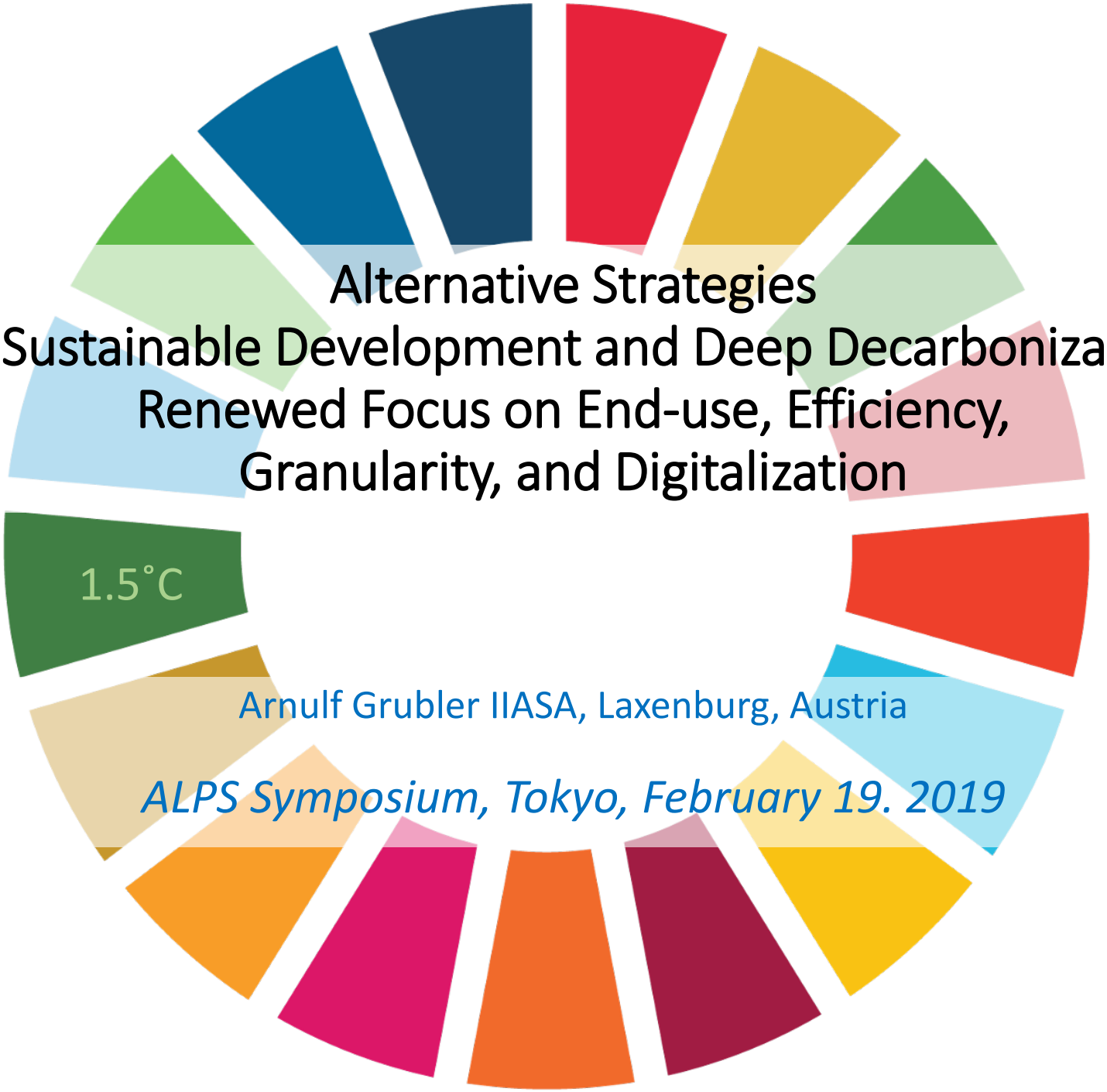
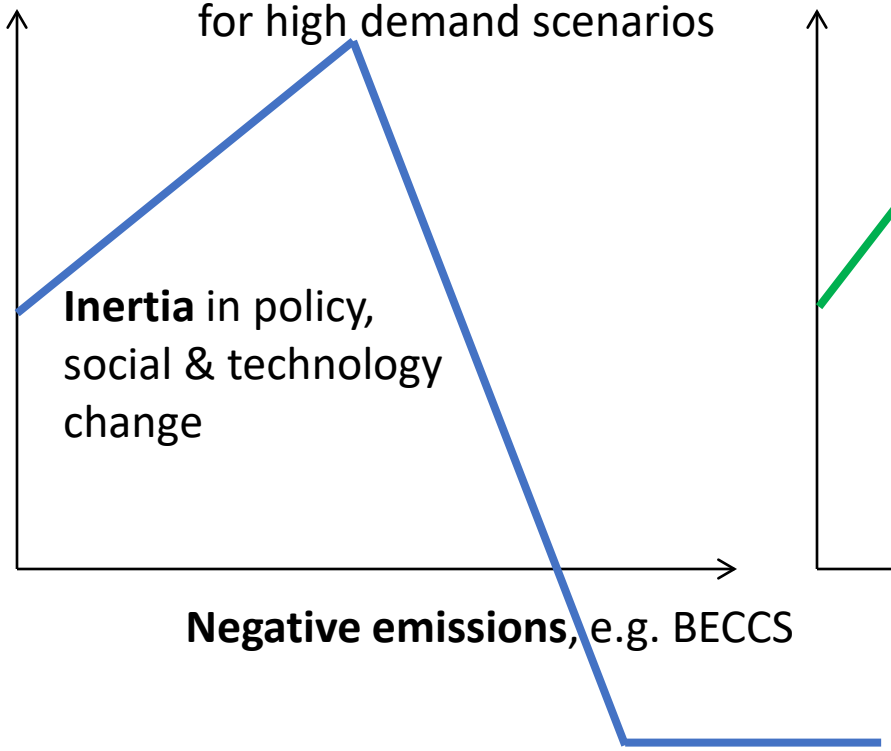
Alternative Strategies for Sustainable Development and Deep Decarbonization. Renewed Focus on End-use, Efficiency, Granularity, and Digitalization



Arnulf Grubler IIASA, Laxenburg, Austria

ALPS Symposium, Tokyo, February 19. 2019

2 Perspectives on Meeting 1.5 °C
GHG Emissions Profiles

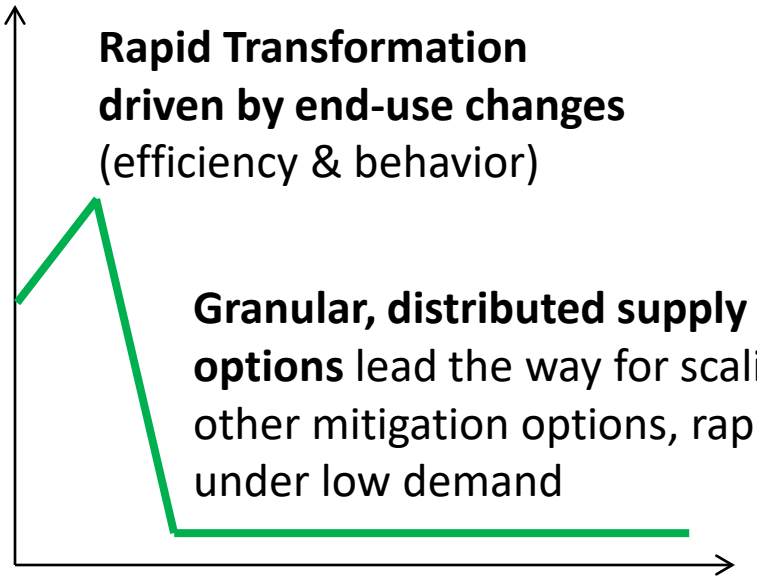


Overshoot as supply-side options scale slowly, but need massive long-term deployment for high demand scenarios

Inertia in policy, social & technology change

Negative emissions, e.g. BECCS

Conventional wisdom 1.5 IAM model run



Rapid Transformation driven by end-use changes (efficiency & behavior)

Granular, distributed supply side options lead the way for scaling other mitigation options, rapid change under low demand

"Grand Restoration" sink enhancement via returning land to nature

LED Scenario narrative and IAM run

Why Focus on End-use?

- Most direct link to SDGs: human welfare
- Changing societal preferences
  (emerging “tectonic shifts”)
- Least efficient part of resource systems
  (eff. = technology *x* behavior *x* business models)
- Improvements translate into
  vast upstream leverage effects (*x* <10!!)
- Dominance of granular technologies
- Rapid transitions possible

New Trends in Social and Technological Change

- Changing consumer preferences (e.g. diets)
- Generational change in materialism
  (service rather than ownership)
- New business models
  (sharing & circular economy)
- Pervasive digitalization and ICT convergence
  (Society 5.0)
- Rapid innovation and cost reductions
  in granular technologies
  and integrated digital services

Social Change:
Change in Car Driving Licenses Held by Young
Trends: near-term: <50%, long-term: ~0?

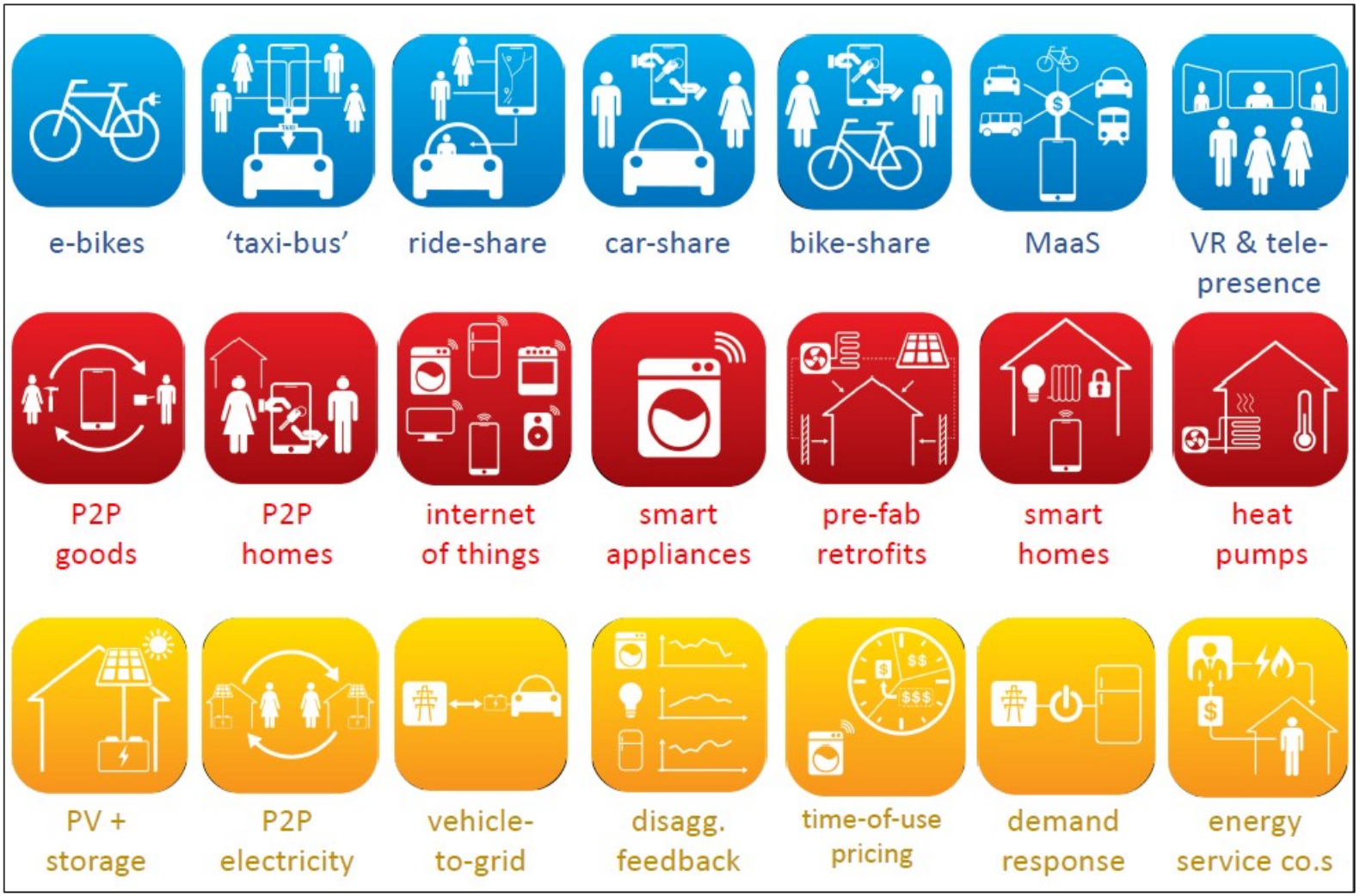
Location	year a	year b	age group	% of age group with drivers license		change
				year a	year b	%-points
Austria 2	2010	2015	17-18	39	28	-11
Germany	2008	2017	18-24	71	66	-5
Great Britain	1995	2008	17-20	43	36	-7
Great Britain	1995	2008	21-29	74	63	-11
Israel 2	2005	2015	17-18	34	30	-4
Israel 2	2009	2016	19-24	65	64	-1
Japan	2001	2009	16-19	19	17	-2
Japan	2001	2009	20-24	79	75	-4
Norway	1991	2009	19	74	55	-19
Norway	1991	2009	20-24	85	67	-18
Sweden	1983	2008	19	70	49	-21
Sweden	1983	2008	20-24	78	63	-15
Switzerland	1994	2015	18-24	71	61	-10
USA	1983	2014	18	80	60	-20
USA	1983	2014	19	86	69	-17
USA	1983	2014	20-24	91	77	-14

Location	year a	year b	age group	% of age group with drivers license		change
				year a	year b	%-points
Austria 1	2006	2010	17-18	32	39	7
Finland	1983	2008	18-19	37	68	31
Finland	1983	2008	20-29	51	82	31
Israel 1	1983	2008	19-24	42	64	22
Israel 1	1983	2008	25-34	62	78	16
Netherlands	1985	2008	18-19	25	45	20
Netherlands	1985	2008	20-24	64	64	0
Spain	1999	2009	15-24	37	50	13

Note in particular much larger prevalence of declining driving license ownership and shift from growth to decline trends in Austria and Israel around 2008/2010 (for Finland, Netherlands, Spain no more recent data available to uncover similar trend breaks)

Data sources: Sivak & Schottle, 2011; Delbosc & Currie, 2013; Nat.Stats, 2017 for Austria, Germany, Israel, Switzerland

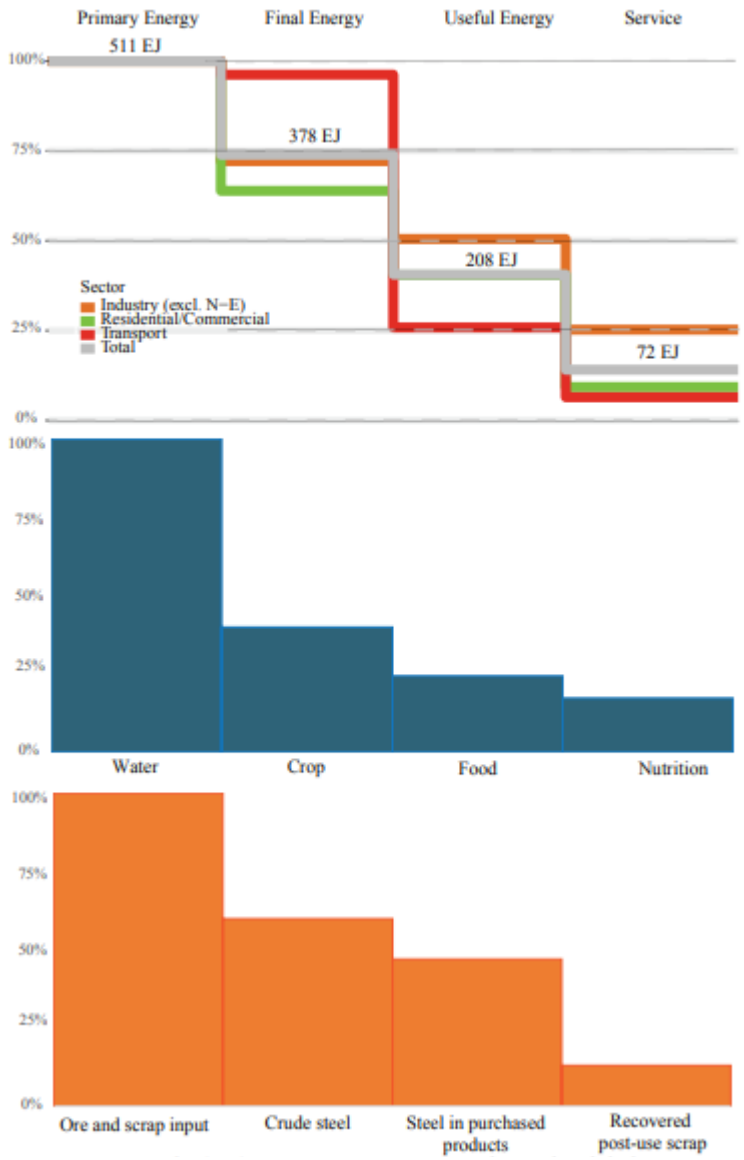
Disruptive End-user Innovations



(1) From ownership to usership – (2) Sharing Economy – (3) From atomized to connected

Source: Charlie Wilson

End-use and Supply Efficiencies and Upstream Leverage Effect of Savings at Service Level



Energy (all services)
aggr. eff.: 14%
1 EJ saved =
7 EJ primary energy

Water (ex. irrigation)
aggr. eff.: 17%
1 m^3 saved =
6 m^3 water withdrawn

Materials (ex. steel)
aggr. eff.: 13%
1 ton saved =
8 tons ore mined

lumpy
large unit size
high unit cost
indivisible
high risk

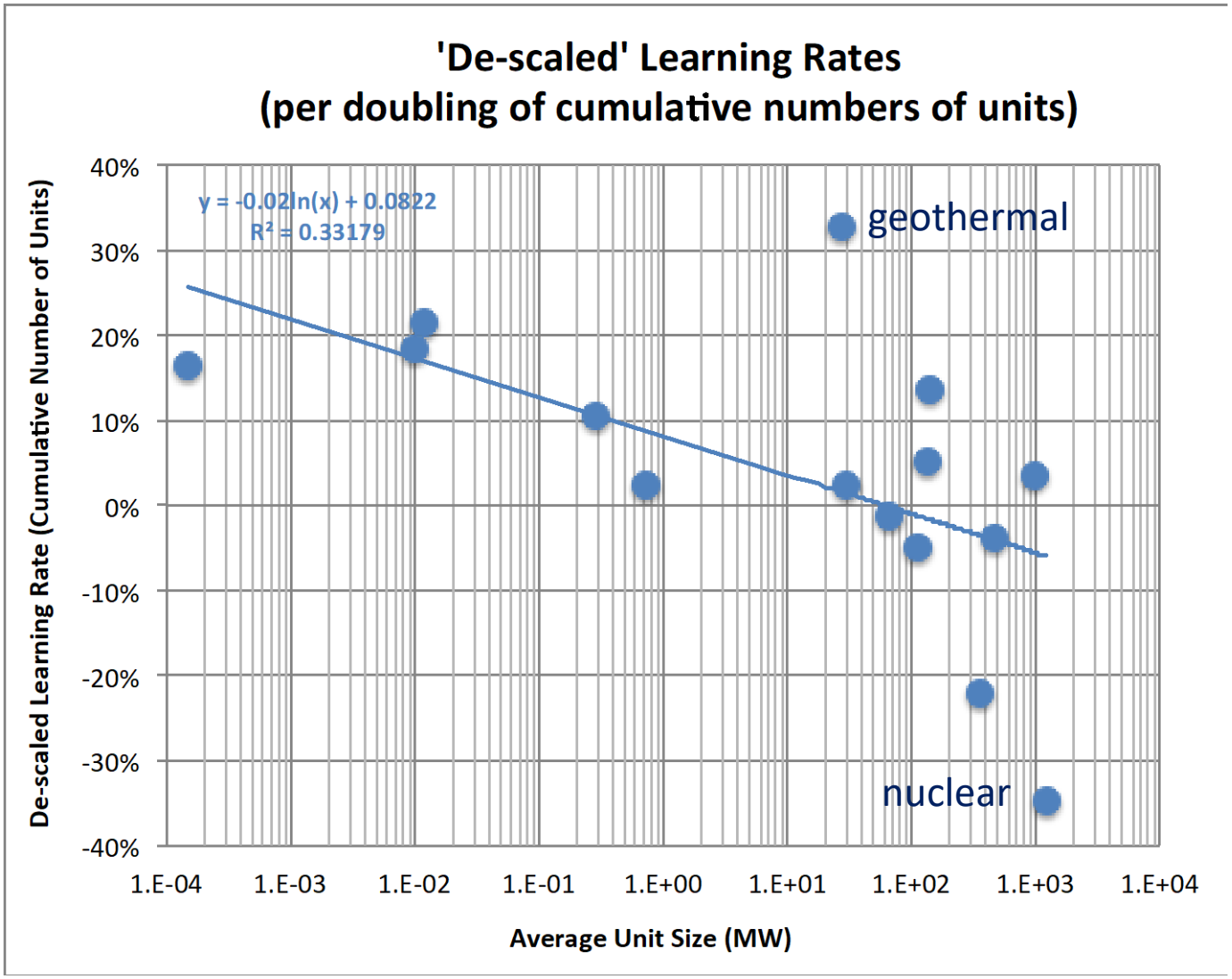
Technology
Unit Size

granular
small unit size
low unit cost
modular
low risk

Source: Grubler
ESA class material

Granularity Benefits

Higher Learning with Smaller Unit Scale After Accounting for Economies of Scale



smaller units

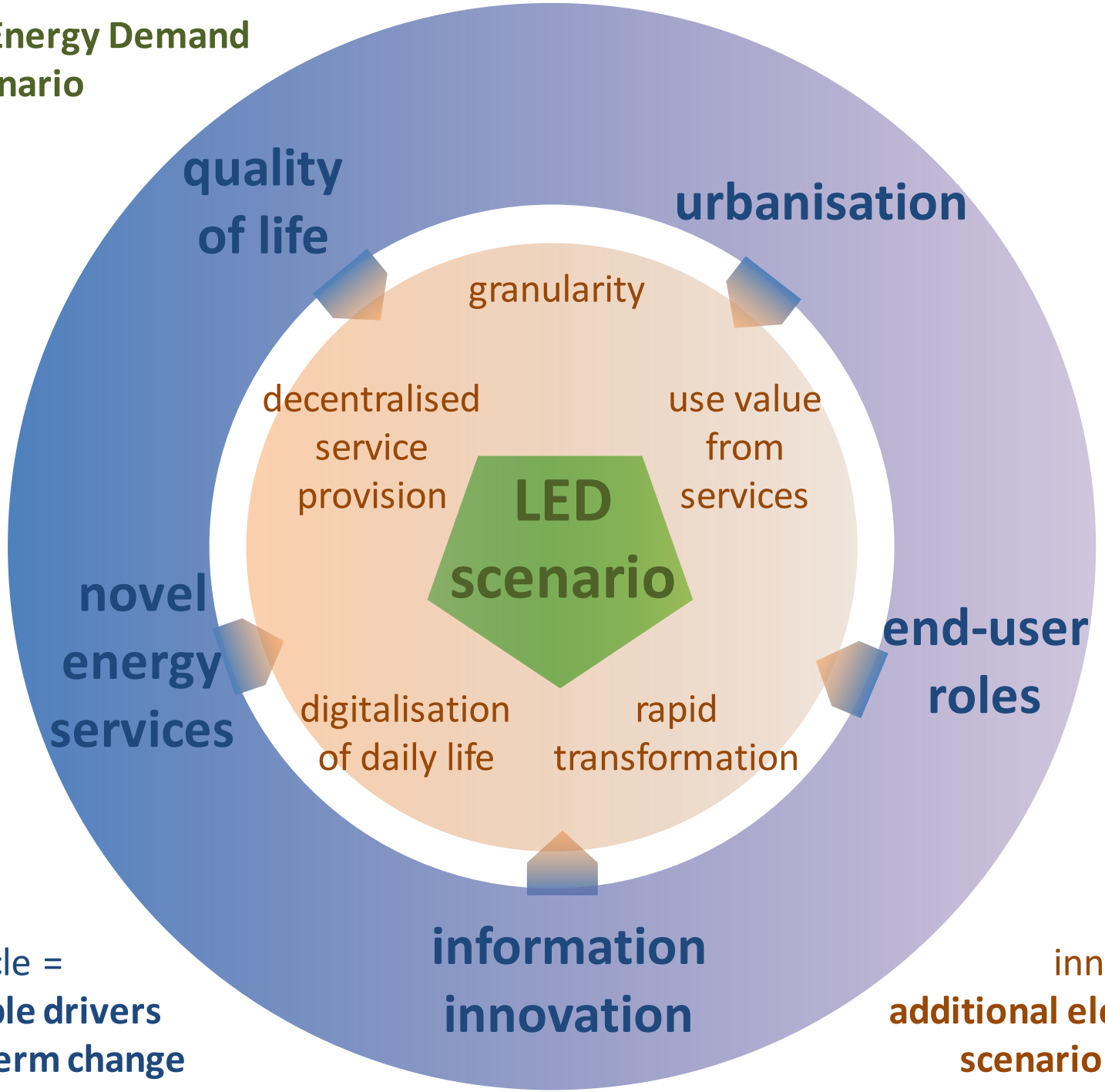
-> more units

-> more opportunities to experiment

-> more learning

Healey, S. (2015). Separating Economies of Scale and Learning Effects in Technology Cost Improvements. IR-15-009. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

the Low Energy Demand (LED) Scenario



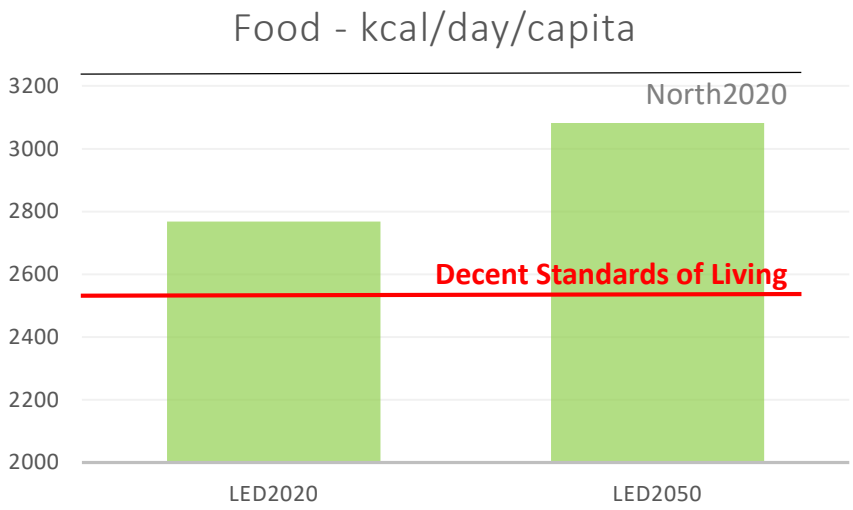
outer circle = **observable drivers of long-term change**

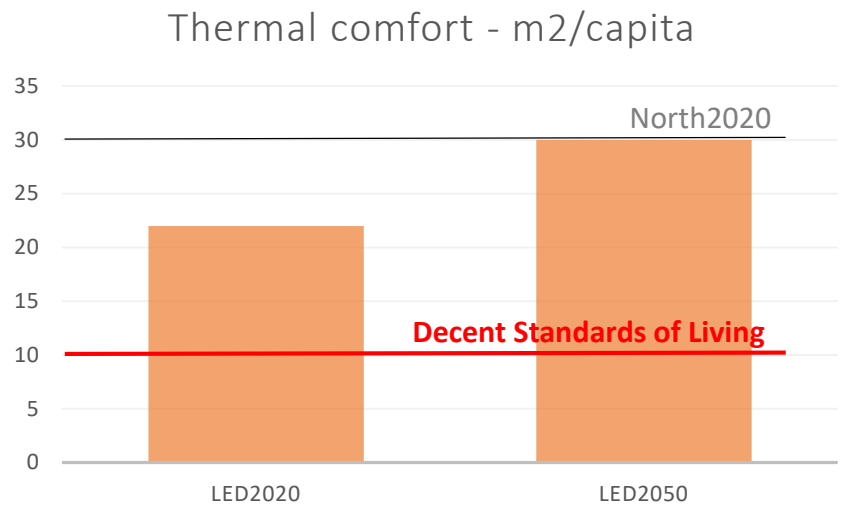
inner circle = **additional elements in scenario narrative**

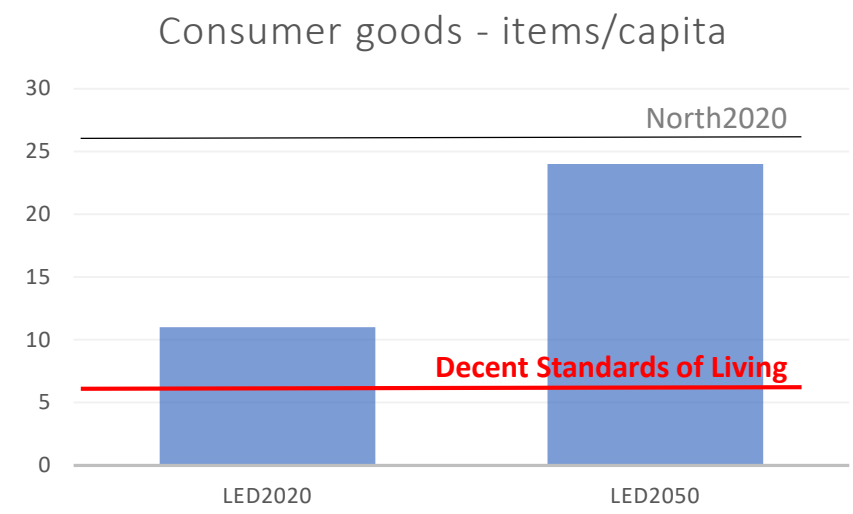
LED Highlights

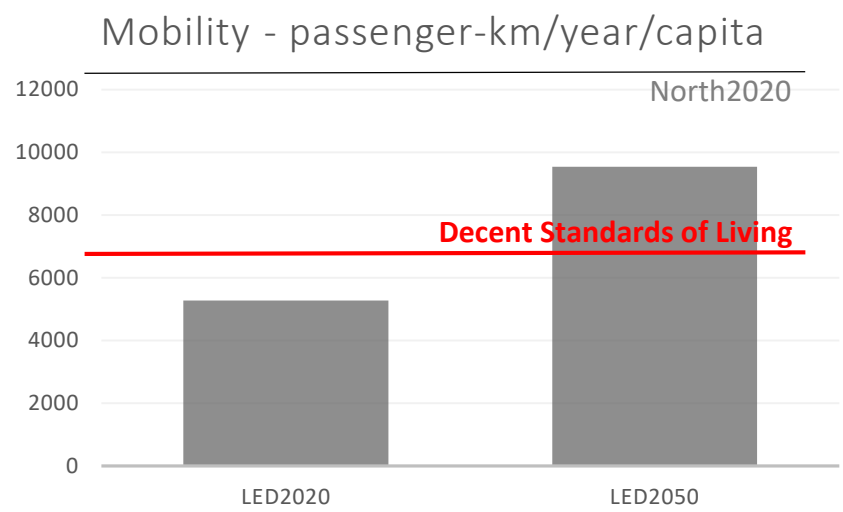
- Higher levels of energy services than even GEA High
- Assuring “decent standards of living” for all (well above access and poverty thresholds)
- (technological & service) efficiency driven “Peak” Energy
- Lowest demand scenario (<250 EJ FE by 2050) ever published
- End-use transformations (efficiency, electrification) drive upstream decarbonization
- Stays below 1.5 with no negative emission technologies
- Significant SDG synergies (>6 SDGs)

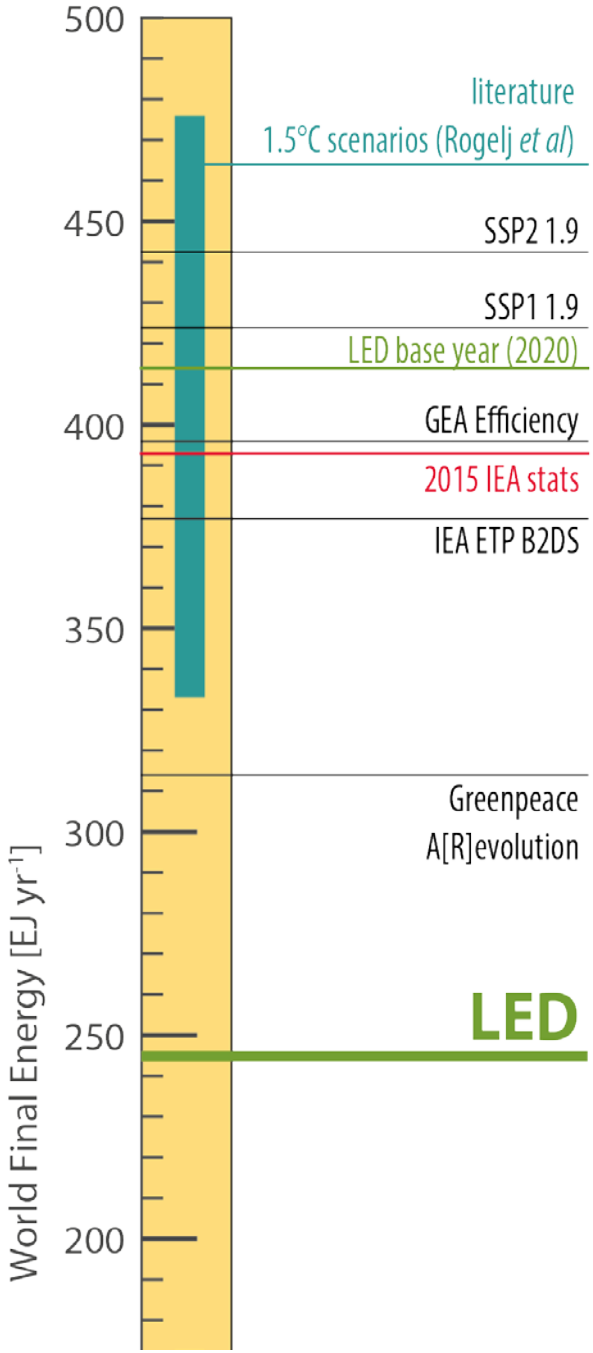
LED - Per Capita Energy Services in the Global South











LED
Final Energy Demand Compared for 2050:

Scenarios with comparable climate outcomes:

IPCC Shared Socioeconomic Pathway 2 (SSP2)
max. 1.9 W/m2 radiative forcing

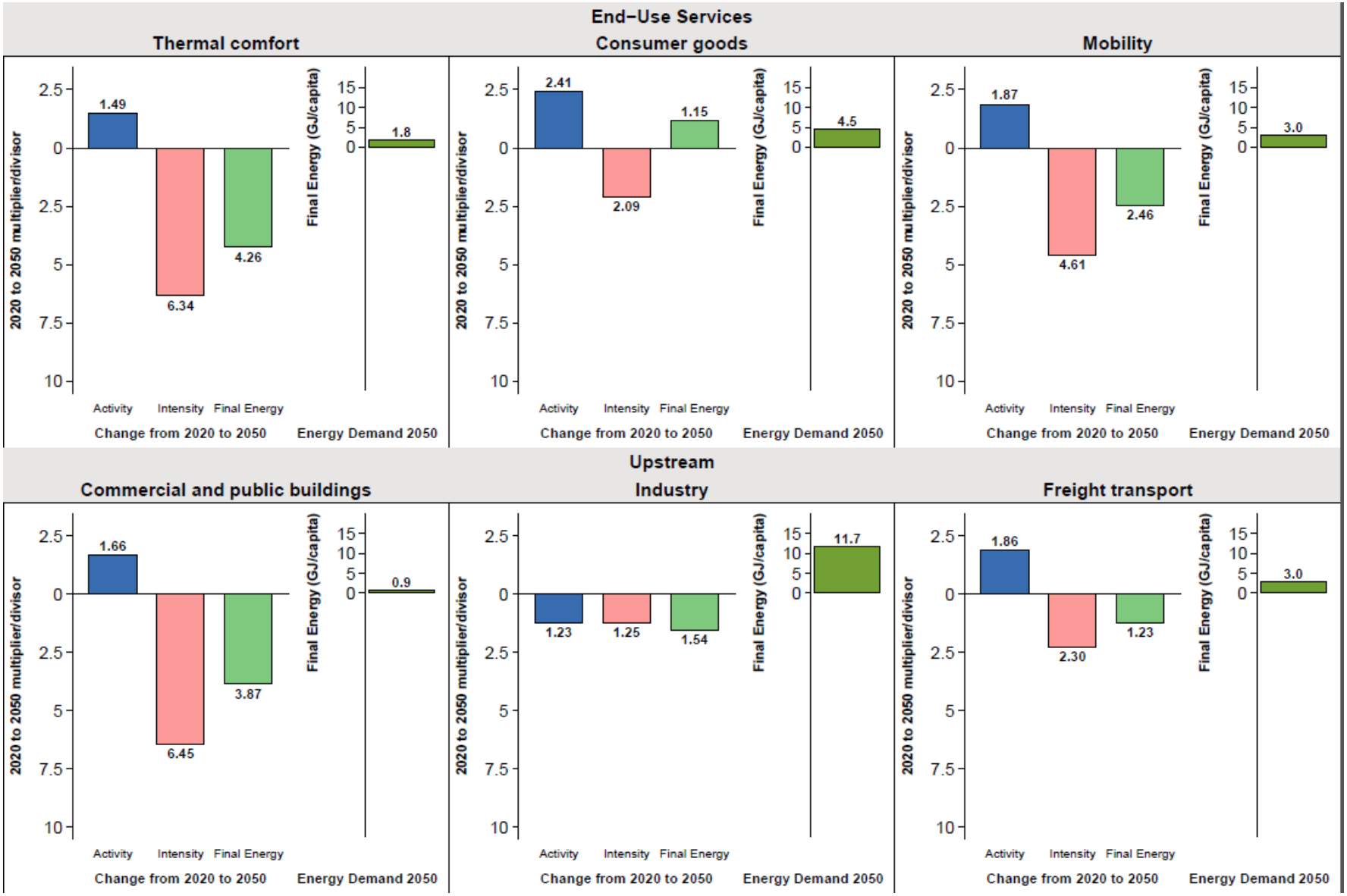
Global Energy Assessment (GEA) Efficiency scenario

International Energy Agency (IEA)
Below 2 Degrees Scenario (B2DS)

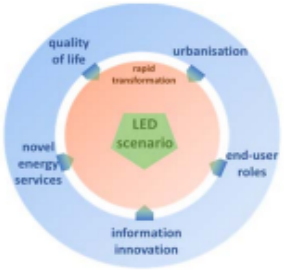
Greenpeace A[R]evolution scenario

LED: Factors of Change 2050/2020 Global:

More services & amenities: Less resource inputs



Example Households: Consumer Goods & Upstream Impact on Industry



consumer goods

changes from 2020 to 2050

increase in *activity*
- factor 3 increase in Global South (~24 devices/capita)

x 2.4

÷ 2.0

reduction in *energy intensity*
- improves 15% per device on average (~82 kWh/device)
- improves >70% in lighting (LEDs!)

+ device convergence (multi-functionality)

+ ownership to 'usership'

0.1 kg of materials
0.3 GJ embodied energy

26 kg of materials
6.1 GJ embodied energy

"upstream (industry) energy: ÷ 23

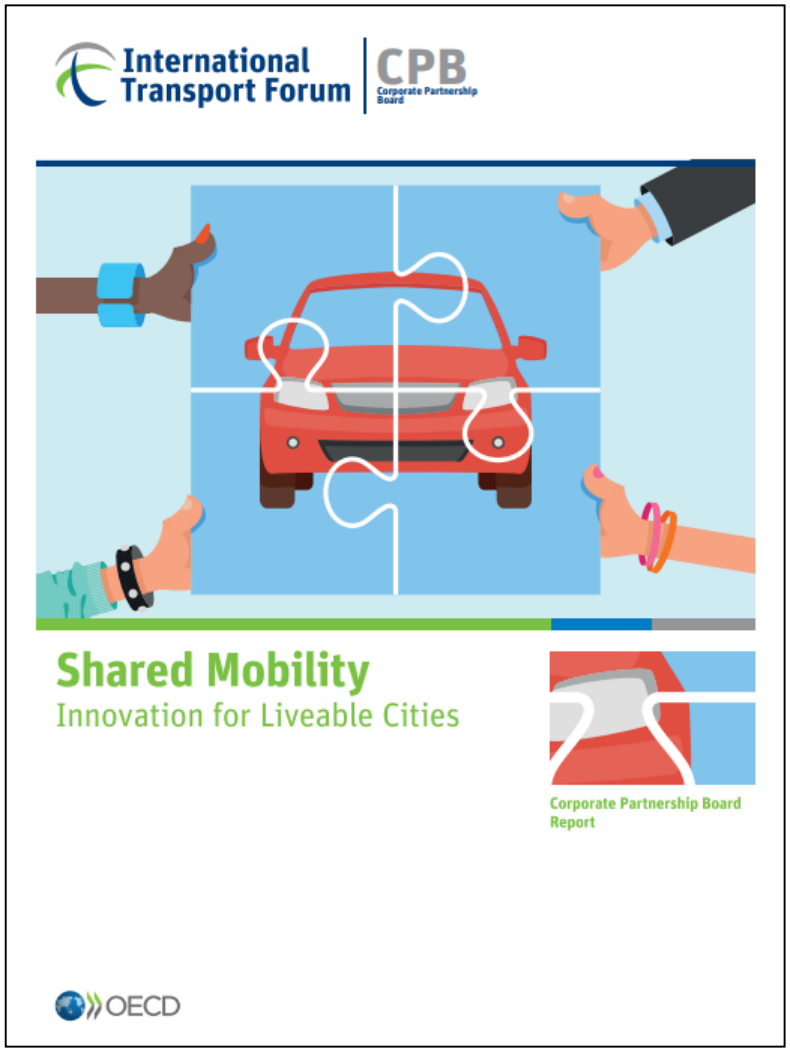
LED Global (compared to 2020) Thermal Comfort: Activity x 1.5, Intensity ÷ 6.3, Energy ÷ 6.3

Mexico: NAMA
low energy social housing projects

Netherlands: Energiesprong
prefabricated thermal retrofits, net-zero housing

Austria: Raiffeisen
First Passivhausstandard office tower retrofit

The “Sharing Economy”: Mobility Case Studies



Reductions (%) in shared mobility scenario compared to status quo

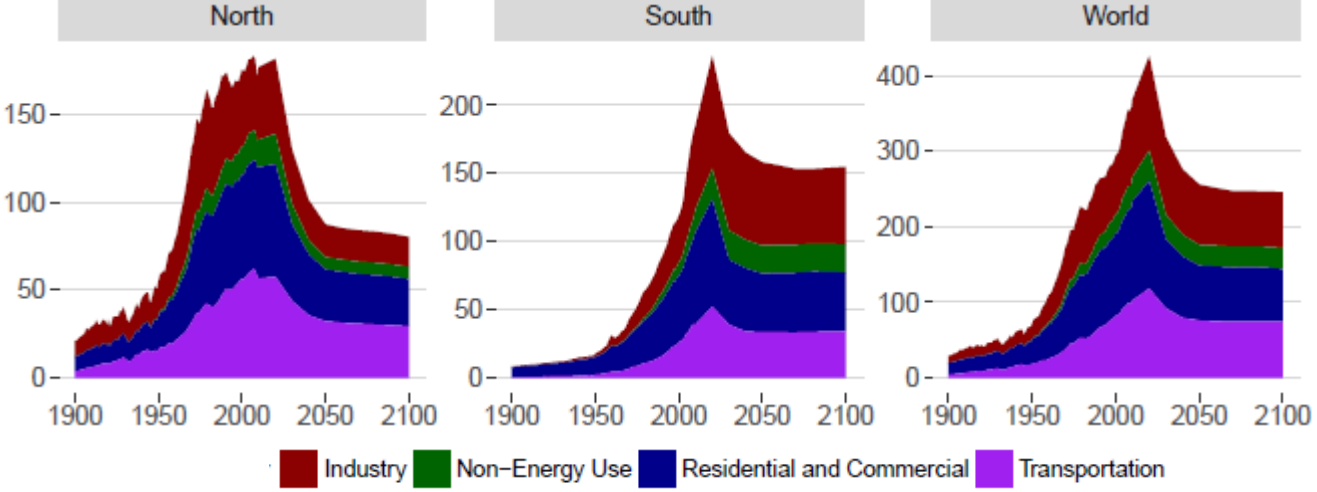
	vehicle fleet	con-gestion	mobility costs	CO2 emissions
Auckland	-95%	-49%	-43%	-54%
Dublin	-98%	-43%	-50%	> -31% *
Helsinki	-96%	-37%	-43%	> -34% *
Lisbon	-97%	-30%	-50%	-62%

* IC vehicle fleets, no electrification

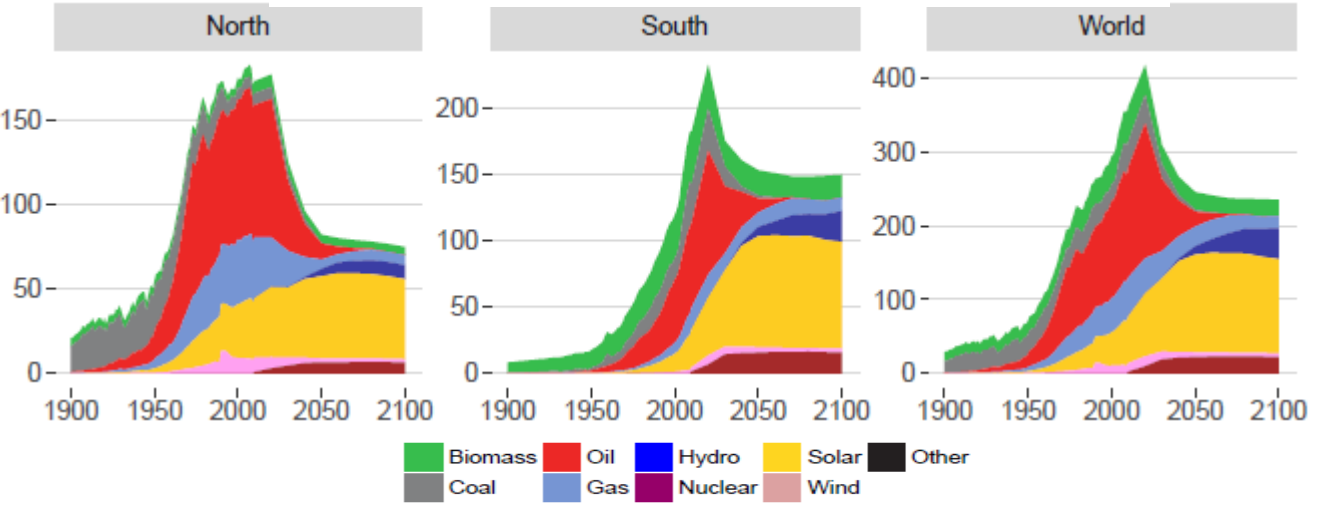
LED Global (compared to 2020) Mobility:
Activity x 1.9, Intensity ÷ 4.6, Energy ÷ 2.5

Main Characteristics of Transitions

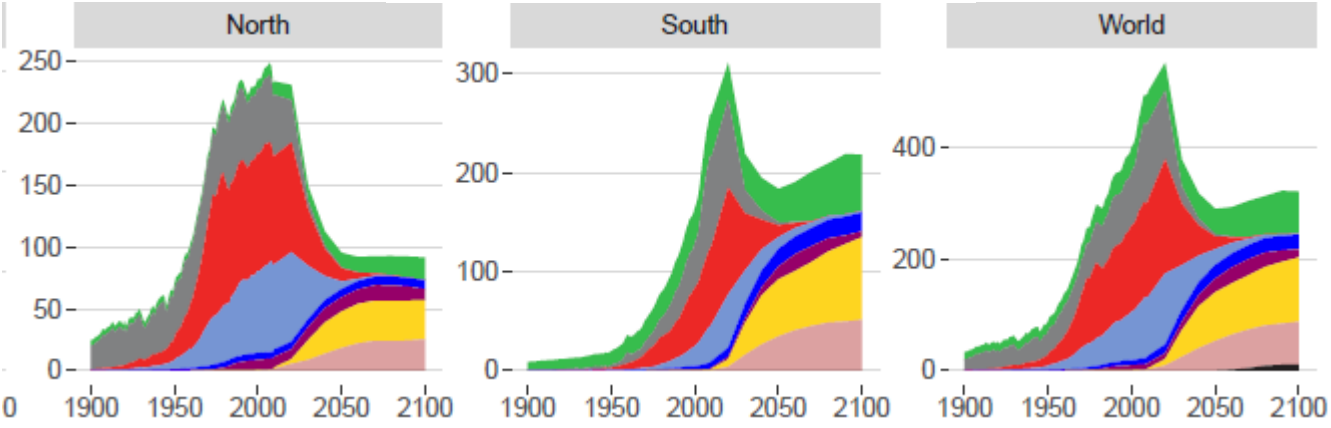
- Scaled-down demand allows faster systems transitions:
  - Faster electrification
  - Higher market share of renewables:
    8% (2020), 32% (2030), 60% (2050)
  - With lower rates of absolute capacity additions
    up to 91%/yr historically, 15% (2020-2030)
    <5% (>2050)
  - With no CCS, BECCS, or geoengineering
- Outperforming all other scenarios on 7 SDG dimensions



LED EJ Final Energy

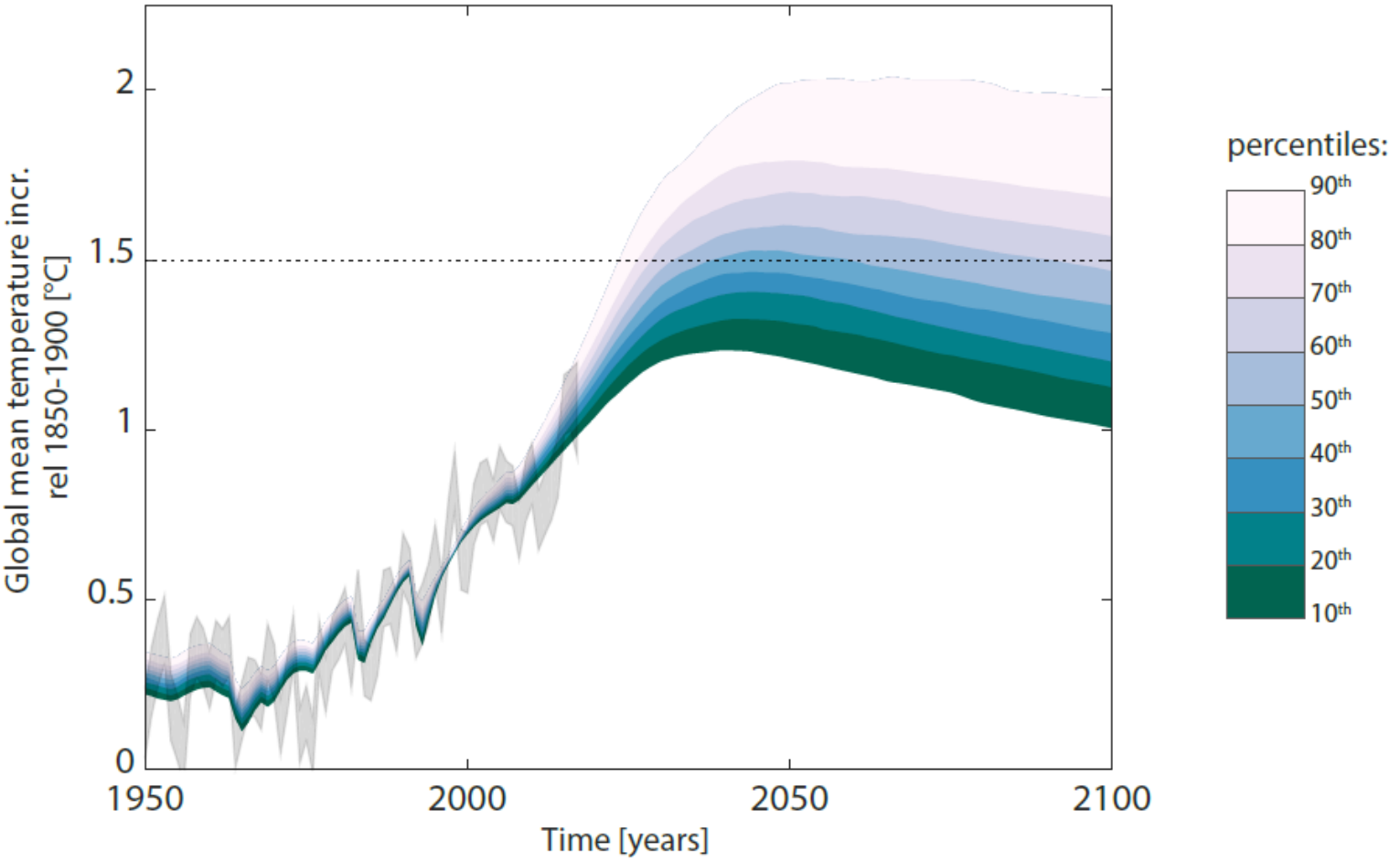


LED EJ Final Energy



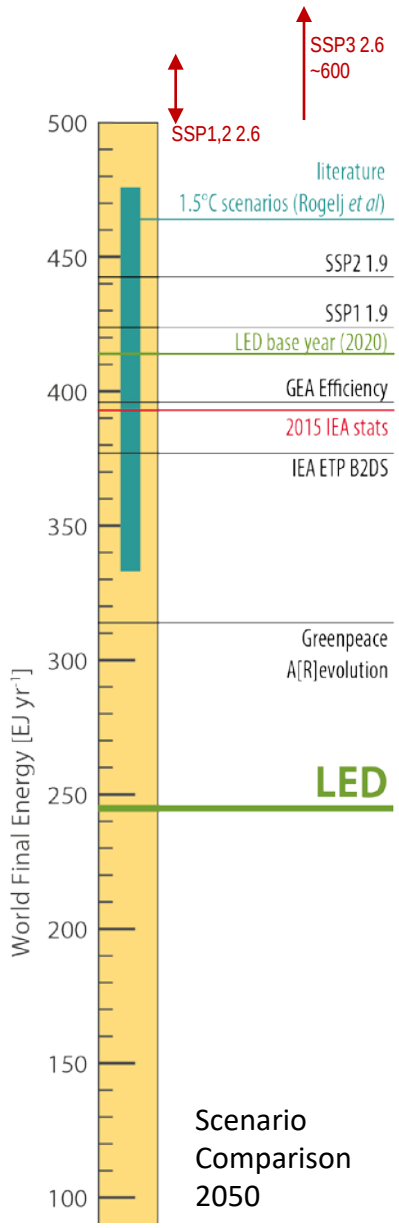
LED EJ Primary Energy

LED: Global Mean Temperature Change
Probabilistic MAGICC Results

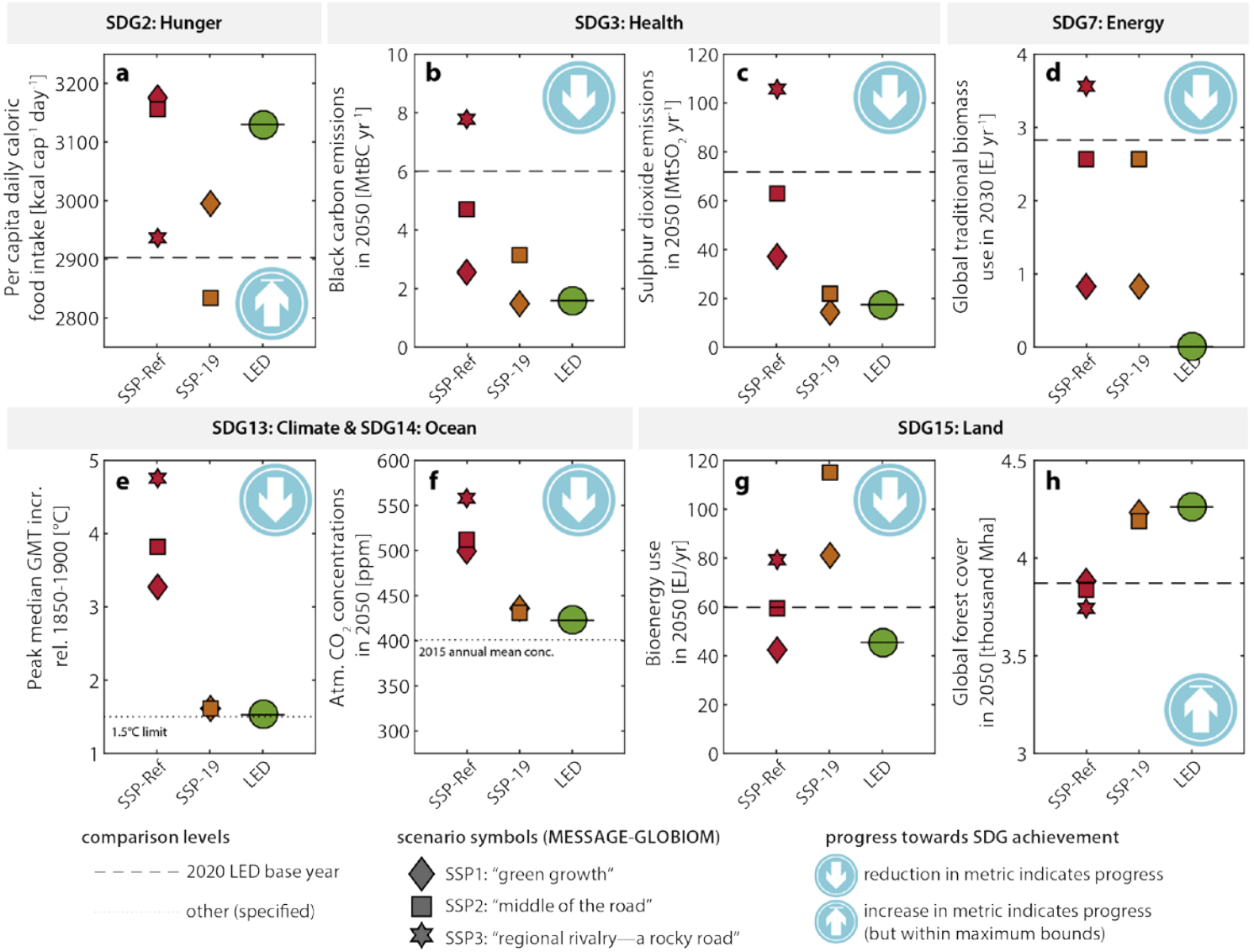


SDG 2, 3, 7, 13, 14, 15 Implications

LED *vs* IPCC SSPs (SSP1-3Ref & 1.9) Scenarios



Scenario Comparison 2050



Conclusion

- Demand (technological and service efficiency) key for SDGs and 1.5
- Transition acceleration possible with end-use & granularity focus
- First global scenario quantification (LED), informed by recent trends and advances in transition modeling
- Implications for Policy Makers: Deemphasizet global climate policy architecture, actor coalitions with urban citizens and farmers, challenge: systemic incentives (land-use, transport, infrastructure)
- Implications for Business: New opportunities with service-oriented business models, building efficiency, granular end-use technology innovation

ありがとう