

Reactive power: an unnecessary and misleading approximation

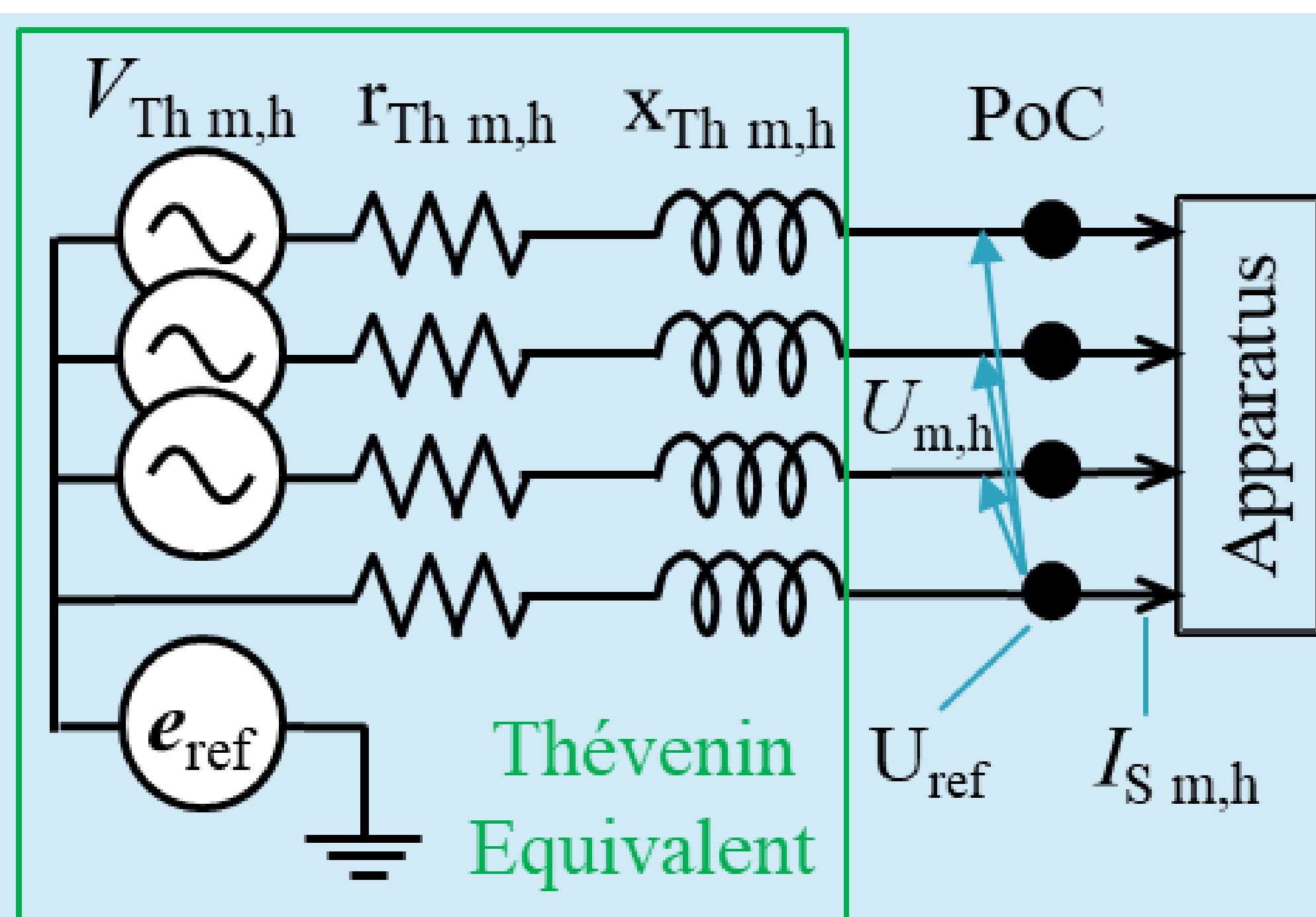
Trevor Gaunt
University of Cape Town

Background

- Single phase and unbalanced nodes in microgrids and smart grids → **phase unbalance**.
- Increasing penetration of non-linear power electronic loads → **distortion**.
- Aim: Understand effects of distortion and unbalance on losses and stability → mitigation by better converters.
- Need: Measurement model for periodic signals, with M-wires, H+1 frequencies, unbalance and distortion → General Power Theory (GPT) consistent with physics, developed and proved in linear algebra.

Theory and Findings

- Inputs: voltage and current vectors + Thévenin equivalent circuit, all measured from PoC.
- Only one of the infinitely possible current vectors delivers same PoC power with minimum loss.
- Outputs: Power – at PoC and Thévenin point, actual loss and minimum delivery loss.
- Unexpected: GPT allows no form of Q. Q is not a physical quantity, not interpretable.
- Converter controller needs no rotating reference frame, no dq , no $\alpha\beta$.



Measurement model



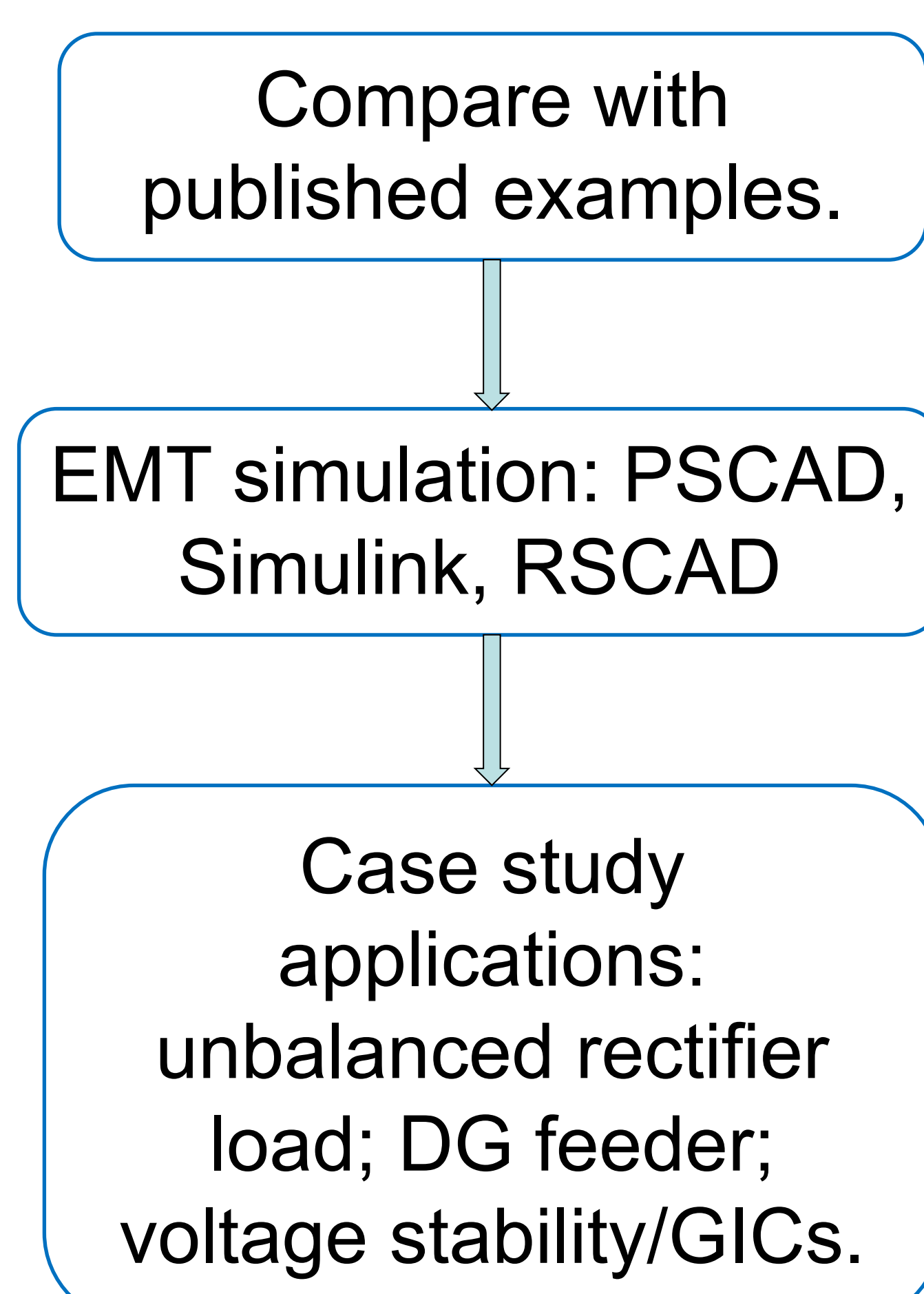
20 kW concept demonstration testing



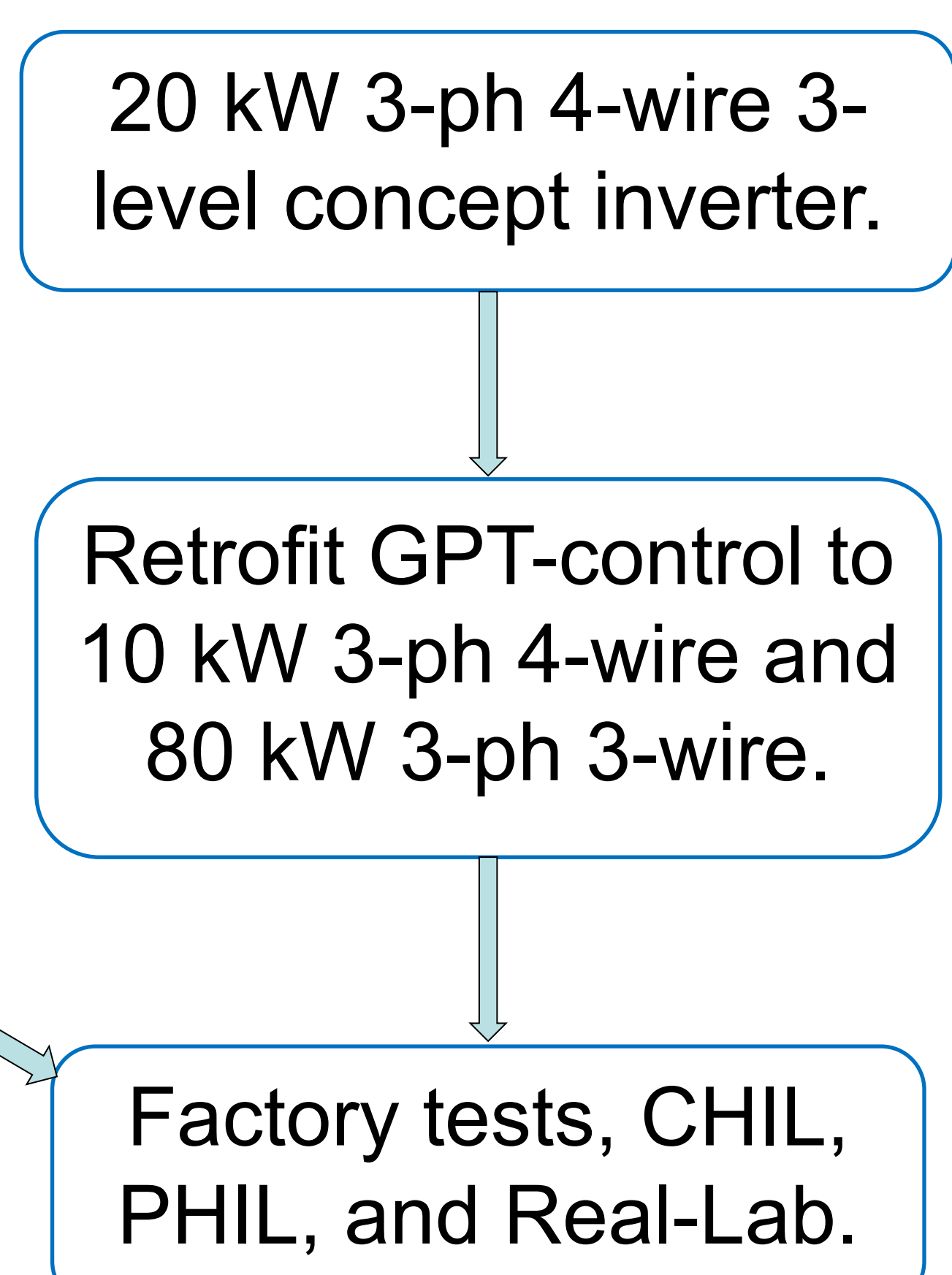
80 kW inverter in Real-Lab test bay

GPT Testing

Studies



Hardware



Implications

- Q's operational definition is an approximation that can mislead decisions.
- GPT represents practical systems; no Q, no approximations of unknowable uncertainty.
- Analytic loss optimisation.
- One set of scientific-legal definitions of power terms (power, harmonic power, apparent power, power factor) for all systems, unbalance, distortion → interoperability.
- Stand-alone, no communications required.
- Var, kvarh, Q-capability are not justifiable for tariffs.
- All equations with Q (even PQS power triangle) or q need review.
- Teaching and research opportunities.

