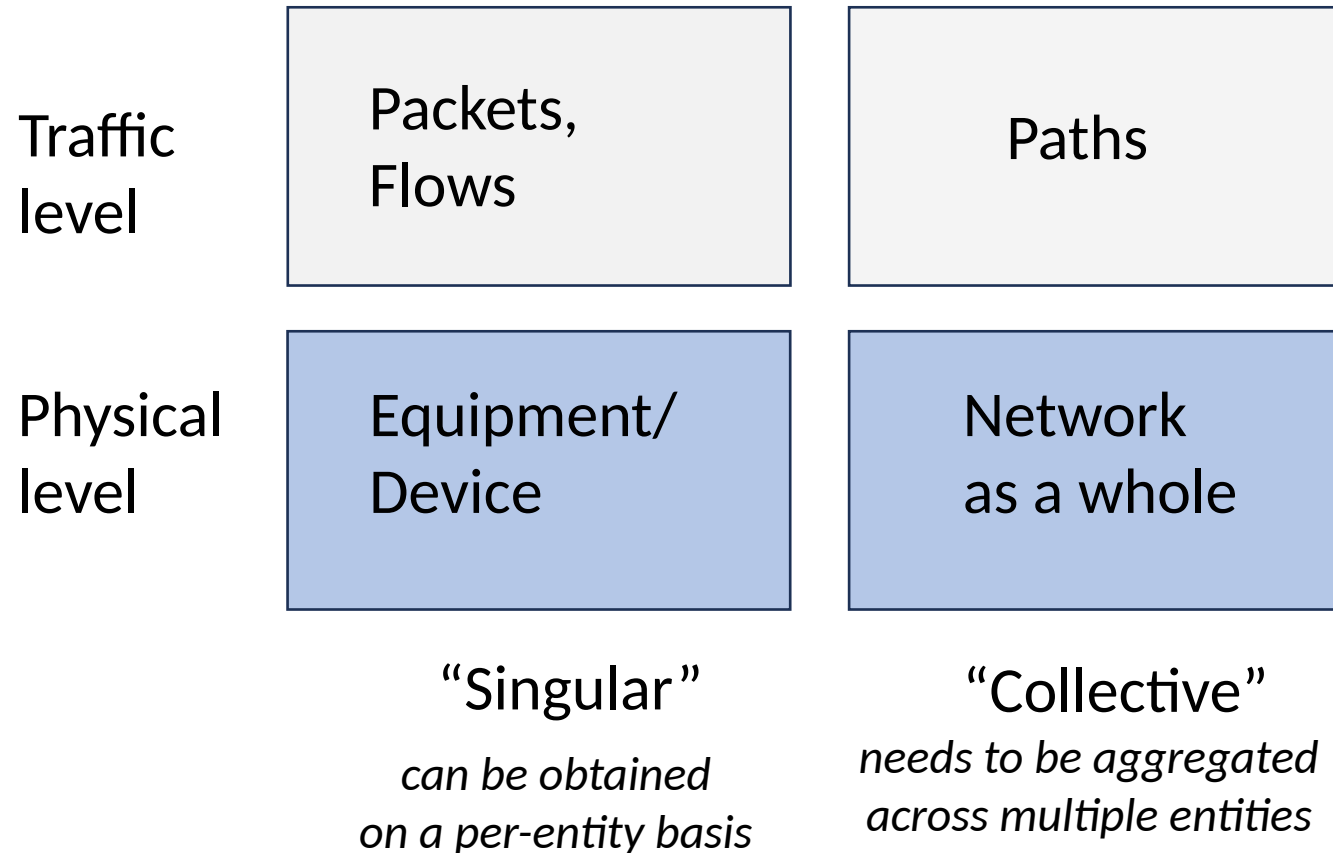
Metrics vs Data Models vs Instrumentation

- Metrics
 - What are the metrics that matter:
for control loops, to assess and compare effectiveness
- Data Models
 - How do we represent and organize metrics
 - How to relate them to different entities
- Instrumentation
 - How do we implement software to provide actual data instances
 - May involve internal instrumentation on a device,
but also measurements & supporting protocols



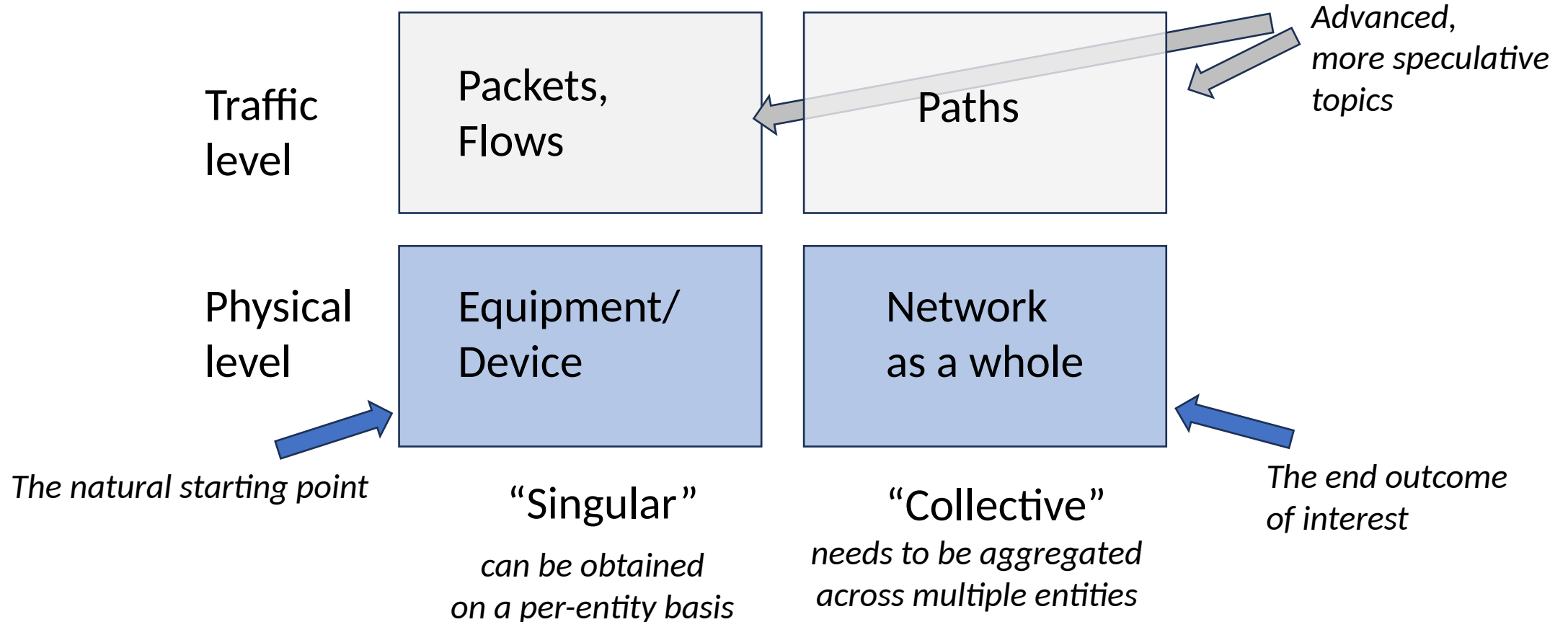
Metrics

Green Networking Metrics: <https://datatracker.ietf.org/doc/html/draft-cx-green-metrics-02>



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Metrics space

Equipment/ Device

Energy consumption, energy utilization efficiency

Examples

Power consumption absolute / normalized, per chassis/line card/port, etc

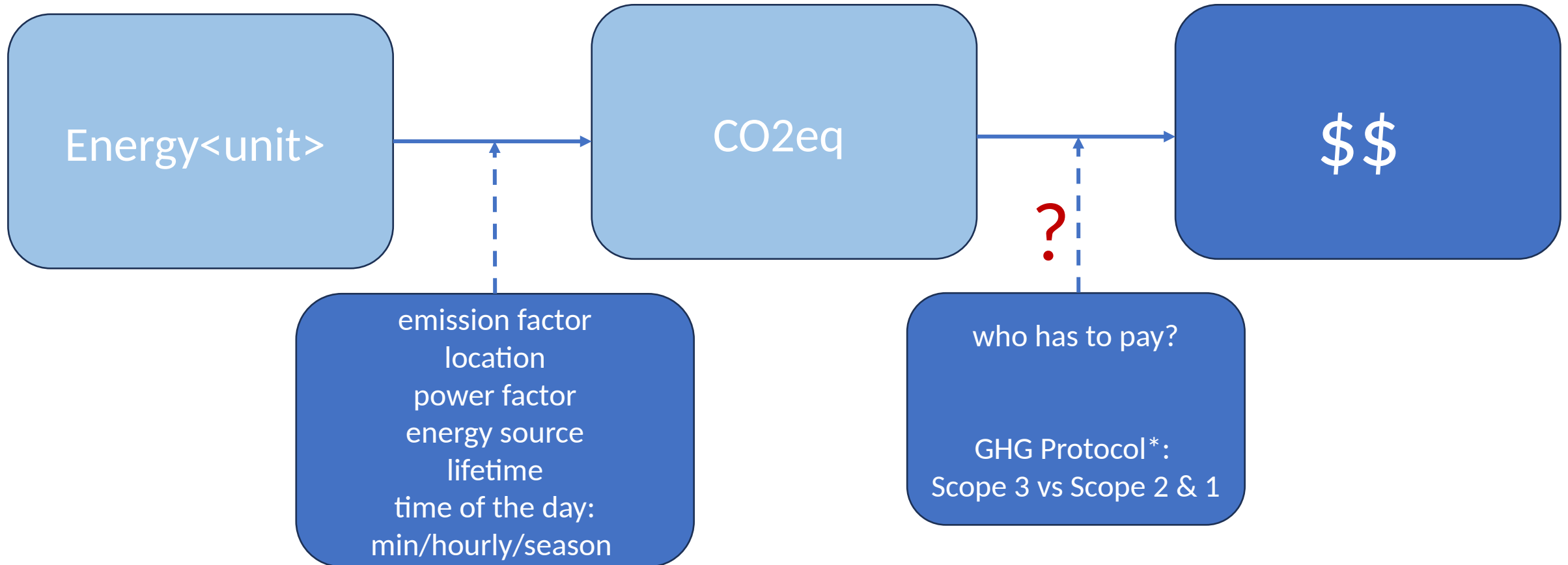
Consumption ratings (datasheet stuff)

But it is not just about equipment power but about greenhouse gas emissions

Account for sources (e.g. energy mix), deployment context (e.g. HVAC)

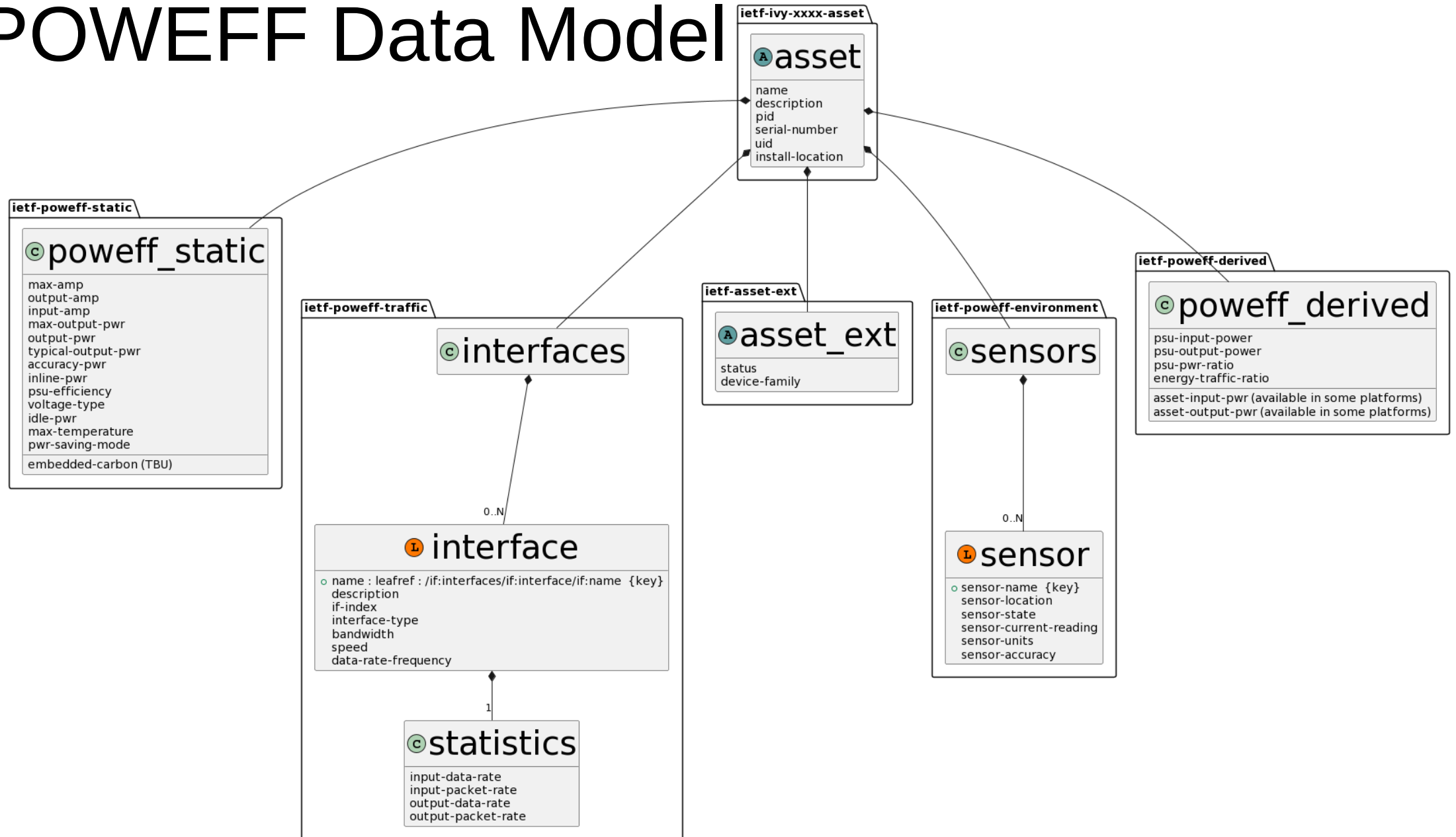
Conversion factors between “power” and “carbon”

Conversion is a choice?



Not an inclusive list of possible factors: e.g. deployment context (e.g. HVAC / "building tax"), amortization of embedded carbon

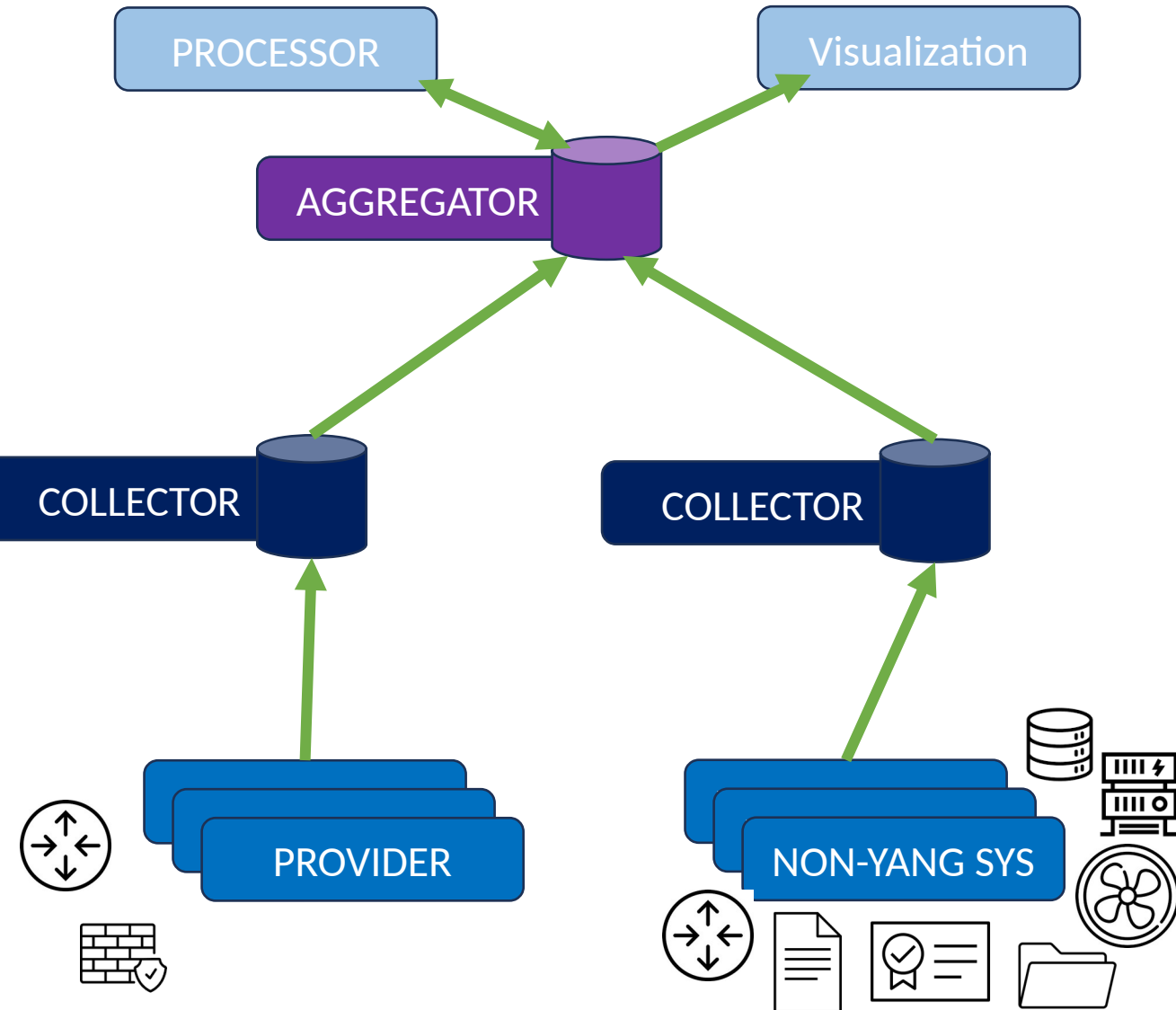
POWEFF Data Model



Metrics under POWEFF-derived

Metric	Description
Energy consumption (kWh)	This represents the energy consumed by the device. Represented by the Power Draw
Power to traffic ratio (watts/Gbps)	Power measure on device (watts) / Traffic throughput (Kbps)
Extrapolated CO2 emissions (g CO2eq)	Use current energy consumption (kwh) and the device geo-location (e.g. -34.6037°, -58.3816°) to query carbon factor (ie from Electricity Maps) and calculate extrapolated CO2 emissions
PSU ratio (%)	Power supply efficiency (offered powered vs consumed power)

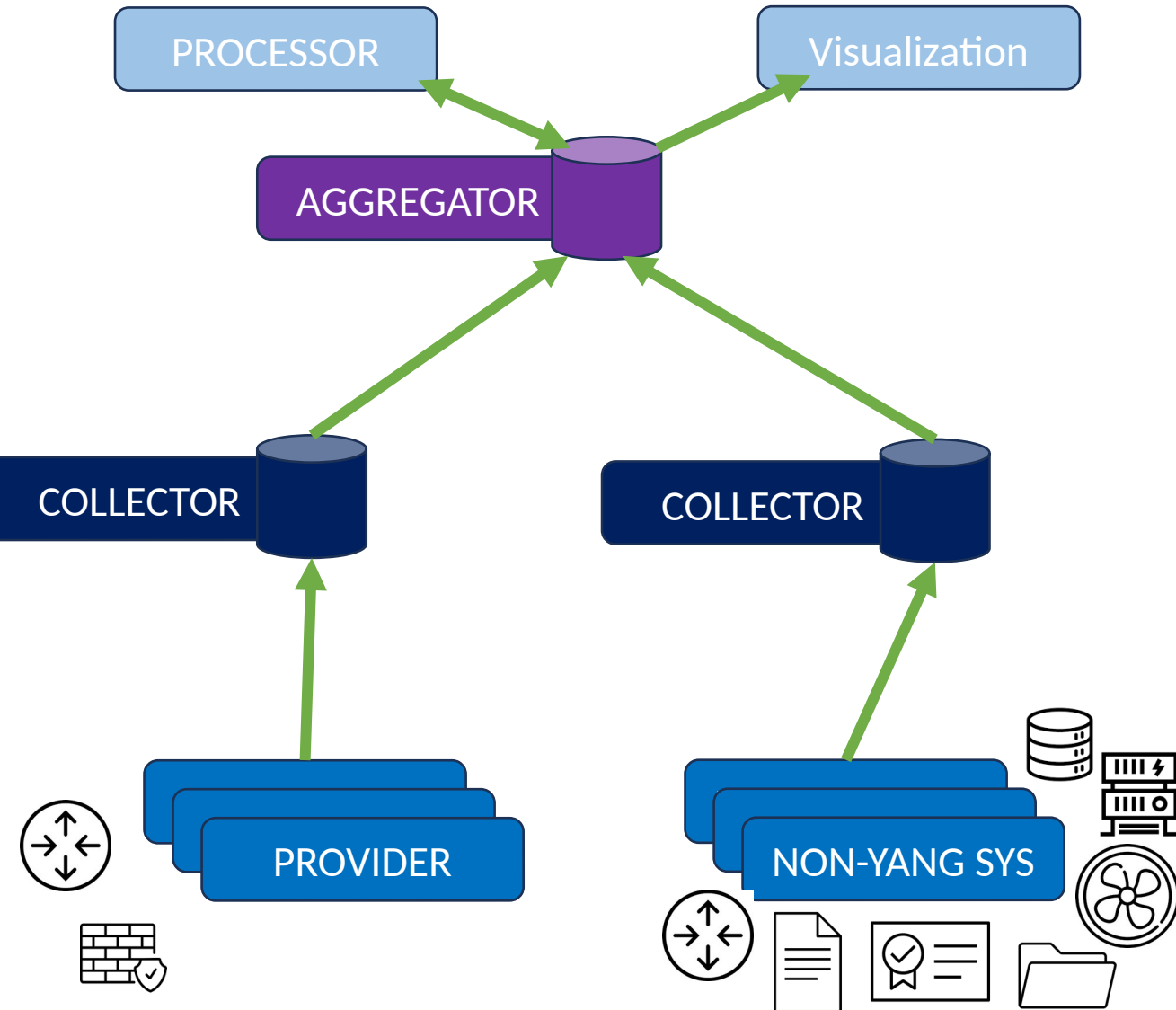
Sustainability Insights Framework



Data Standardization

- Where?

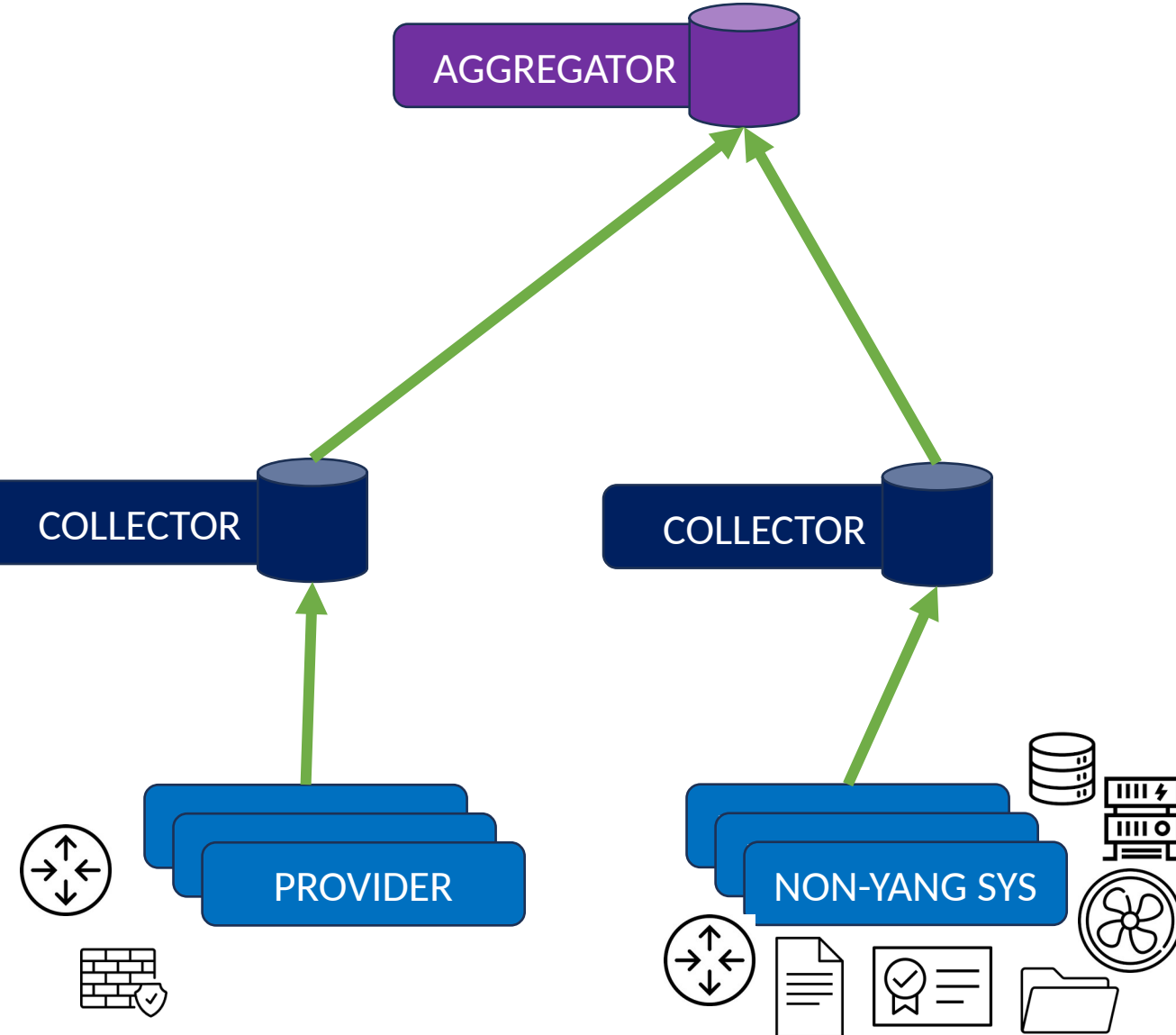
Sustainability Insights Framework



Circularity

- materials, R's, packaging, transport, etc...=> YANG or any other language defining semantic is required

Sustainability Insights Framework



Optimization

What to Optimize?

- Reduce CO2eq emissions
- Reduce e-Waste
- Reduce embedded carbon
- Accuracy of the measurements
- Simulated vs Real metrics
- Cross Domain (Ex: Traffic Path Optimization based on energy constraints)

Metrics space (contd.)

Flows	Relate carbon footprint to flows and service instances Function of volume and duration Additional considerations for packet replication, loss, etc. Carbon flow statistics, enable carbon-based accounting Examples: Energy consumption / carbon footprint over duration of flow
Paths	Assess carbon intensity of paths and route alternatives Energy-/ Carbon-/ Pollution-Aware Networking Examples: Path energy/carbon ratings (function of carbon ratings of hops)
Network-at-large	Totality of the picture aggregated across network-at-large Consider also HVAC, hidden / non-instrumented devices Examples: Total energy consumption (MWh), Network energy efficiency (MWh/PB)

Individual Metrics Controversies

- Do traffic-level metrics even matter
 - Non-linearity of energy consumption
 - Idle power very close to power at max capacity
 - Traffic volume is subject to many tradeoffs – e.g. efficient encoding may incur cost in compute
 - *Verdict is out, non-linearity may not change, more research is needed that is enabled by such metrics*
- Holistic metrics vs discount factors
 - Energy consumption – CO2 equivalents – greenhouse gas equivalents
 - Formulas and discount factors may introduce inaccuracies; how far do we go
 - *Need to clearly document & maintain separately assumptions and conversion factors vs base metrics*
- Relating sustainability cost to utility being derived as measures of efficiency
 - E.g. power consumption relative to traffic volume
 - *Input needs to be put in relationship with utility that is being derived*
 - *Volume of traffic (e.g. W/GB) is a flawed measure of utility, but better alternatives are lacking*
 - *Any one metric can paint a distorted picture and can be gamed*
 - *It's the holistic picture that counts*

Selected Open Issues

- Data and metrics, specifically beyond device-level
 - Consistently applied and broadly supported
- Energy consumed \neq greenhouse gas emissions
 - Which conversion factors are needed & how are they precisely defined
 - Energy mix, deployment factors, embedded carbon tax, CO2/GG equivalents
- Dealing with imprecision and uncertainty
 - Specify ranges vs absolute values in some cases (e.g. power consumption of links)
- Measuring of utility delivered for efficiency measures
 - Can we do better than traffic volume
- Virtualization - do we need virtual energy metrics
- Compliance and certification
 - Including incentive structure for accurate instrumentation
- Instrumentation of legacy equipment

+ on a practical level in IETF/IRTF, landing spots are not always clear

Backup

Context

- Reducing greenhouse gas emissions to address climate change is one of mankind's "grand challenges"
- This challenge also extends to network technology
 - How to reduce environmental impact of networks?
 - How to make them more sustainable & what can we do at IETF?
- E-Impact Program sponsored by the IAB
 - Following several earlier activities:
E-Impact workshop, side meetings at IETF 115-117
 - Several Internet Drafts have begun to appear, loosely coordinated here
 - Landing spots for those drafts are not always clear
e.g. <https://datatracker.ietf.org/doc/html/draft-cx-green-metrics-02>:
opsawg? ippm? somewhere else?