

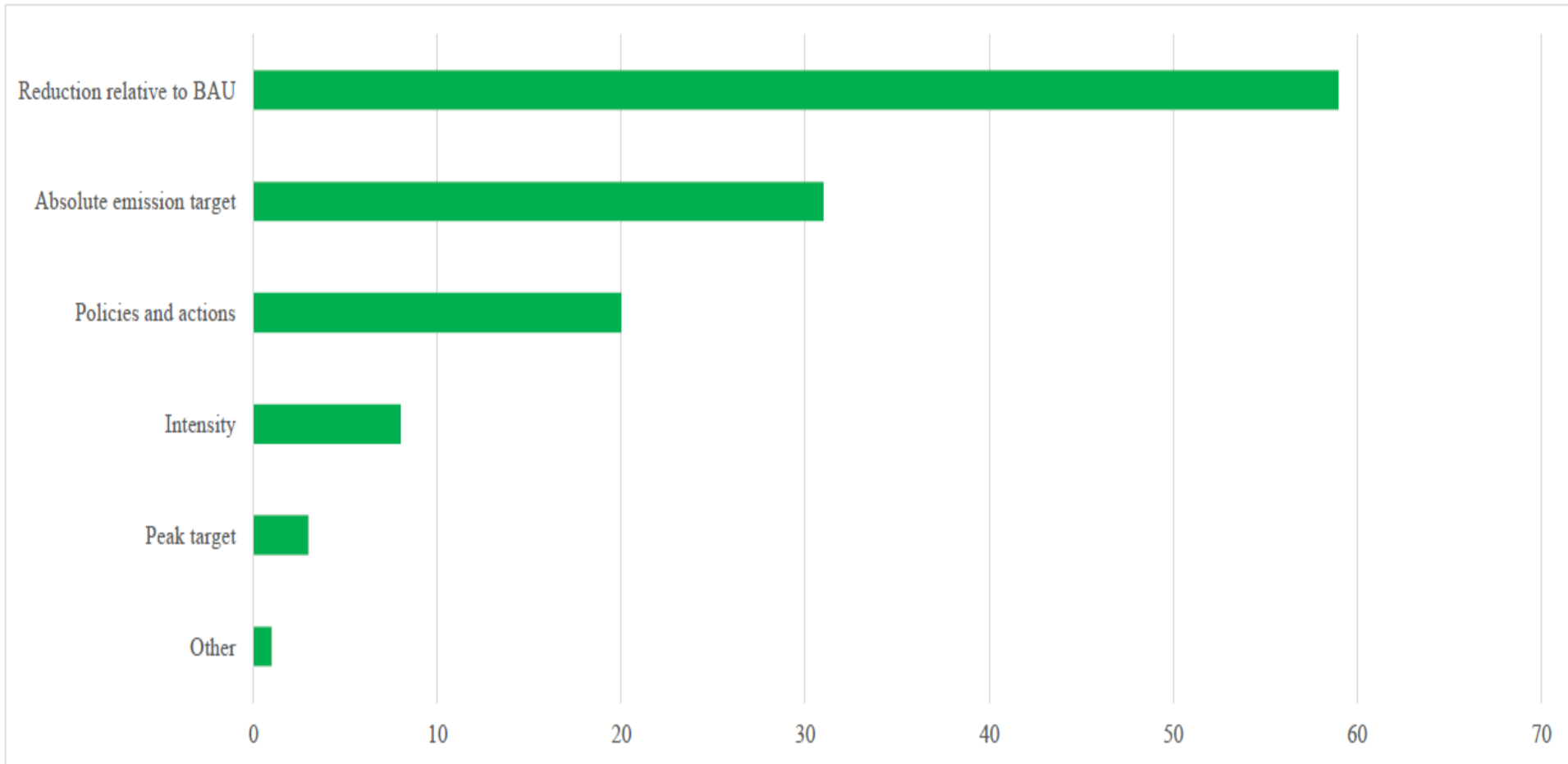
Post COP21 and Thereafter:

The need for new concepts to monitor progress and compliance and for assisting policy

arnulf.grubler@yale.edu

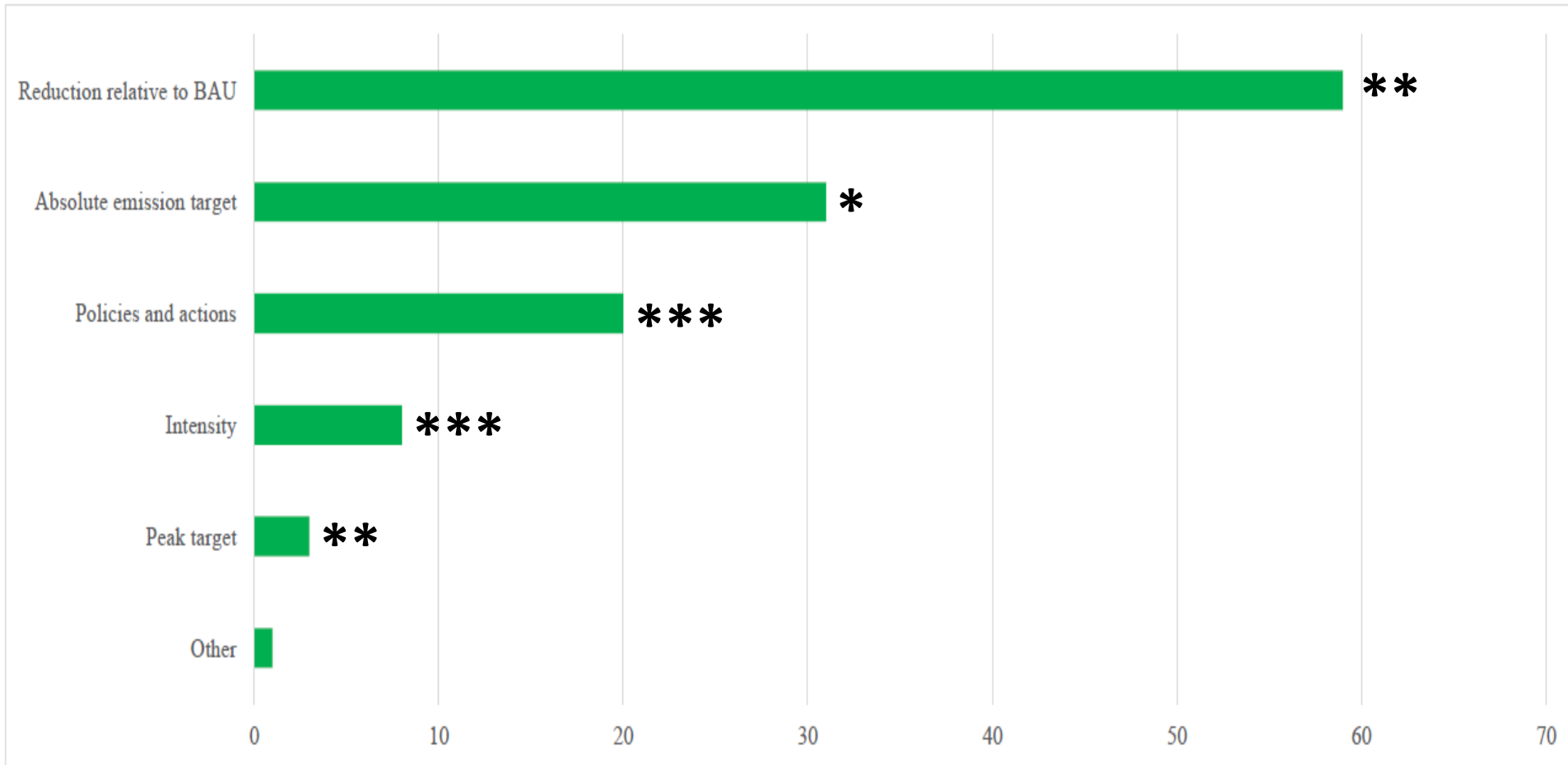
ALPS International Symposium
Tokyo, February 10, 2016

Paris INDC by Type of Target



Source: UNFCCC, 2015

Paris INDC by Type of Target



***** Monitoring and Compliance sensitive to: emissions uncertainty

****** Sensitive to: emissions AND forecasting uncertainty

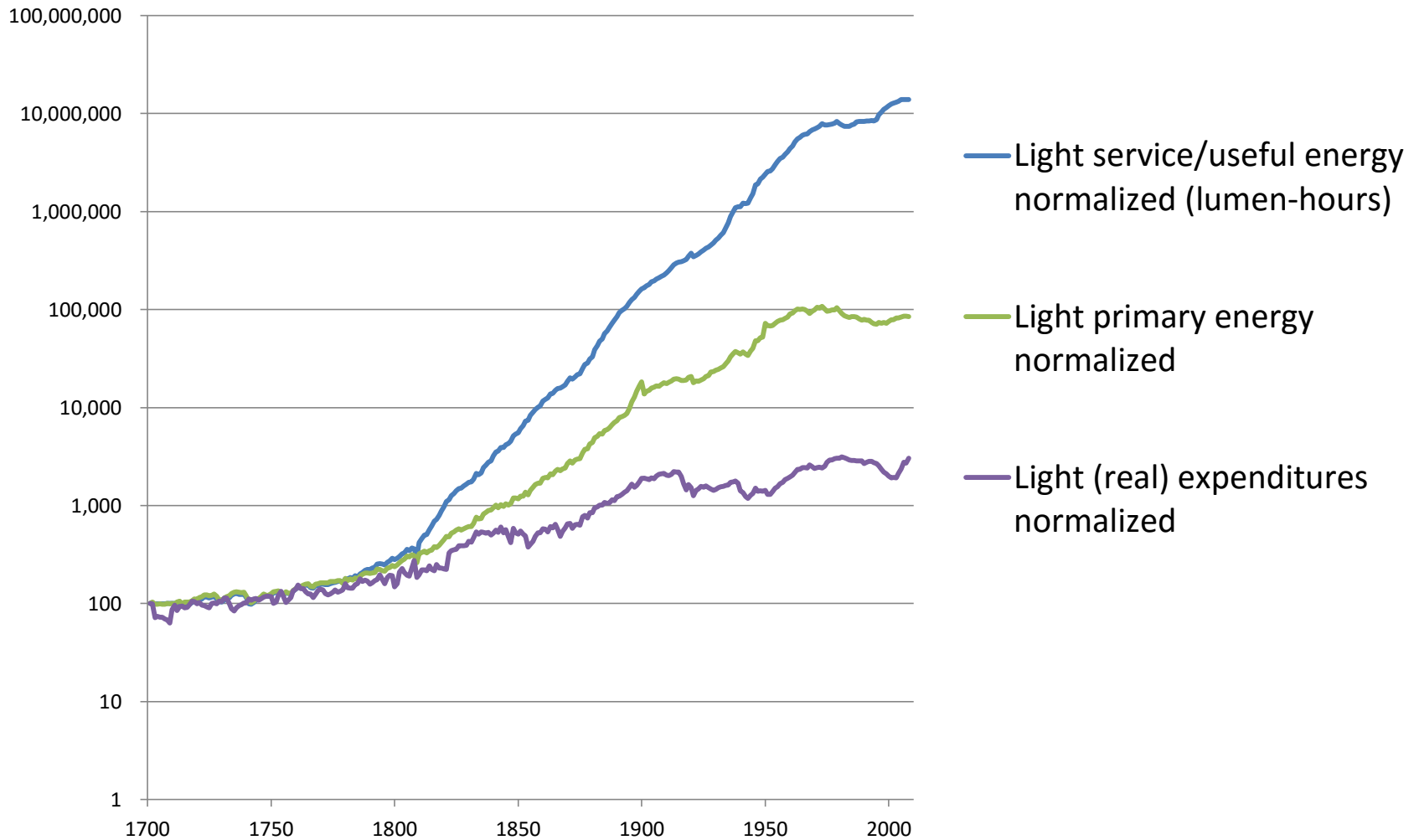
******* Sensitive to: emissions AND forecasting uncertainty, AND measurement biases

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)

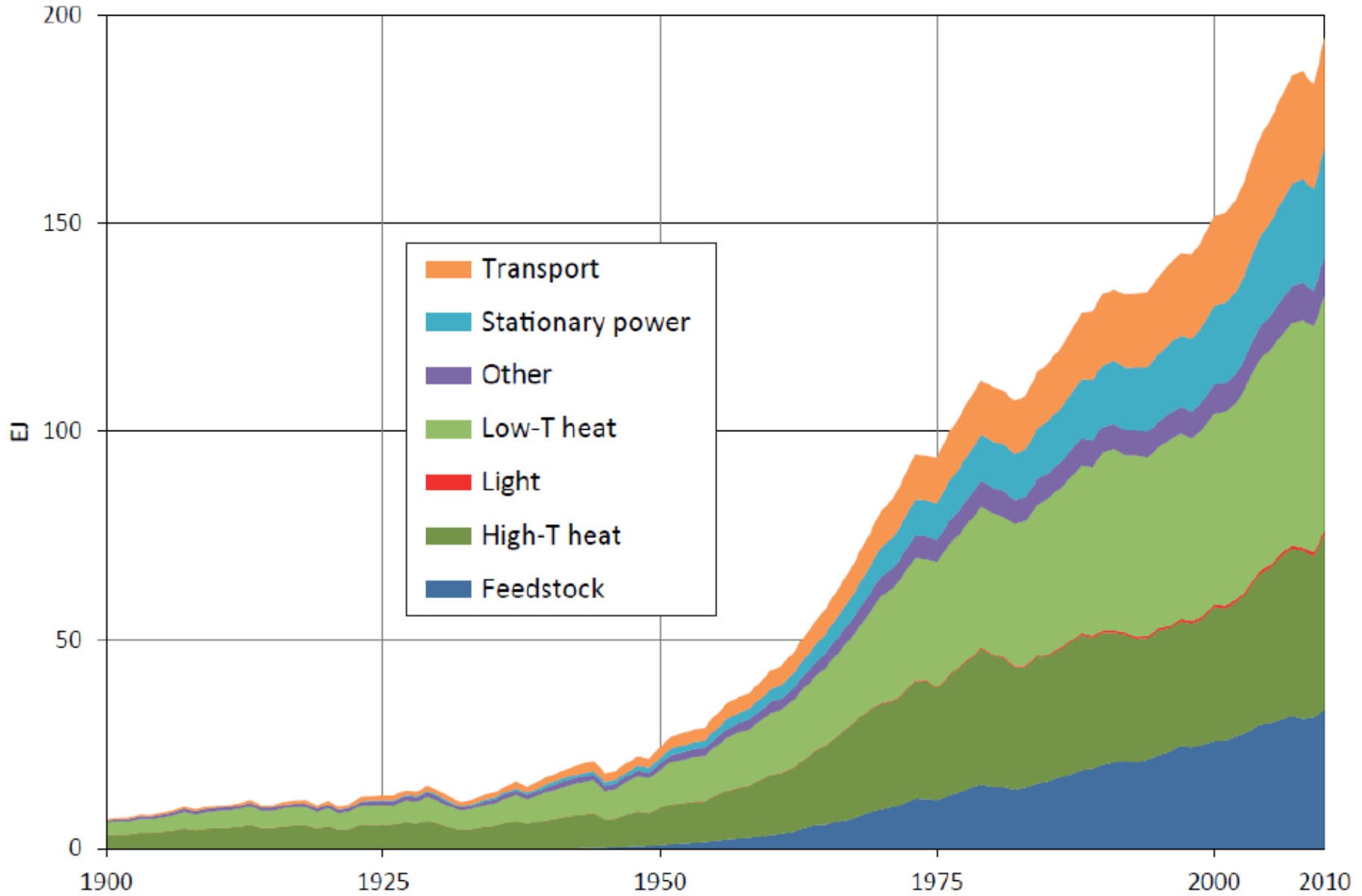


Source: Grubler (in press) based on Fouquet, 2008

New Data

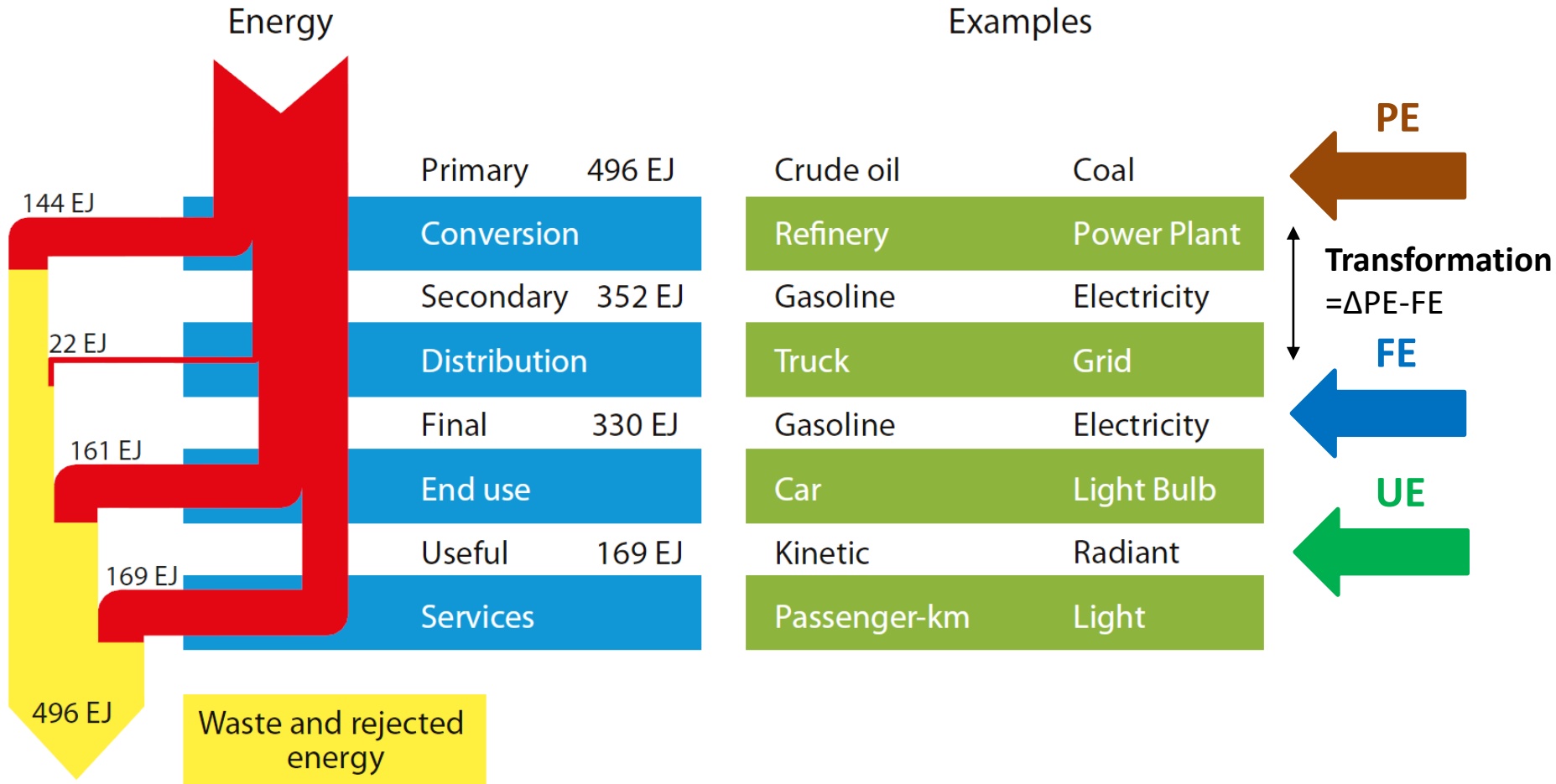
- PFUDB: Primary, Final, Useful Energy Balances countries, regions, world 1900 to 2010
 - energy AND exergy
 - by end-use service
 - by sector
 - by fuel
- Online: <https://tntcat.iiasa.ac.at/PFUDB>
- Documentation: S. De Stercke, IIASA IR-14-013

World – Useful Energy by Service

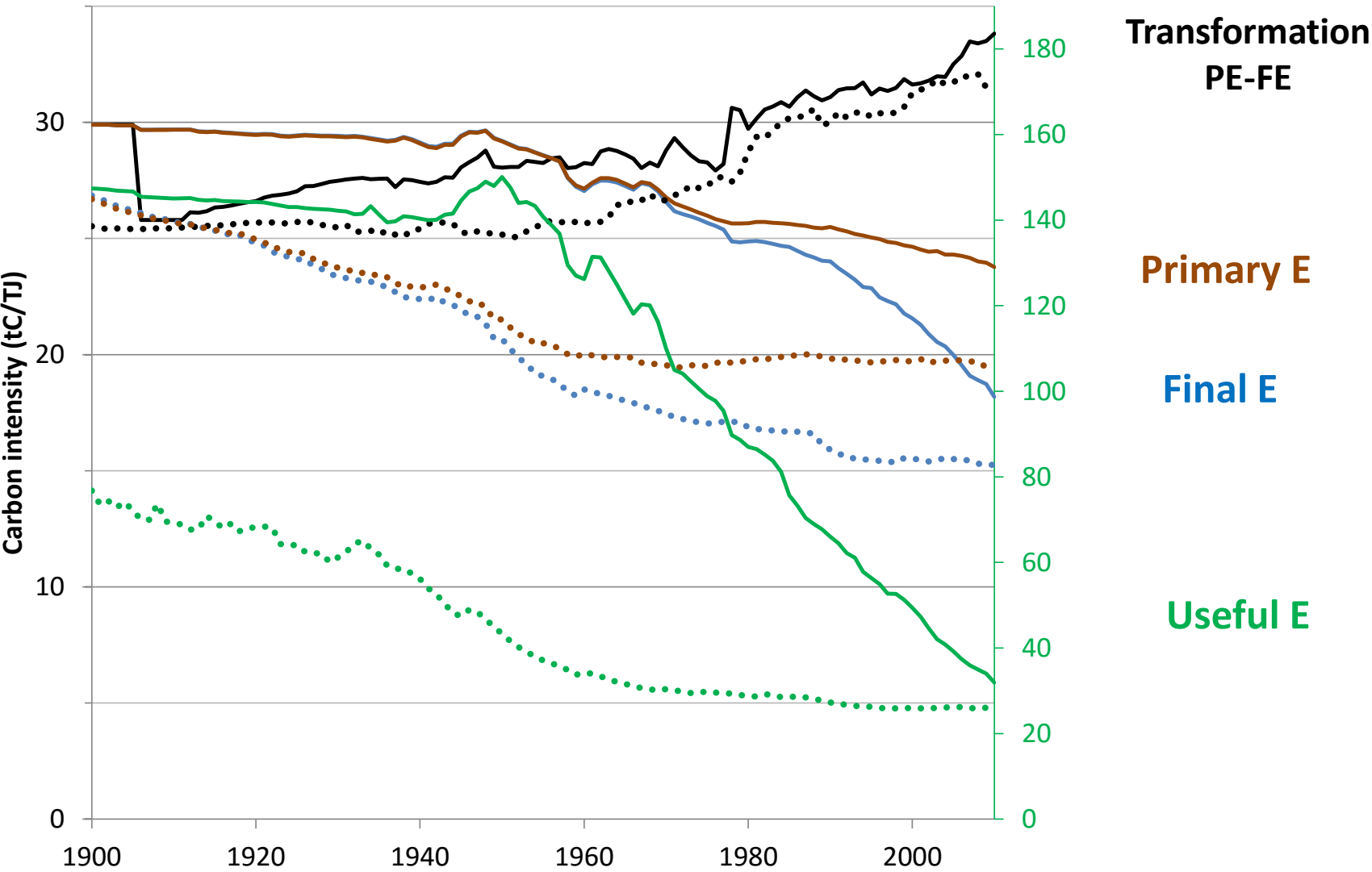


Source: EnergyPrimer.org

Global Energy Flows 2005 (EJ) & Measurement Points for Decarbonization



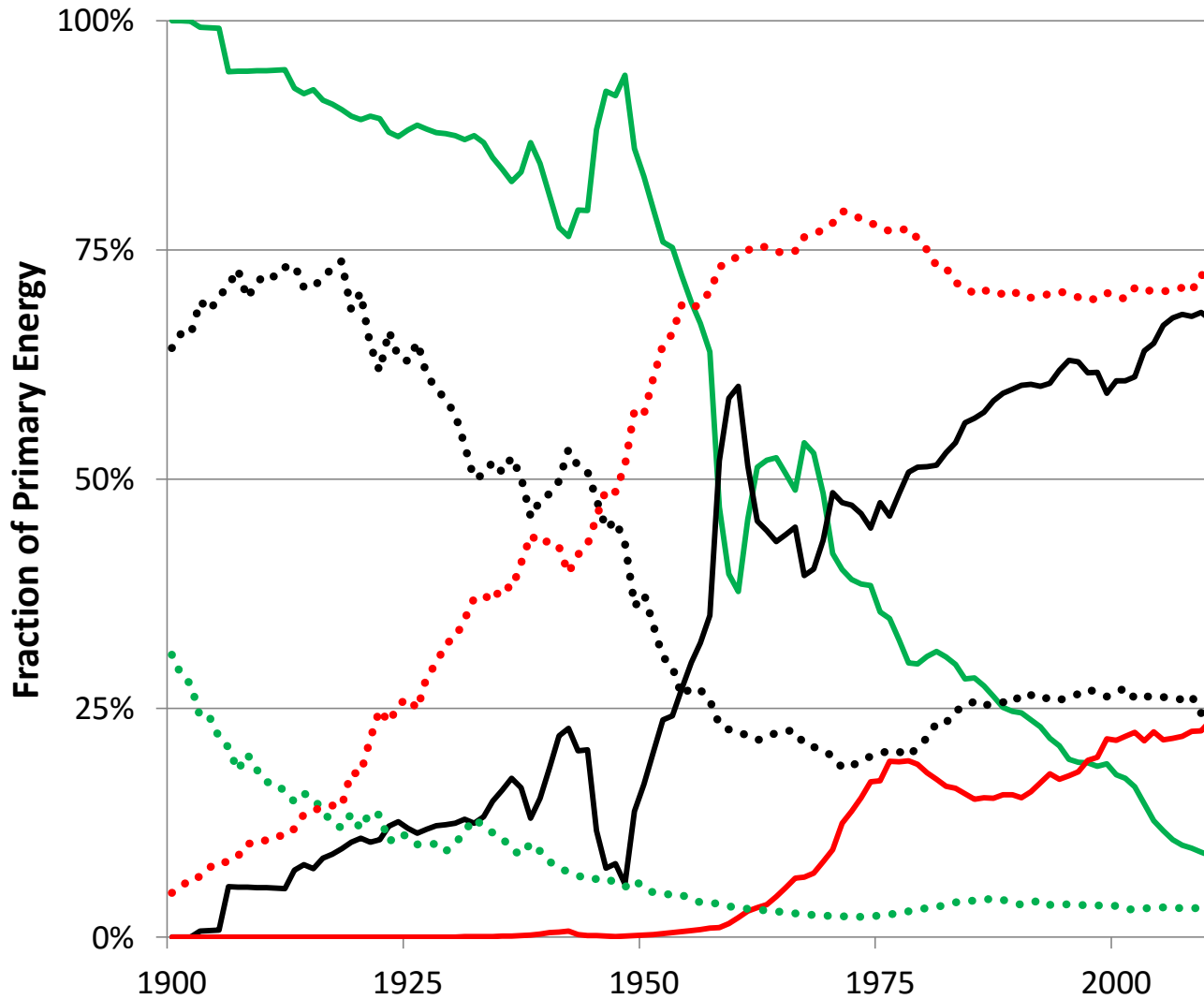
Decarbonization at 4 Levels: China vs. US



Transitions in Primary Energy Inputs: China vs. USA

trad. Biomass → Coal → modern PE (oil/gas+0-carbon)

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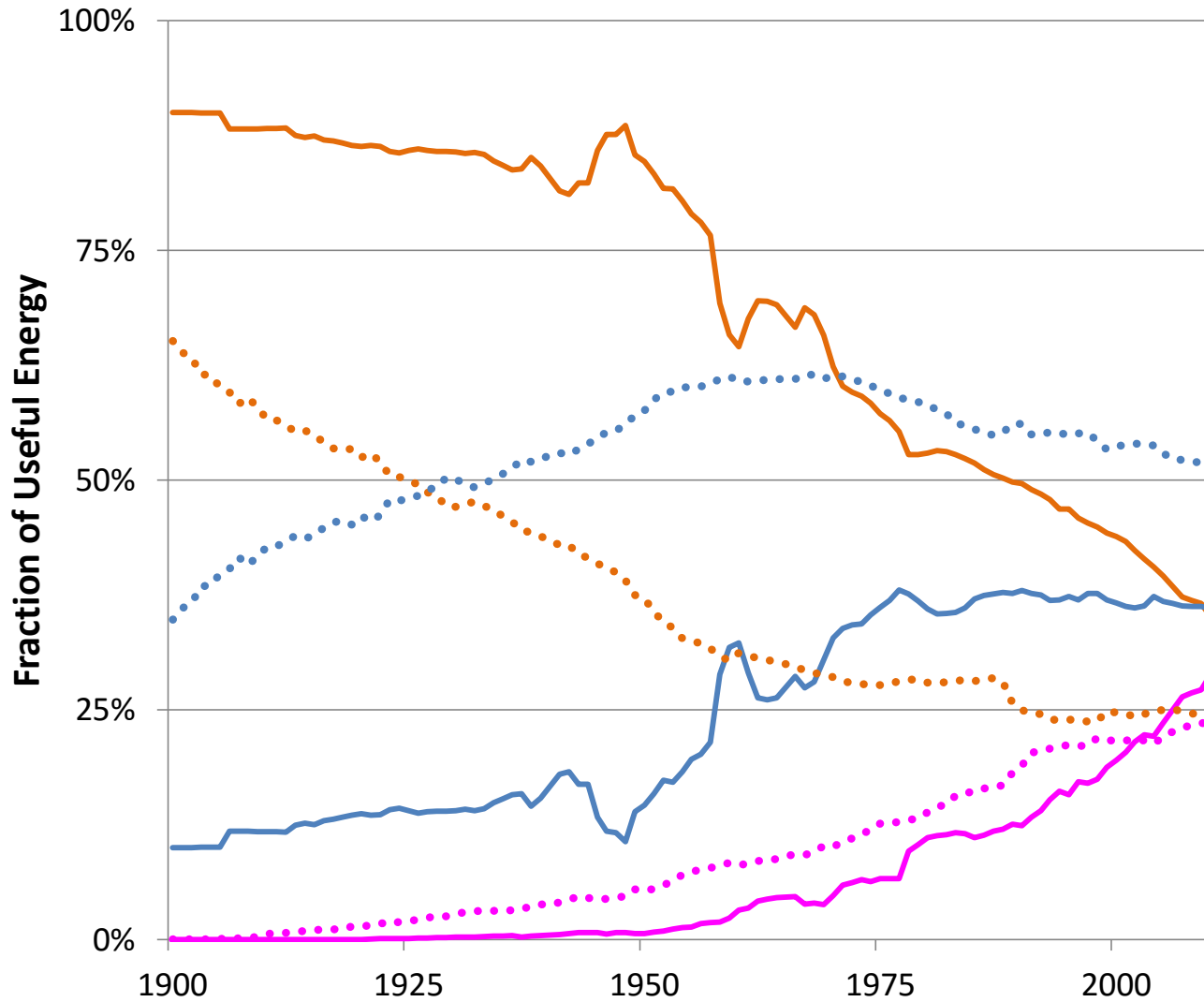
China – USA
Lag (of 50% midpoint)
Biomass: 100 yrs
Modern: 130 yrs

Transitions speed (dT)
Biomass: 80 vs 120 yrs
Modern: 240 vs 70 yrs

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

Carbon → Hydrogen → Electrons

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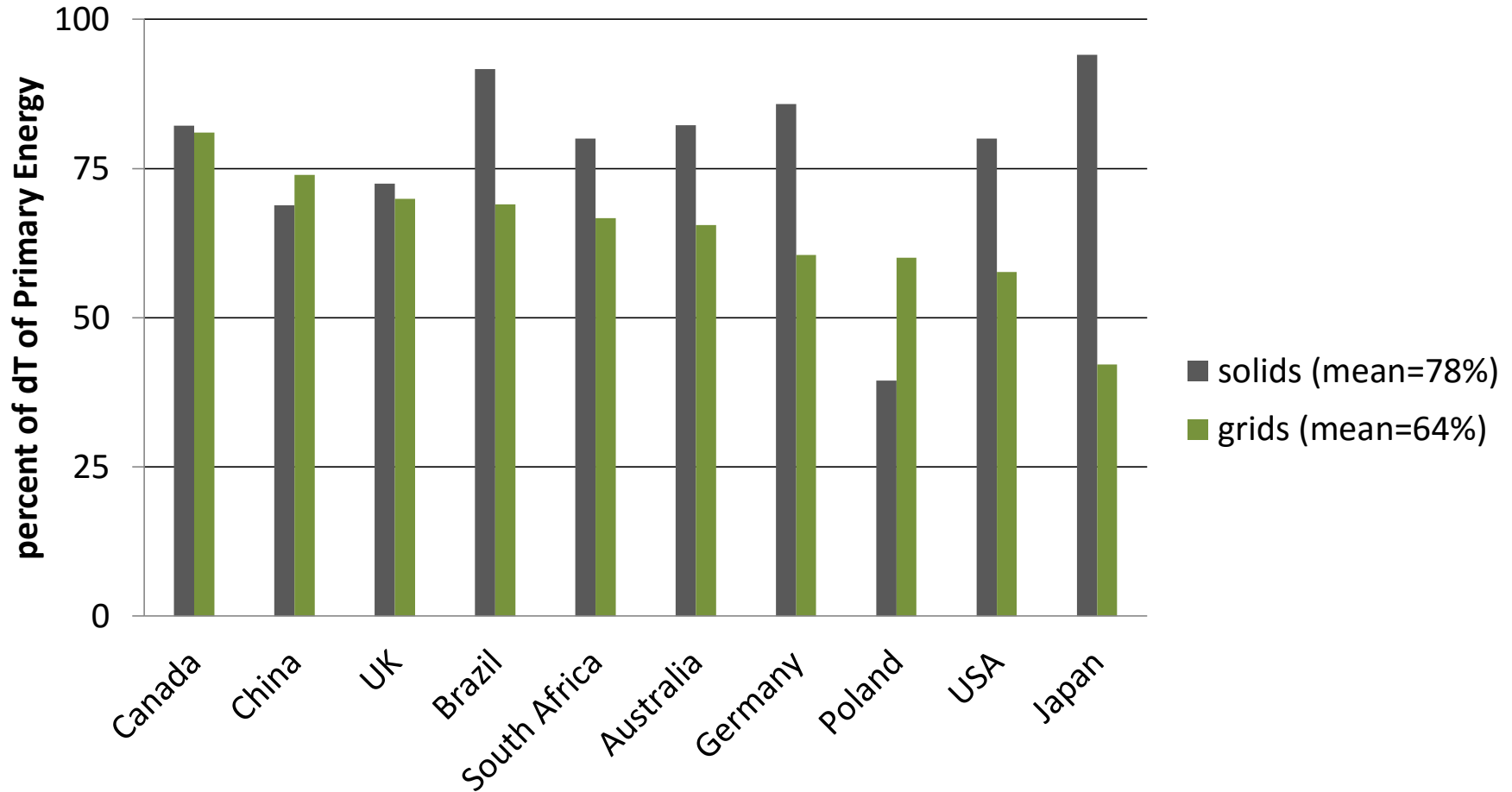


China – USA
Lag (of 50% midpoint)
C: 70 yrs
e: 0 yrs

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

Transition Dynamics compared

(dT useful energy as % of dT primary energy)

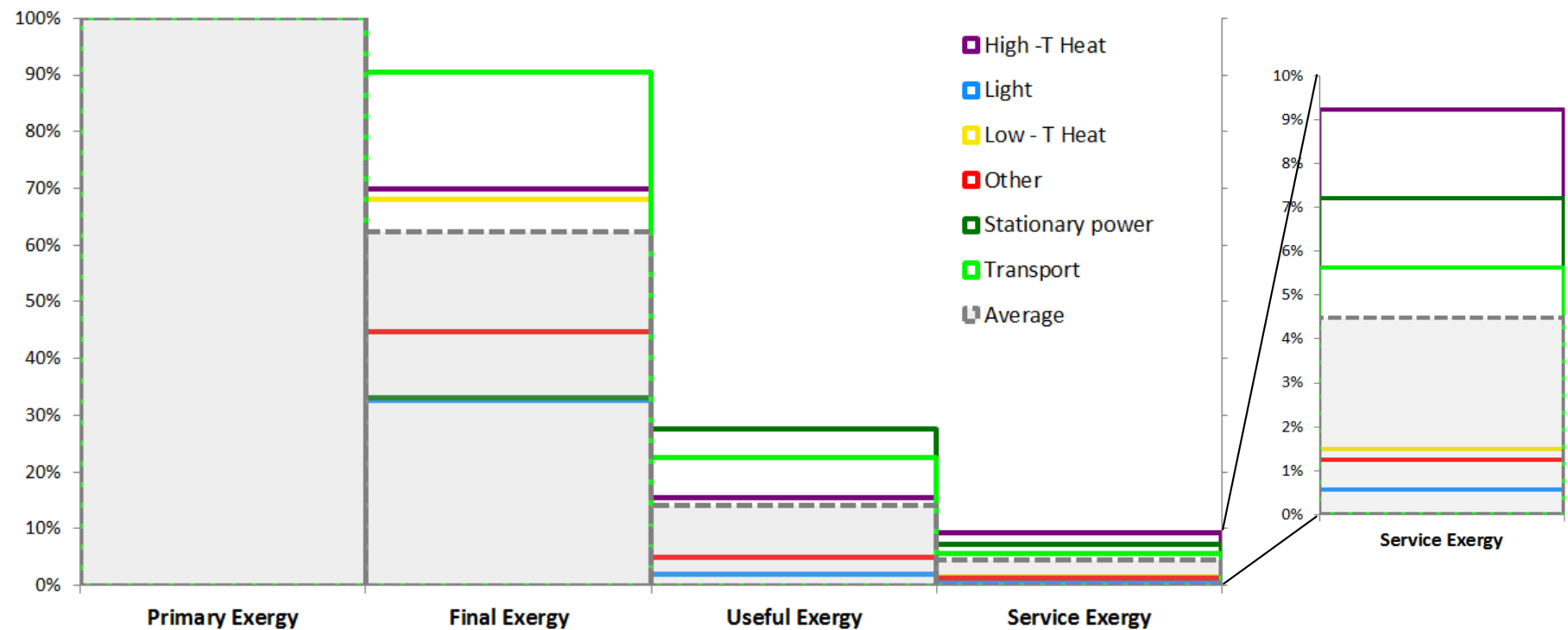


Why Faster Transitions in Outputs?

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

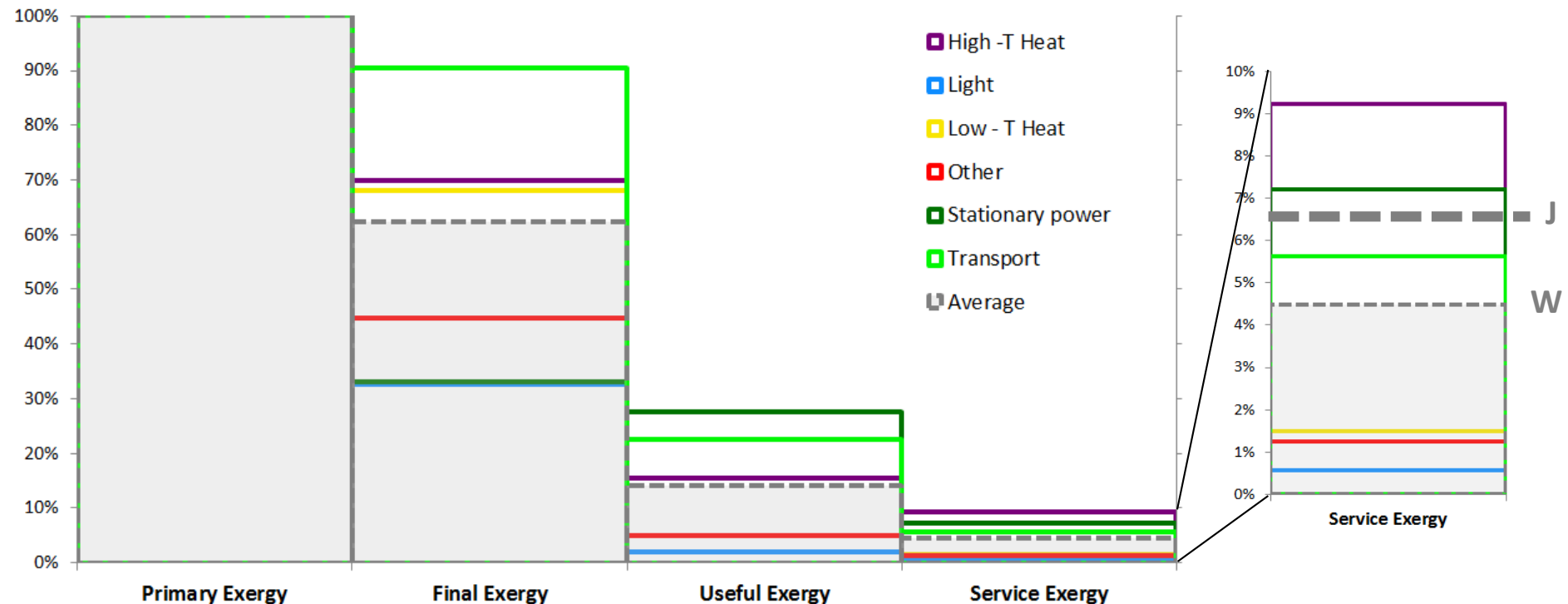
World Exergy Efficiencies in 2010

(as percent of primary exergy)

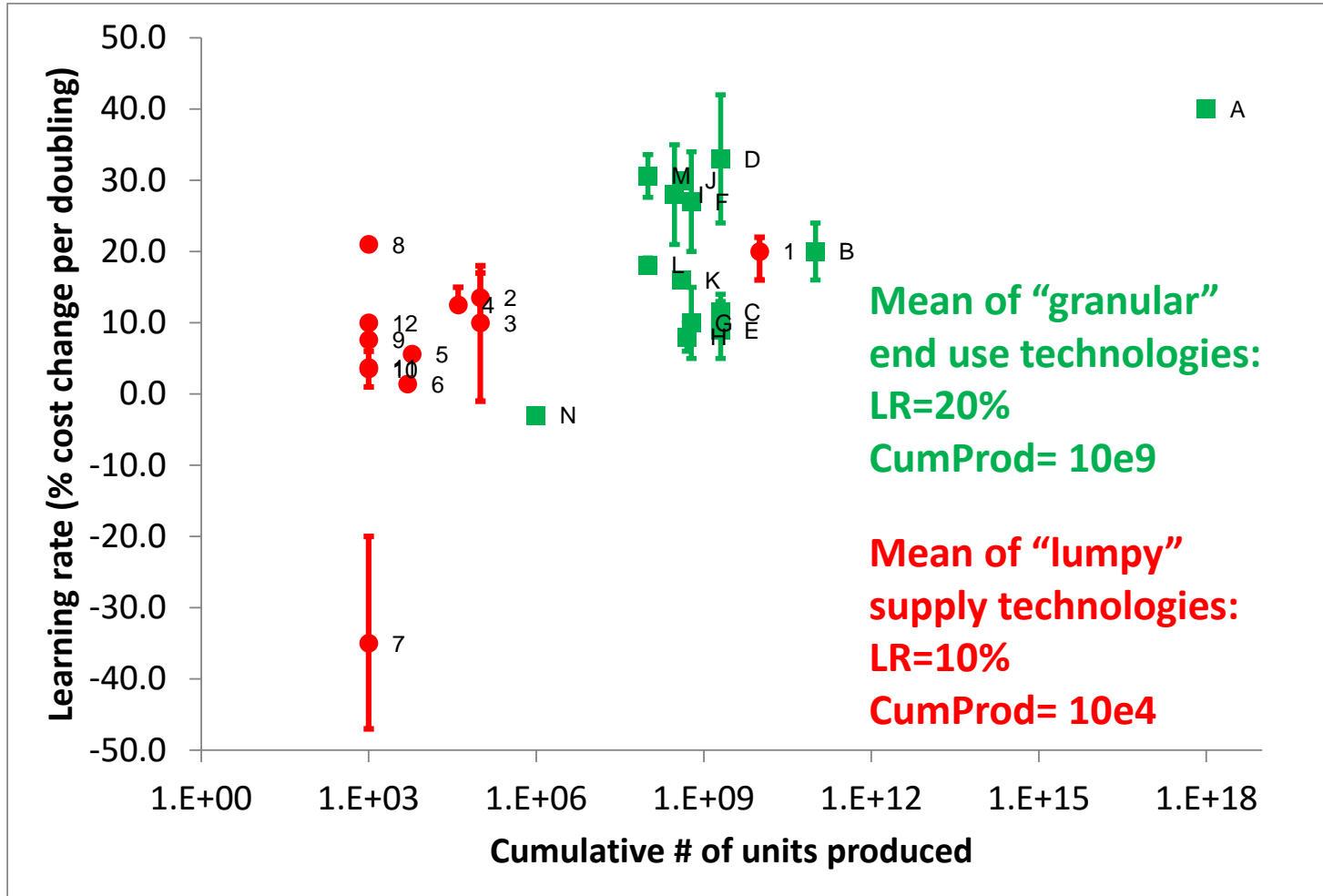


World Exergy Efficiencies in 2010

(as percent of primary exergy)



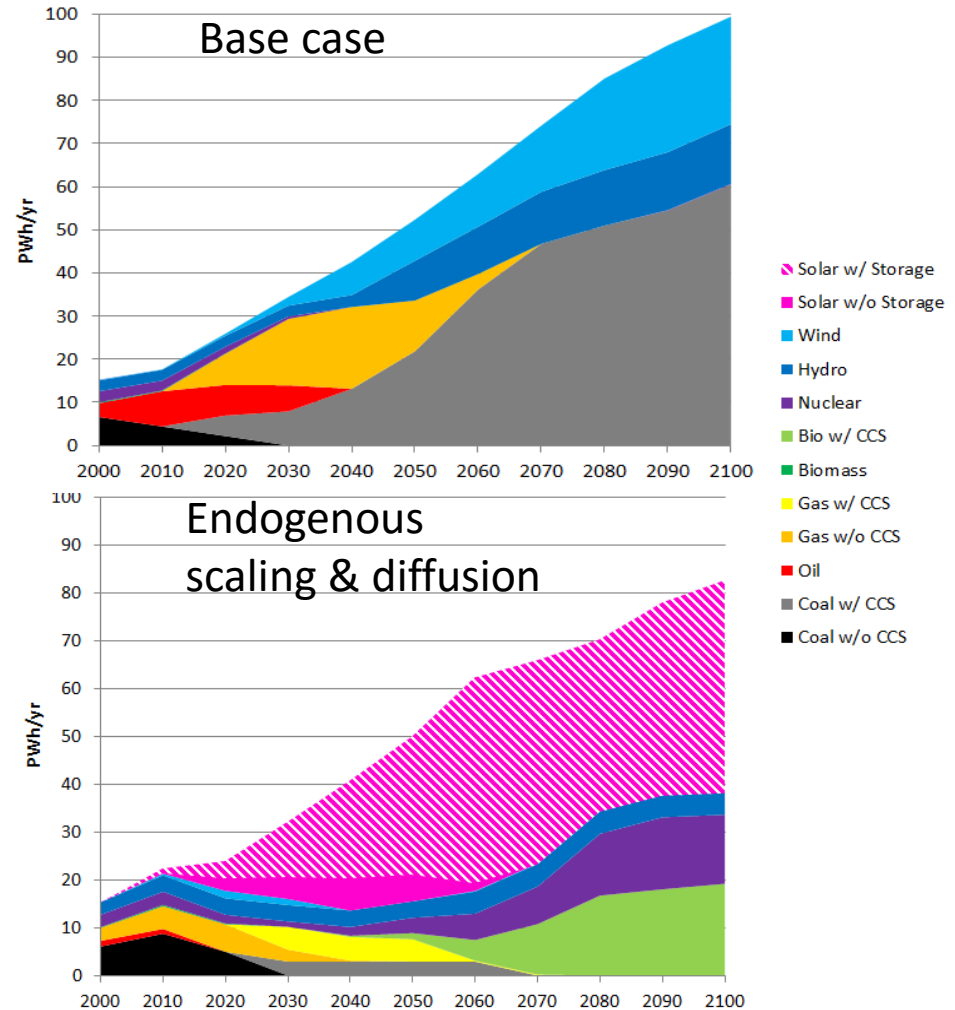
Learning Rates of Energy Technologies: Supply vs End-use



- A Transistors
 - B DRAMs
 - C Automobiles
 - D Washing machines
 - E Refrigerators
 - F Dishwashers
 - G Freezers (upright)
 - H Freezers (chest)
 - I Dryers
 - J Calculators
 - K CF light bulbs
 - L A/C & heat pumps
 - M Air furnaces
 - N Solar hot water heaters
-
- 1 PV modules
 - 2 Wind turbines
 - 3 Heat pumps
 - 4 Gas turbines
 - 5 Pulverized coal boilers
 - 6 Hydropower plants
 - 7 Nuclear reactors
 - 8 Ethanol
 - 9 Coal power plants
 - 10 Coal power plants
 - 11 Gas pipelines
 - 12 Gas combined cycles

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

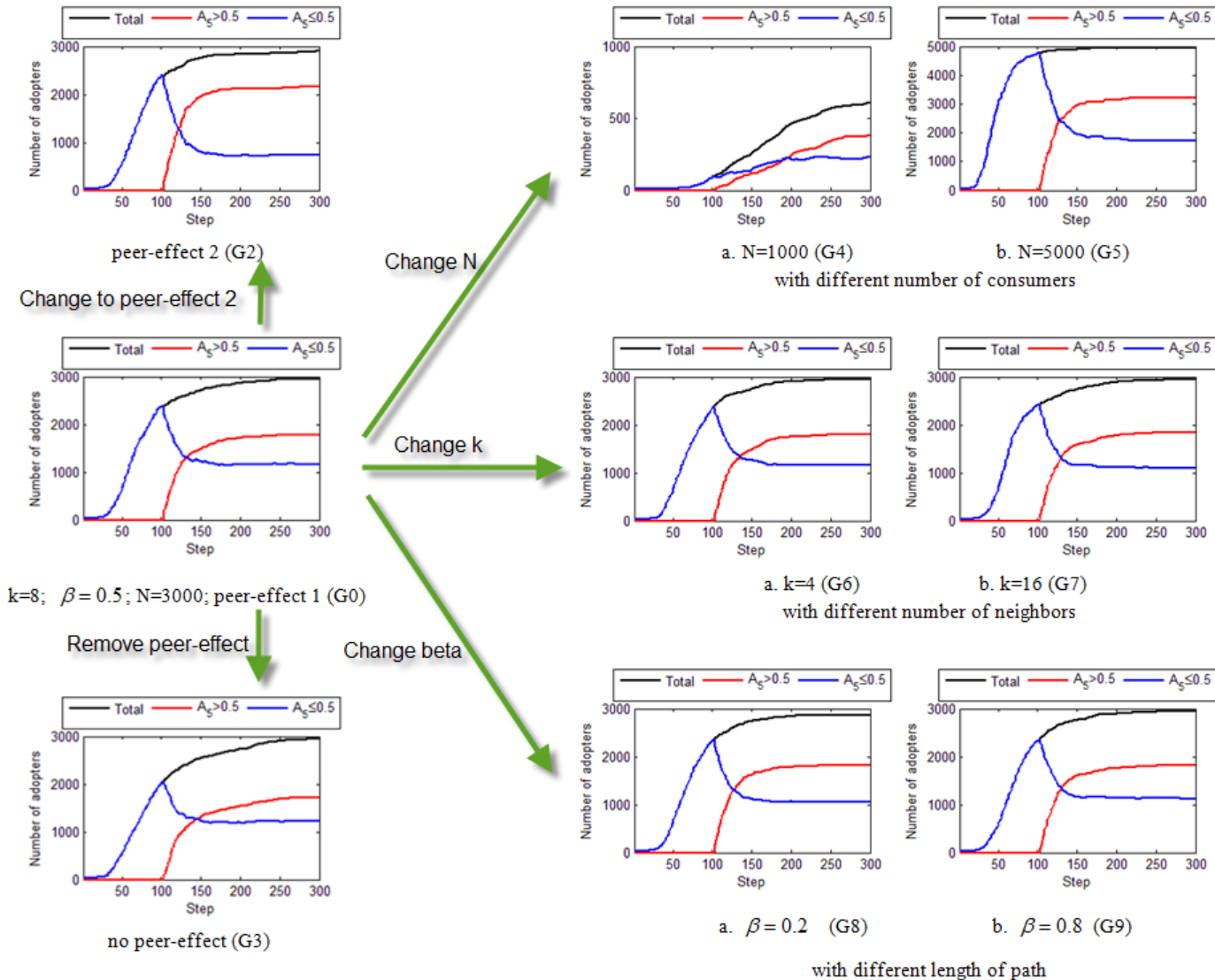


ABM - Agent-Based Modeling

- 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)

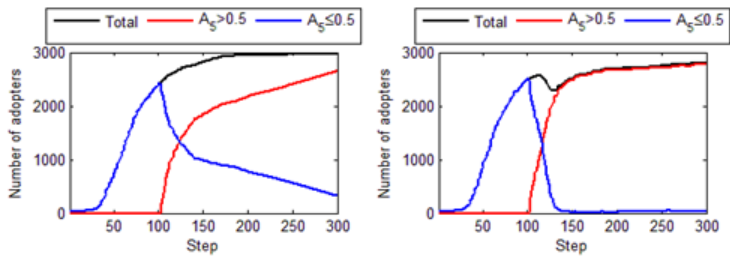
Results ABM - Network Effects:

Network size (critical threshold level) \gg peer effect
 $>$ # of neighbors and their distance



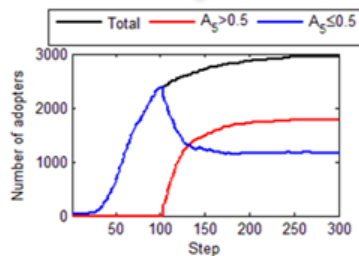
Results ABM Policy Leverages:

Δ consumer preferences \gg C-tax $>$ R&D subsidy



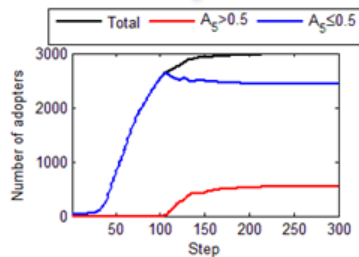
a. slowly, $\sigma = 1$ (G10)
b. fast, $\sigma = 10$ (G11)
with weights to A5 being increased

+Educate consumers \uparrow



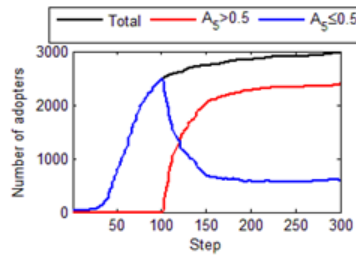
$\sigma = 0, \gamma = 0, \lambda = 0, \phi = 0$, consumers care about A5 (G0)

Consumers do not care about A5 \downarrow

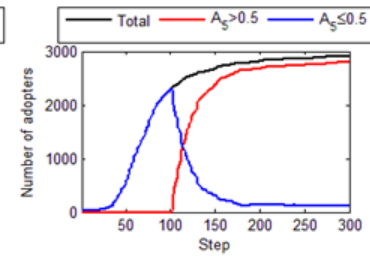


Consumer do not care about A5 (G18)

+Subsidize consumers



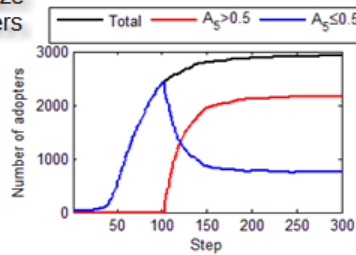
a. low subsidy, $\gamma = 20$ (G12)



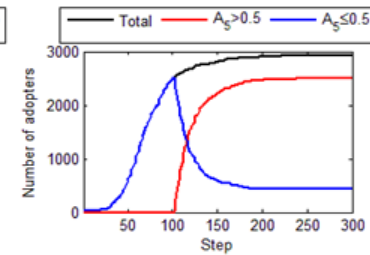
b. high subsidy $\gamma = 50$ (G13)

with subsidy to consumers

+Impose a carbon tax



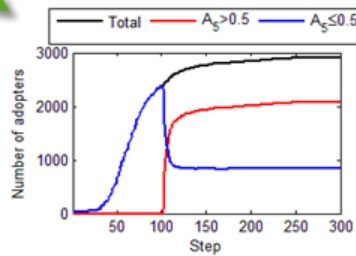
a. low carbon tax, $\lambda = 20$ (G14)



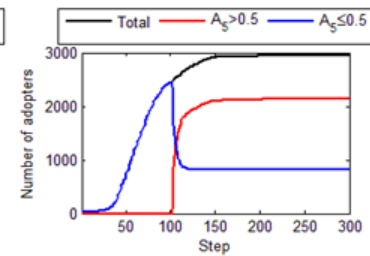
b. high carbon tax $\lambda = 50$ (G15)

with carbon tax to consumers

+Subsidize R&D



a. low R&D subsidy, $\phi = 10$ (G16)



b. high R&D subsidy, $\phi = 1000$ (G17)

with R&D subsidy to producers

Conclusions

- INDCs:
 - Verification, plausibility, “ratchetability” 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