Post COP21 and Thereafter:
The need for new concepts to monitor progress and compliance and for assisting policy

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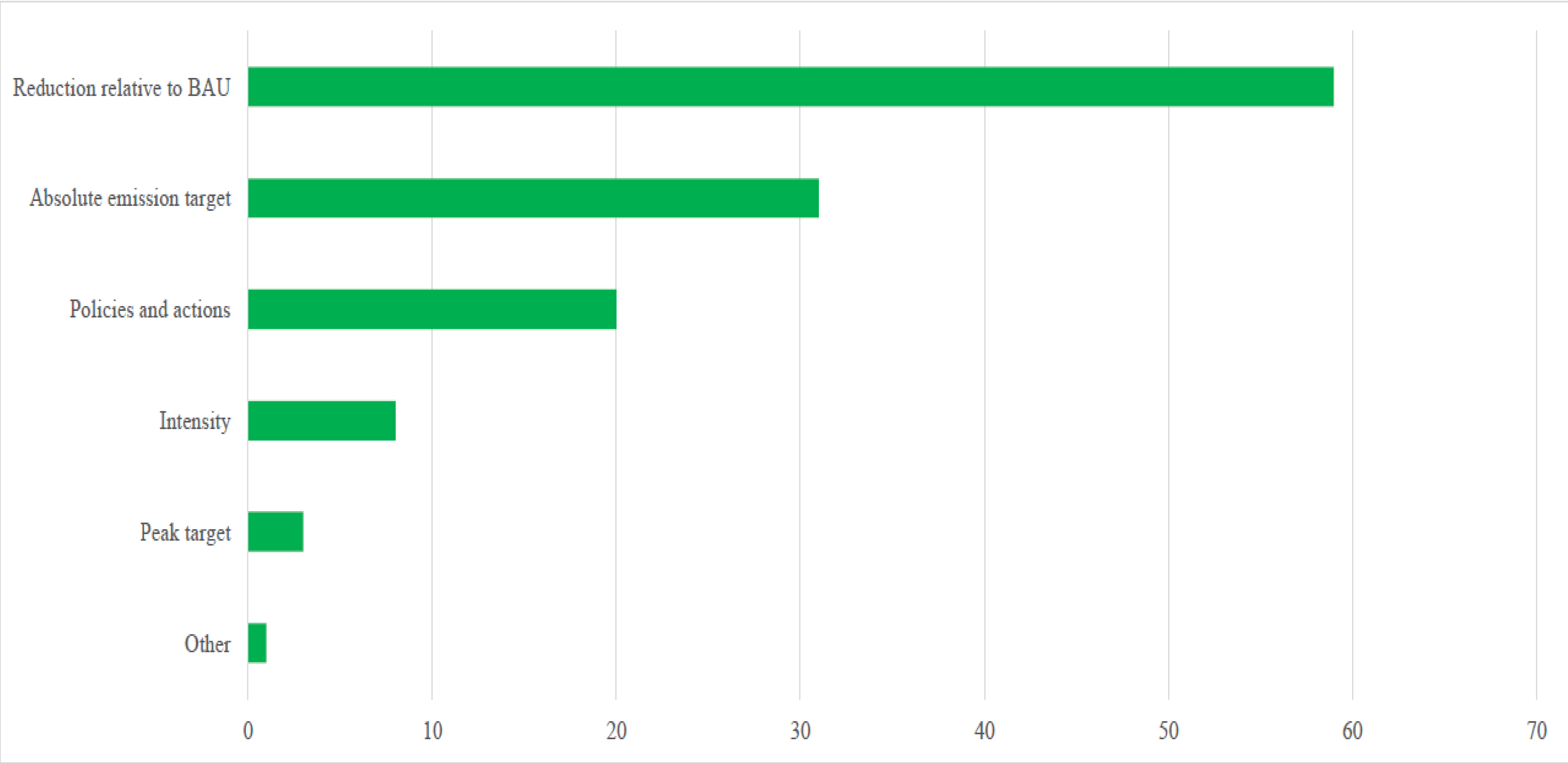
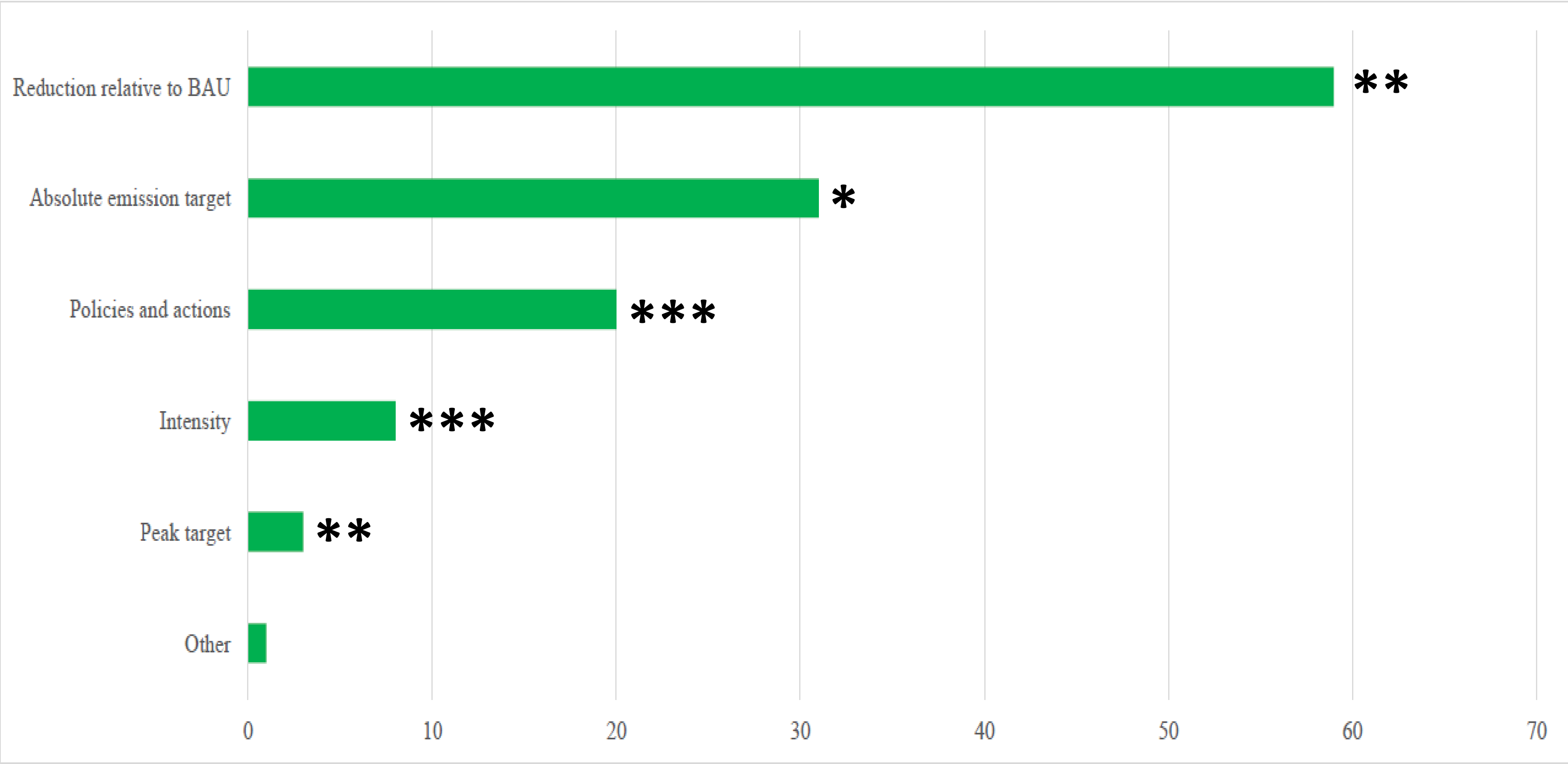
Paris INDC by Type of Target



Source: UNFCC, 2015

Paris INDC by Type of Target



*   Monitoring and Compliance sensitive to: emissions uncertainty

**   Sensitive to: emissions AND forecasting uncertainty

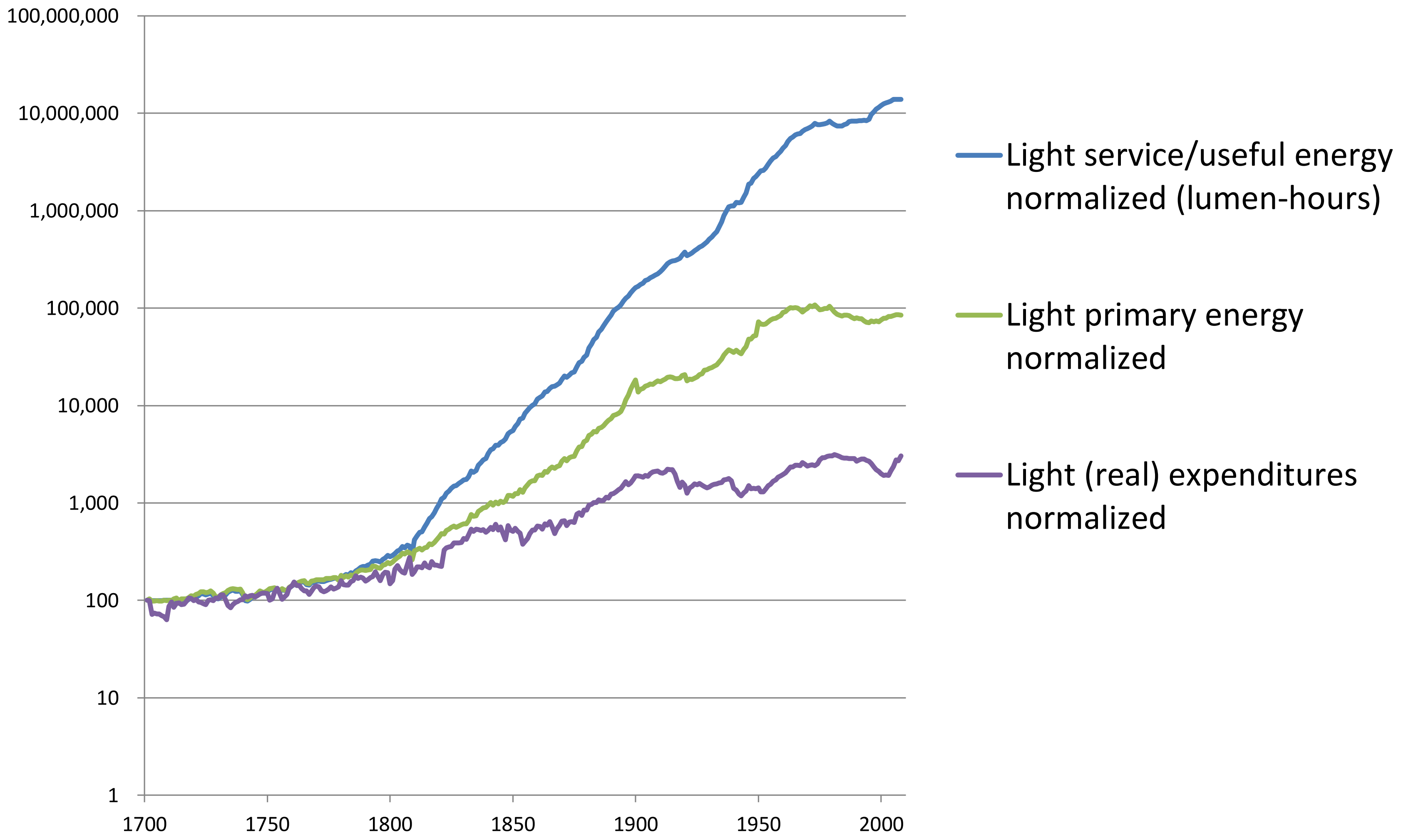
*** Sensitive to: emissions AND forecasting uncertainty, AND measurement biases

Measurement Issues in Transitions and Decarbonization

- Traditional: Input oriented, aggregate (primary energy, emissions) - Observed historical rates of change are slow: 80-130 yrs
- New: Output oriented, sectorial (useful energy, transformation) – Much faster (x2) dynamics and deeper decarbonization
- Reasons for acceleration of transitions and decarbonization in output measures: efficiency, granularity, learning, spillovers, and social network effects – illustrative ALPS modeling

Input vs. Output Measures of Growth

(example lighting services UK, index 1700=100)

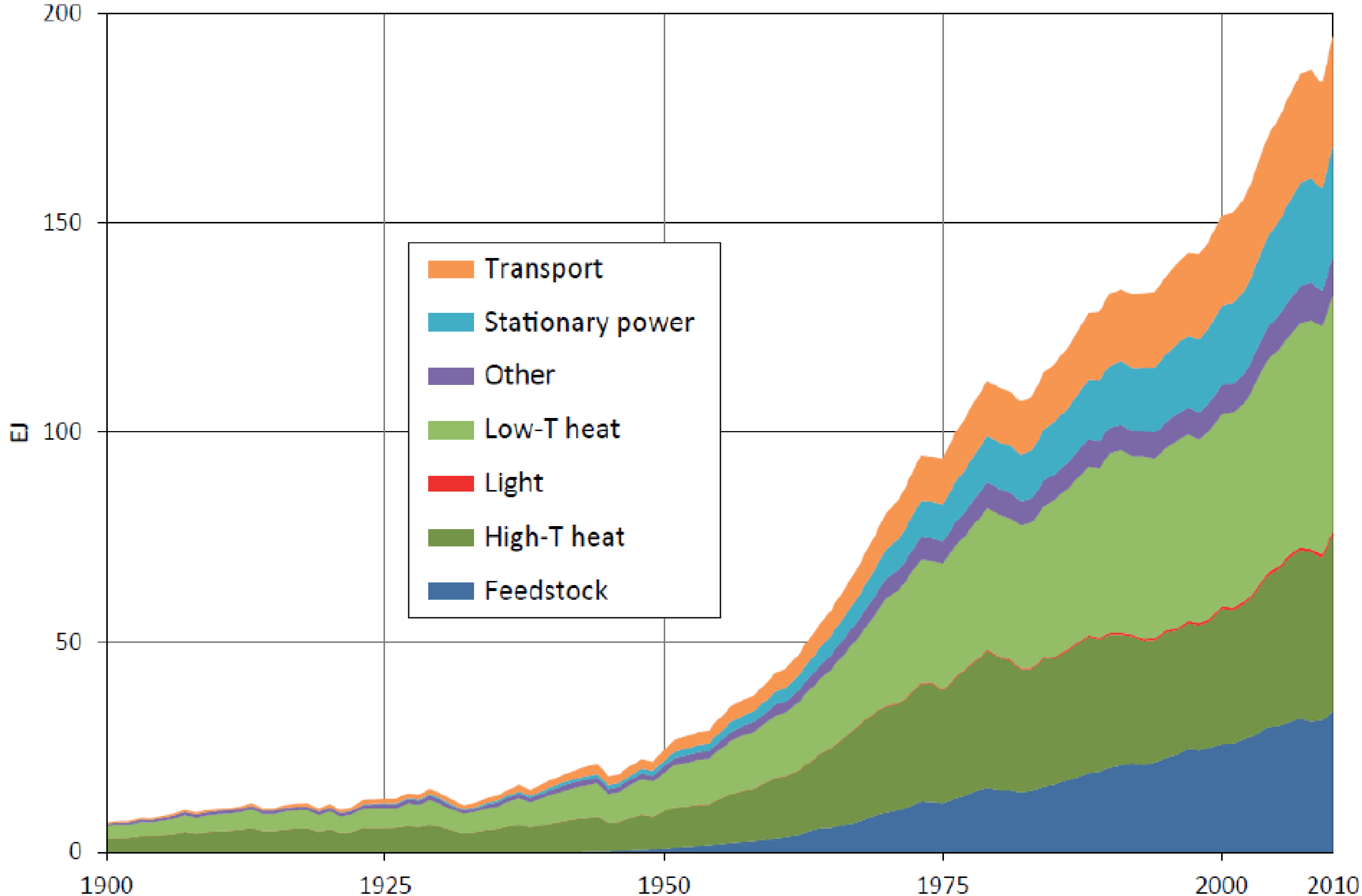


Source: Grubler (in press) based on Fouquet, 2008

New Data

- PFUDB: Primary, Final, Useful Energy Balances
  countries, regions, world
  1900 to 2010
  - energy AND exergy
  - by end-use service
  - by sector
  - by fuel
- Online: https://tntcat.iiasa.ac.at/PFUDB
- Documentation: S. De Stercke, IIASA IR-14-013

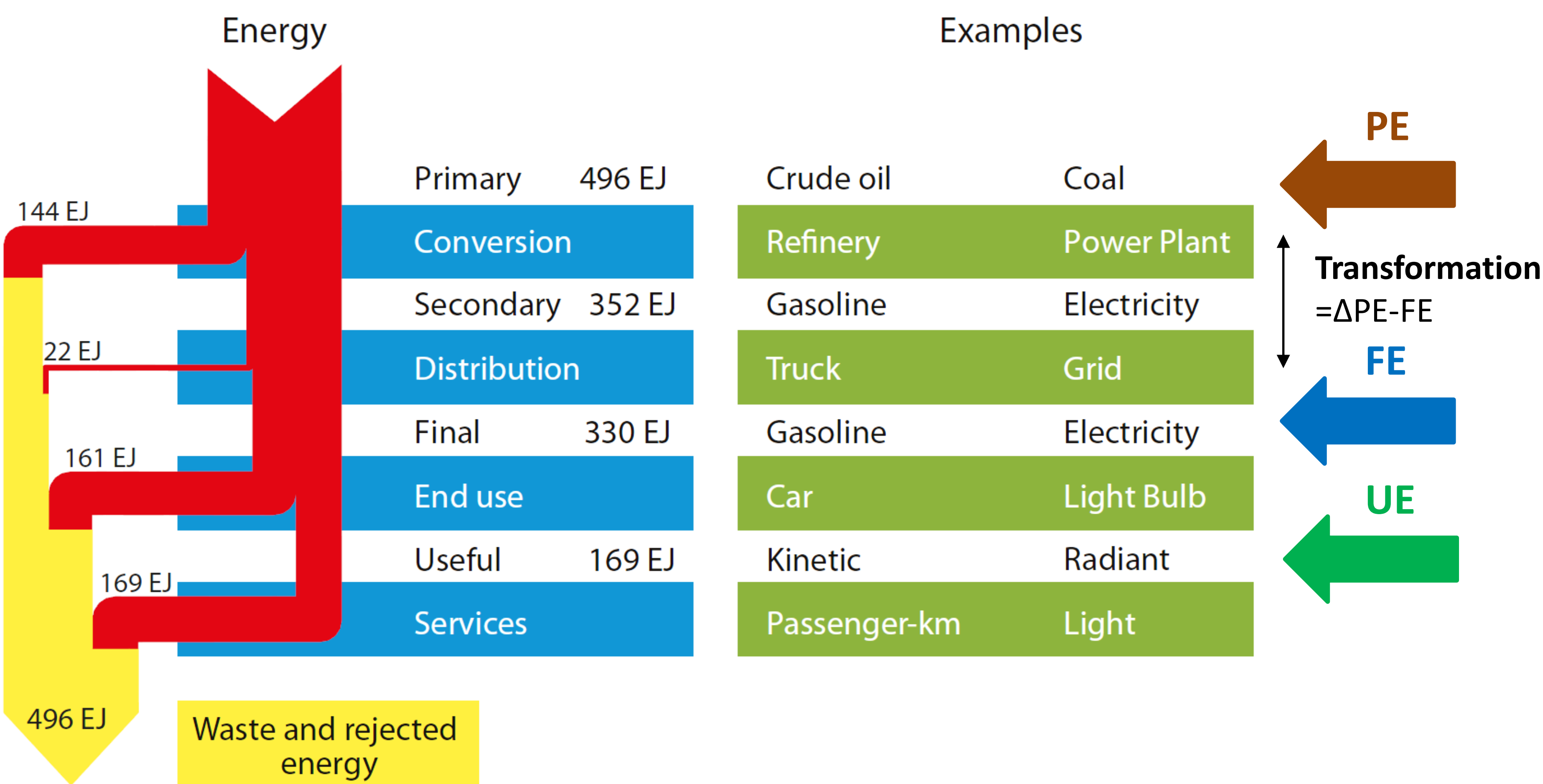
World – Useful Energy by Service



Source: EnergyPrimer.org

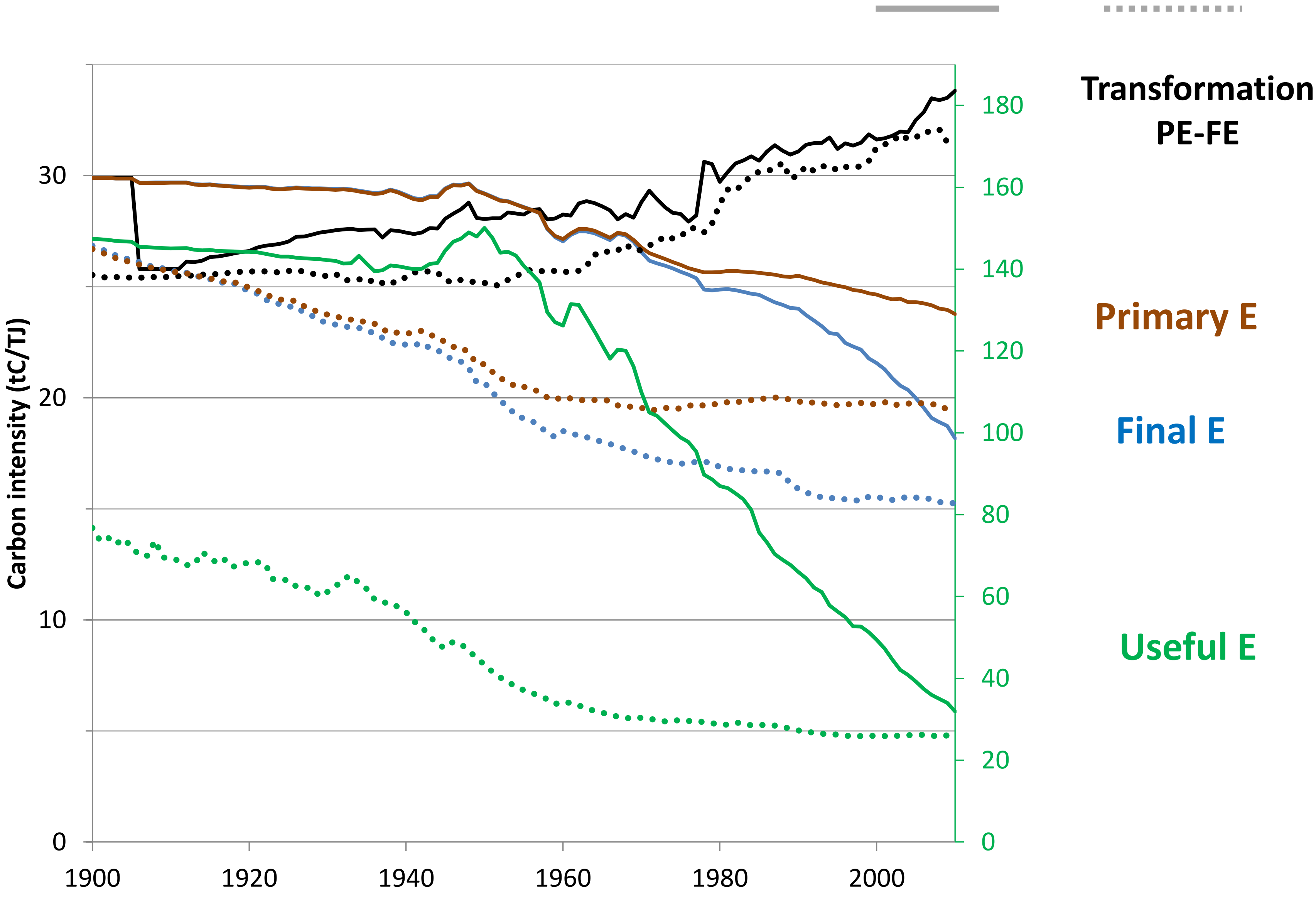
Global Energy Flows 2005 (EJ)

& Measurement Points for Decarbonization

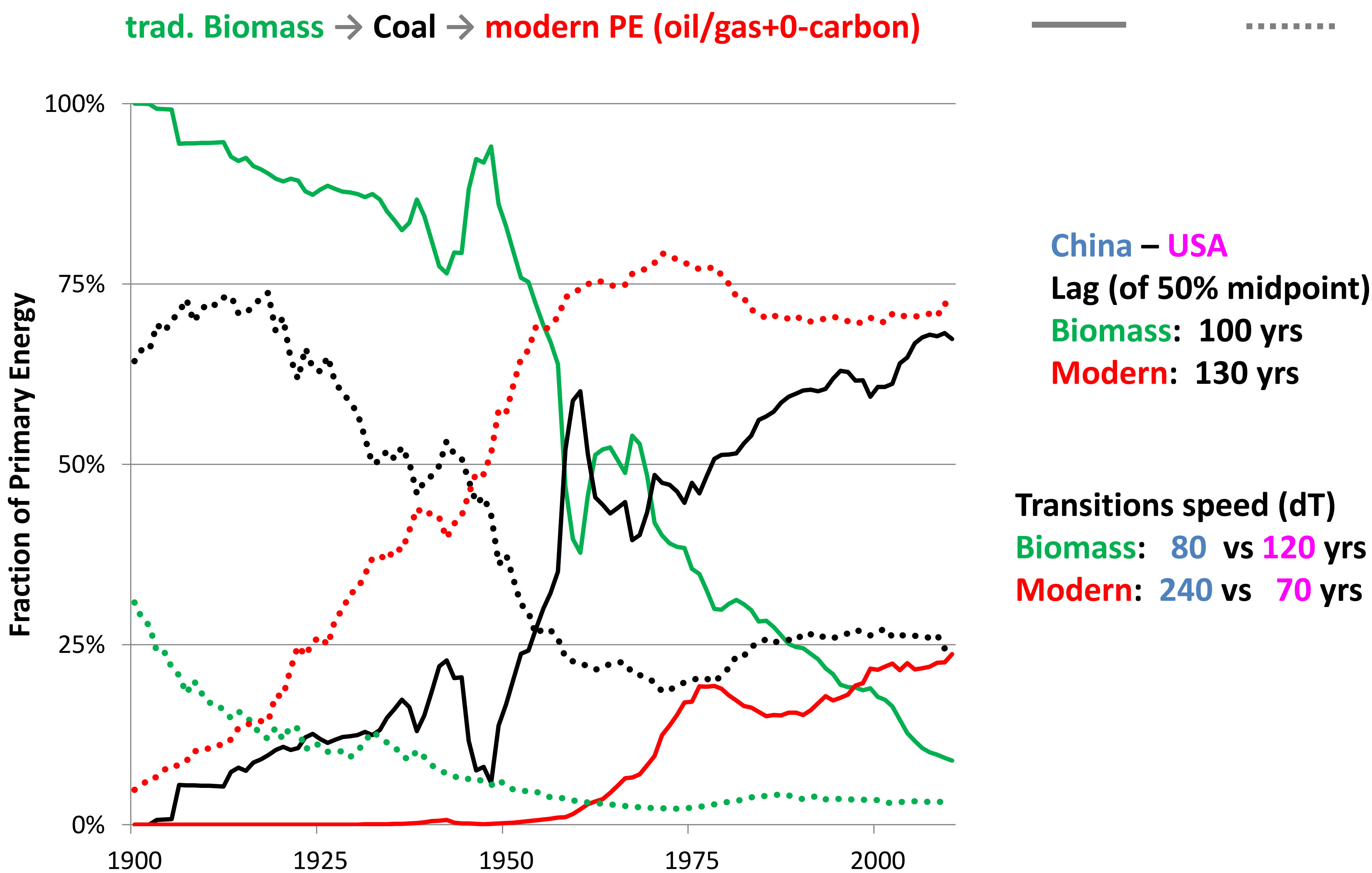


Source: EnergyPrimer.org

Decarbonization at 4 Levels: China vs. US

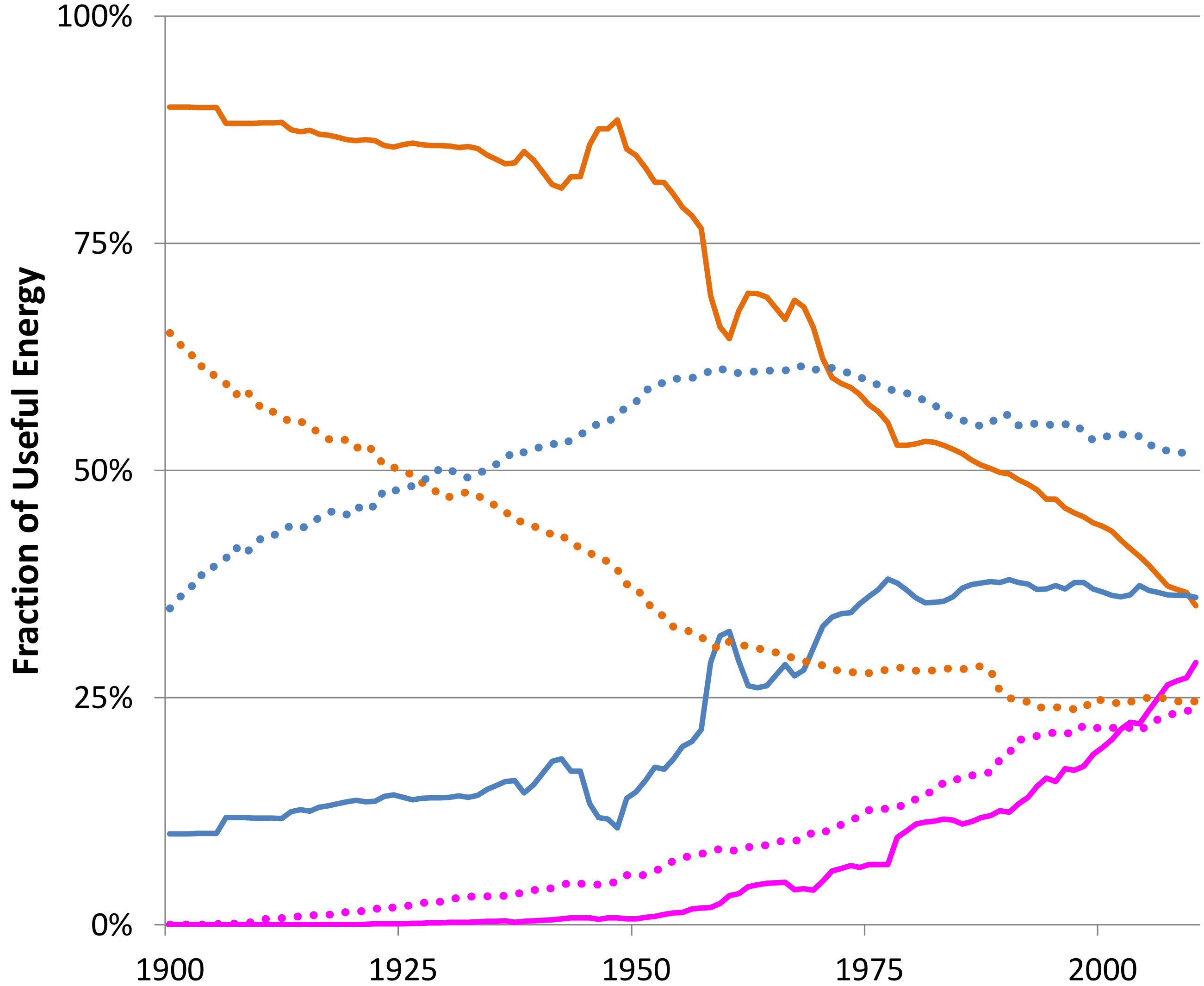


Transitions in Primary Energy Inputs: China vs. USA



Transitions in Energy Outputs (UE) : China vs. USA

Carbon → Hydrogen → Electrons

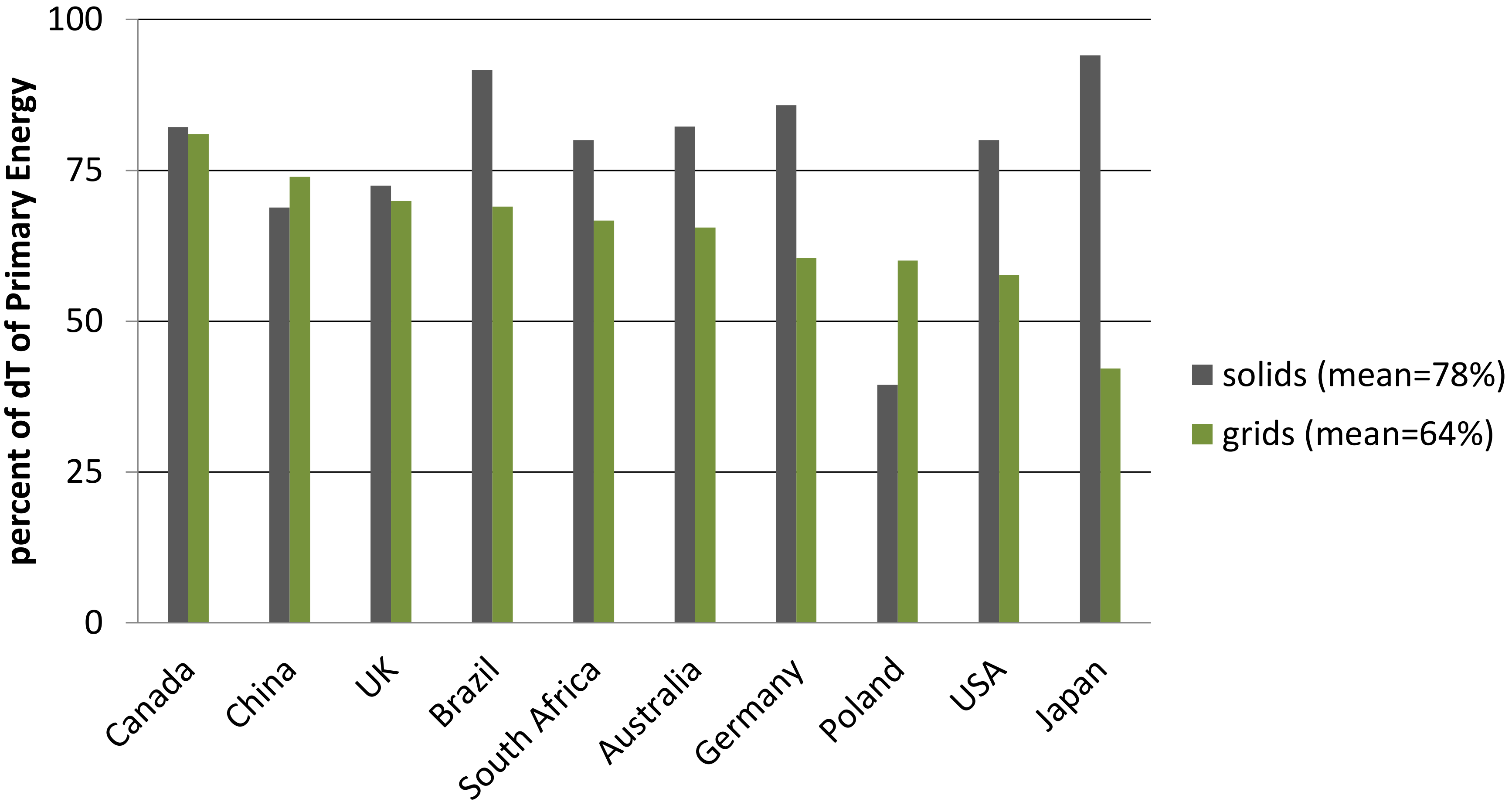


China – USA
Lag (of 50% midpoint)
C: 70 yrs
e: 0 yrs

Transitions speed (dT)
C: 160 vs 200 yrs
e: 90 vs 120 yrs

Transition Dynamics compared

(dT useful energy as % of dT primary energy)

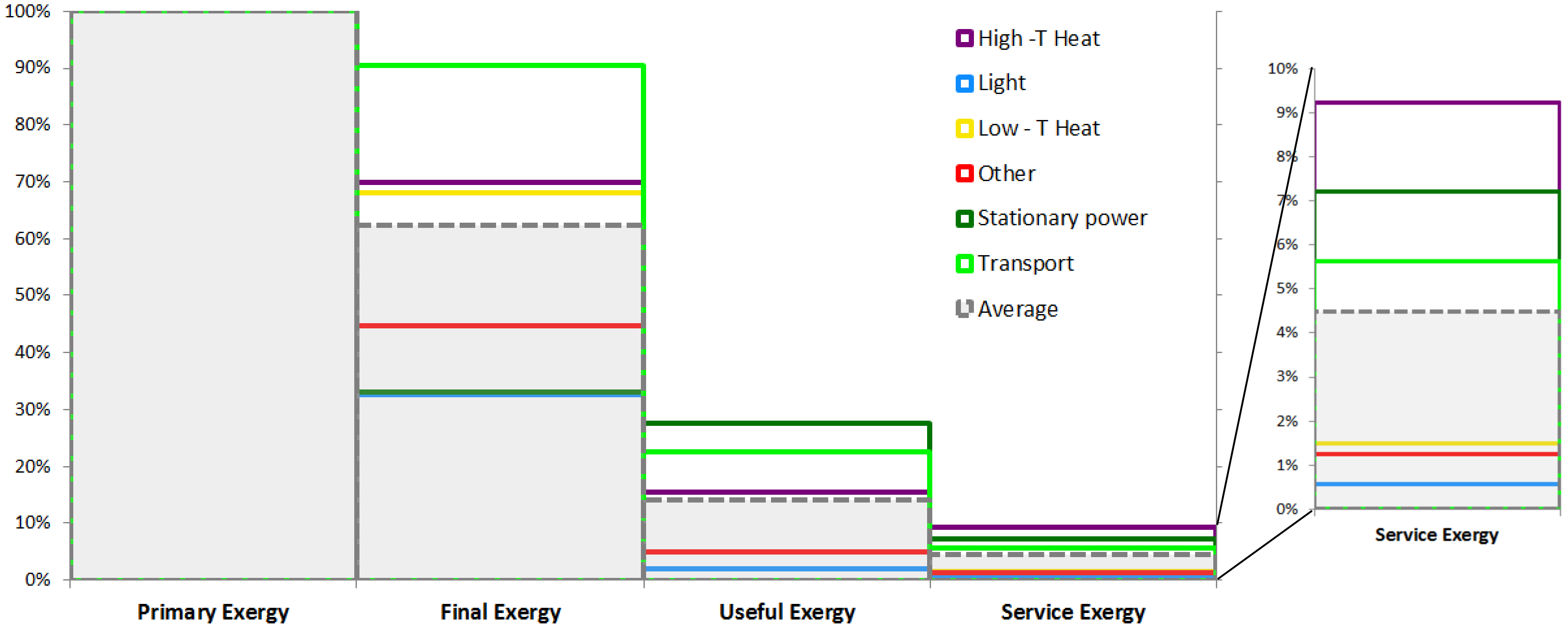


Why Faster Transitions in Outputs?

- Efficiency gains
- Nature of technologies (“granularity”) leading to faster learning & improvements
- Performance, rather than price driven
- Social network and peer effects

World Exergy Efficiencies in 2010

(as percent of primary exergy)



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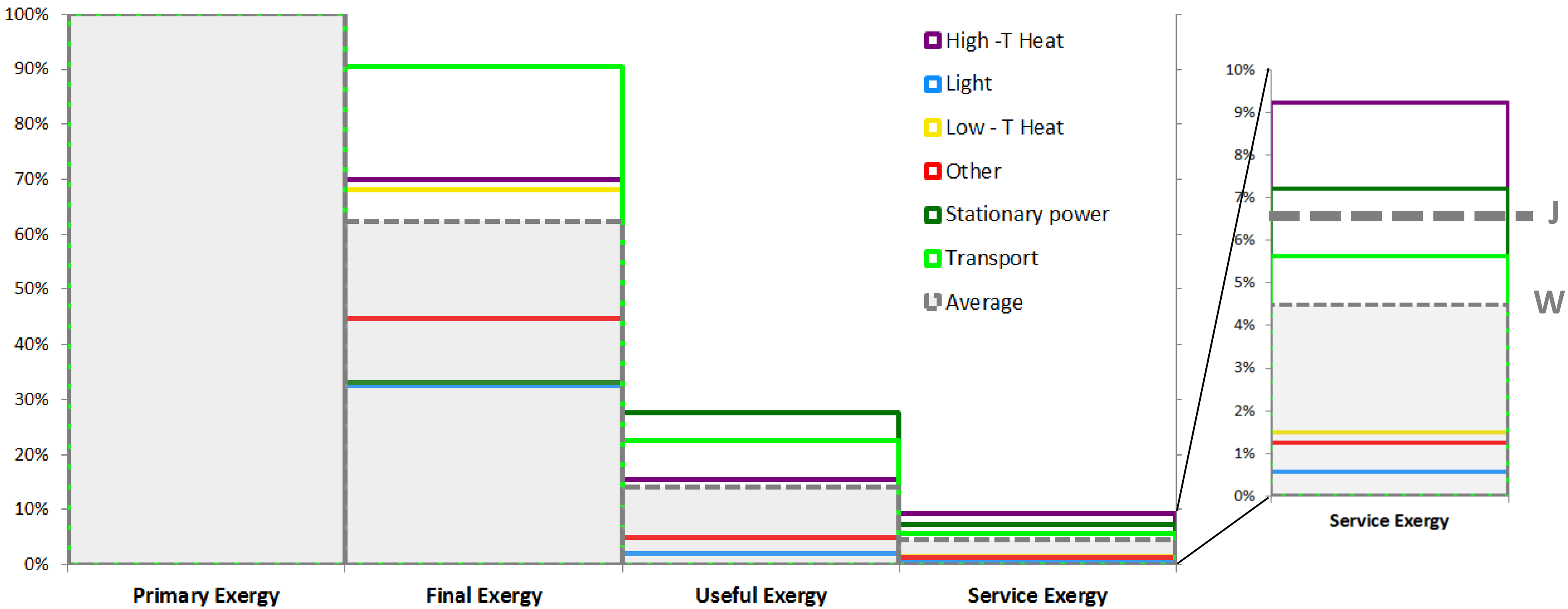
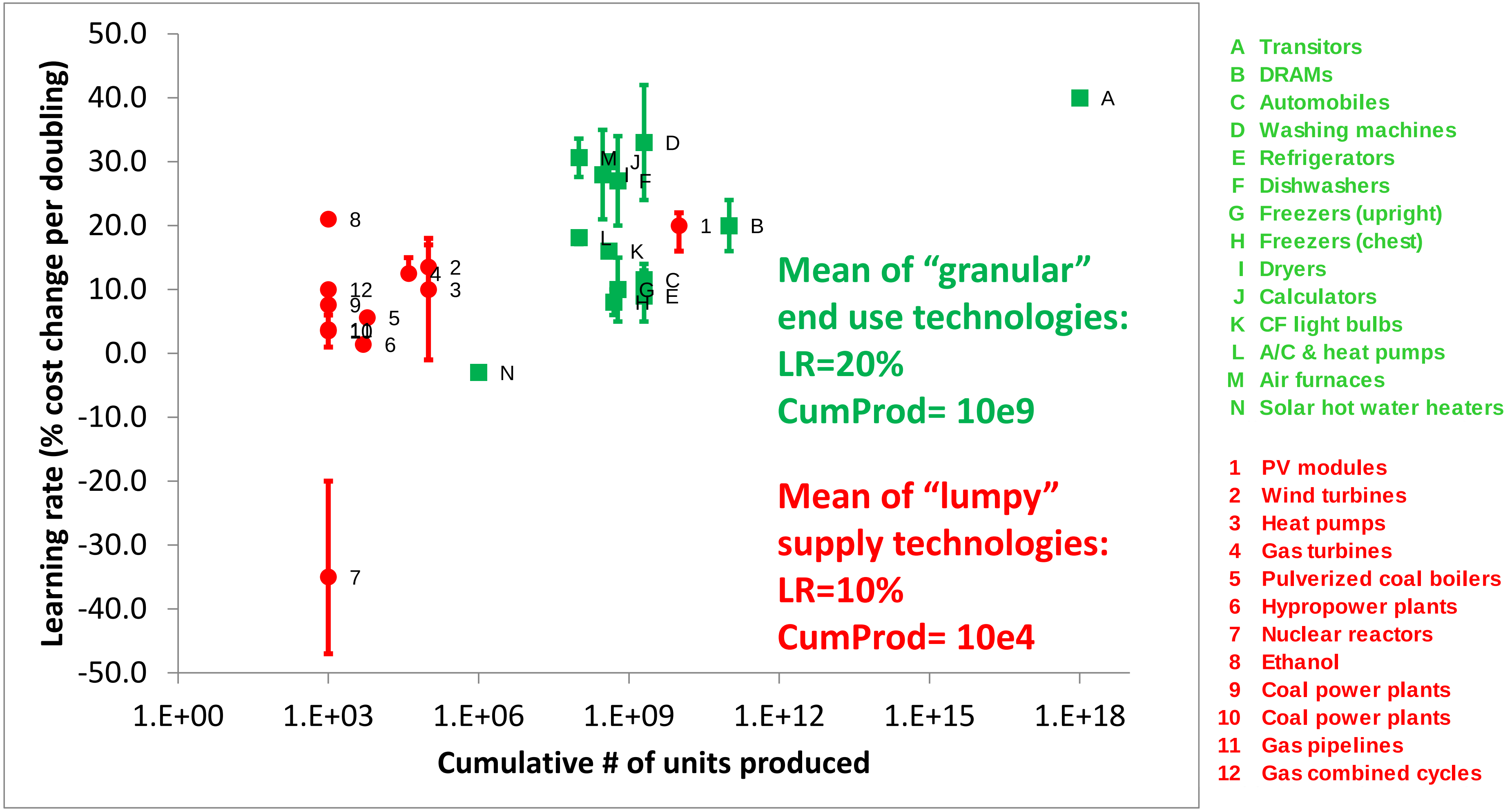


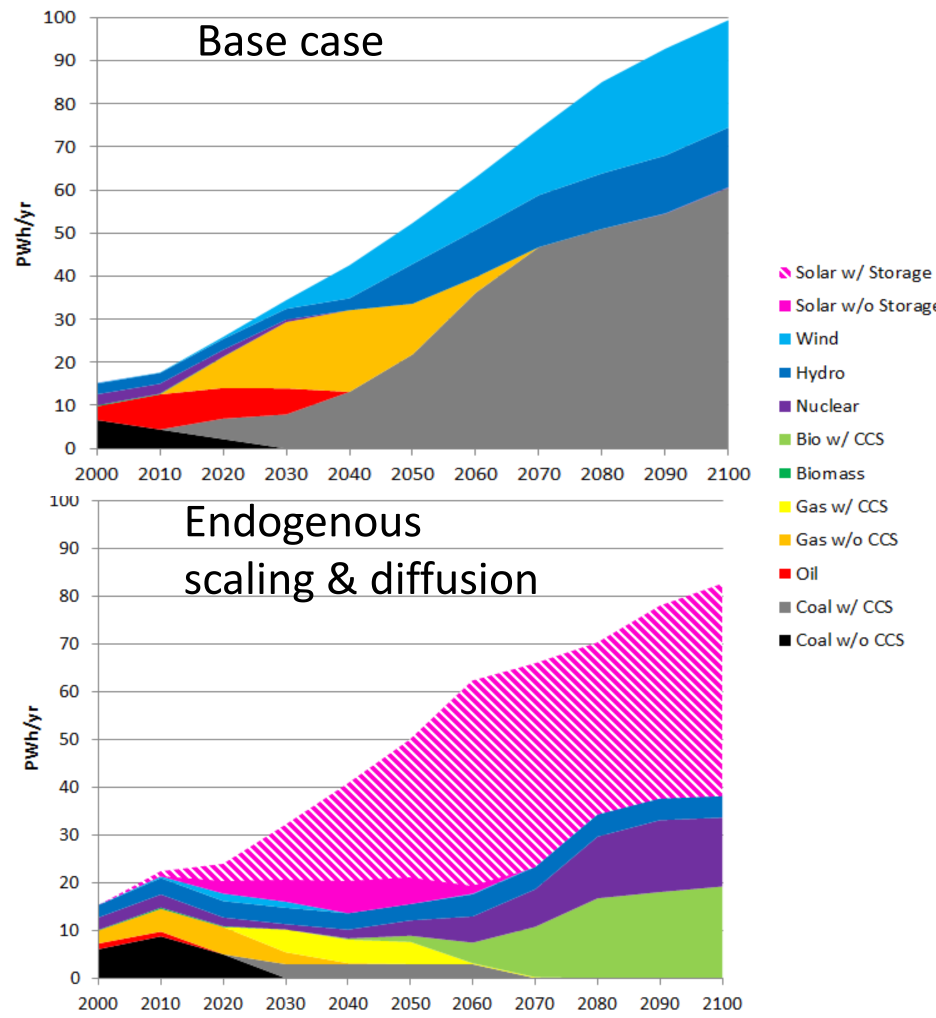
Learning Rates of Energy Technologies: Supply vs End-use



Wilson et al. Nature CC S1, 2012

MESSAGE IAM Modeling Implementation

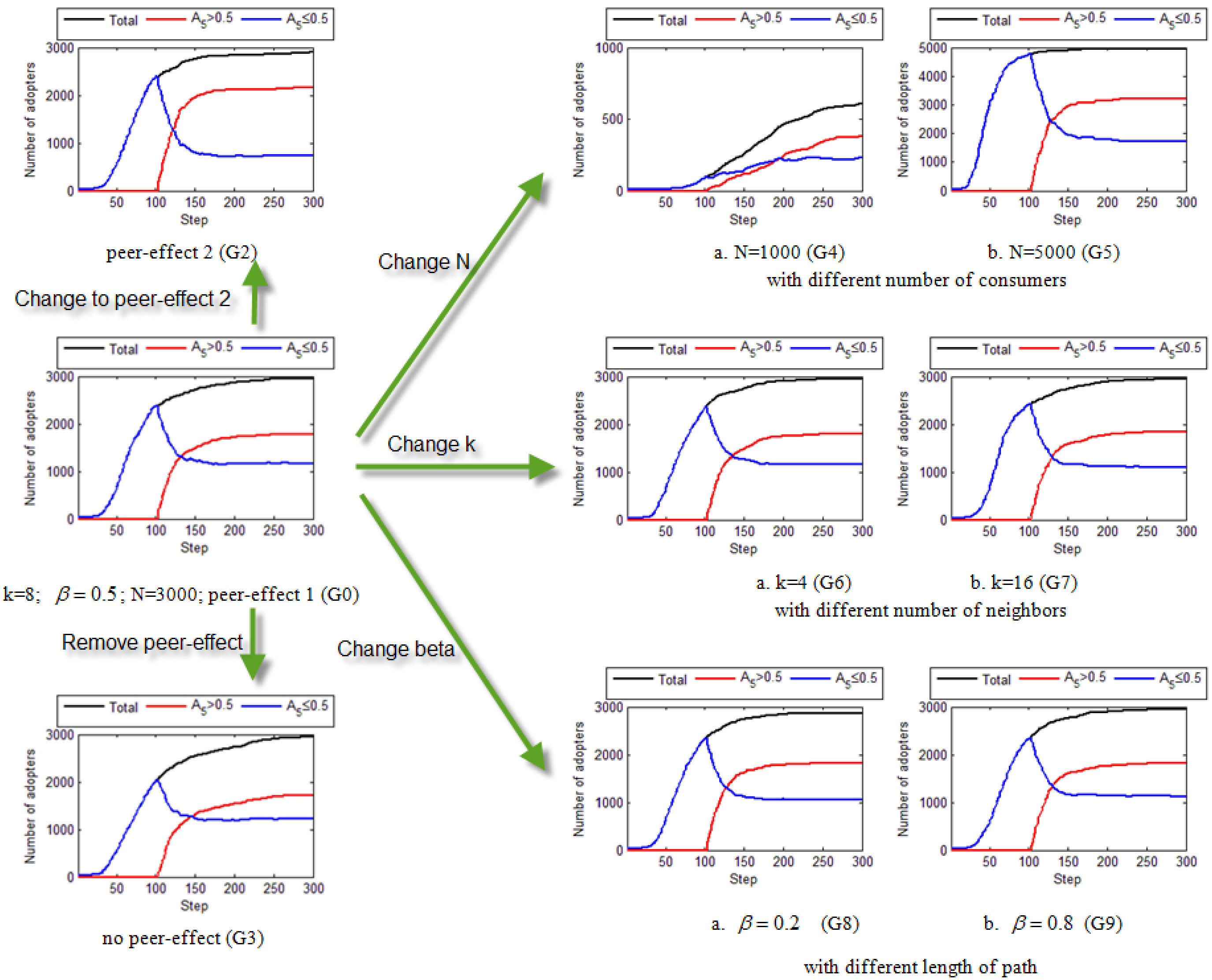
- 5 regional, global IAM MESSAGE+
- Demand @ useful energy (output)
- 2°C climate constraint (LP)
- Endogenous technology diffusion as a function of:
  -- unit scaling
  -- investment risks (granularity)
  -- learning:
    - cost reductions (cumUnits) influencing rel. advantage
    - spatial knowledge spillovers
  -- market size



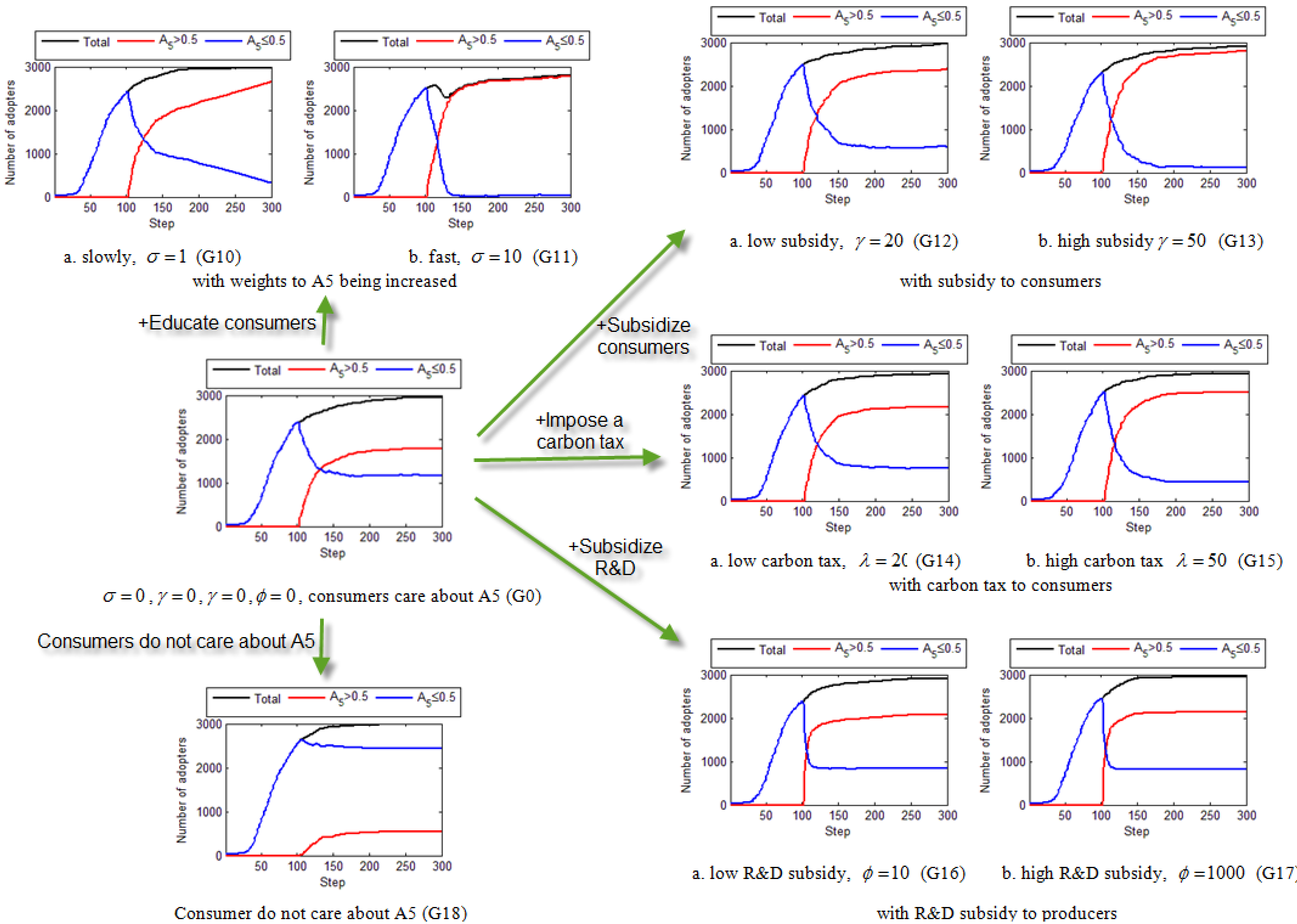
ABM - Agent-Based Modeling

- Representation of producers and adopters
  of technologies (agents) and policy maker (principal)
  micro-level interactions yield aggregate macro-level outcomes
- Heterogeneous products
  (performance, price,…,…, environment)
- Heterogeneous agents
  (producers: technological capability, R&D strategy;
  consumers: preferences and preference weights)
- Agent interaction 1: producers-consumers
- Agent interaction 2: consumers-consumers
  ("small world network" Watts- Strogatz-1998 model)
  depending on:
  -- nature and size of social network
  -- peer effect
- Agent interaction 3:
  policy makers – producers – consumers
  policy options: education, C-tax, R&D subsidy
- Results today: vehicle market sales per product category
  (Attribute A5: environment <0.5, or >0.5 preference weight)

Results ABM - Network Effects: Network size (critical threshold level) >> peer effect > # of neighbors and their distance



Results ABM Policy Leverages:
Δ consumer preferences >> C-tax > R&D subsidy



Conclusions

- INDCs:
  - Verification, plausibility, “rachetability” measures needed
  - Measurement concepts matter
  - Complement traditional, input measures with output based measures (less uncertainty in PE accounting, better perspective on “feasibility”, see e.g. SE4All)
- Policy implications:
  - Differentiated, sectorial targets and measures
  - Renewed emphasis on end-use (efficiency, behavior, organization)
  - Policies need to consider innovation characteristics