EDITS
Energy Demand changes Induced by Technological and Social innovations

RITE Research Institute of Innovative Technology for the Earth

IIASA

Opening remarks and the background of the Energy Demand changes Induced by Technological and Social innovations (EDITS) network

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The side event at the Japanese Pavilion of COP27

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G20 Karuizawa Innovation Action Plan on Energy Transitions and Global Environment for Sustainable Growth (June 2019)

“We recognize the importance of quantitative analysis on better understanding future energy demand and supply and the role of innovation of both sides driven by digitalization, Artificial Intelligence (AI), the Internet of Things (IoT), and the sharing economy. We encourage efforts made by the global scientific community and international organizations and frameworks to further refine and develop the full spectrum of economy-wide scenarios for energy and climate models.”

Note) This is also an annex document of the G20 Osaka Leader’s declaration.

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The EDITS project supported by Ministry of Economy, Trade, and Industry (METI), Japan

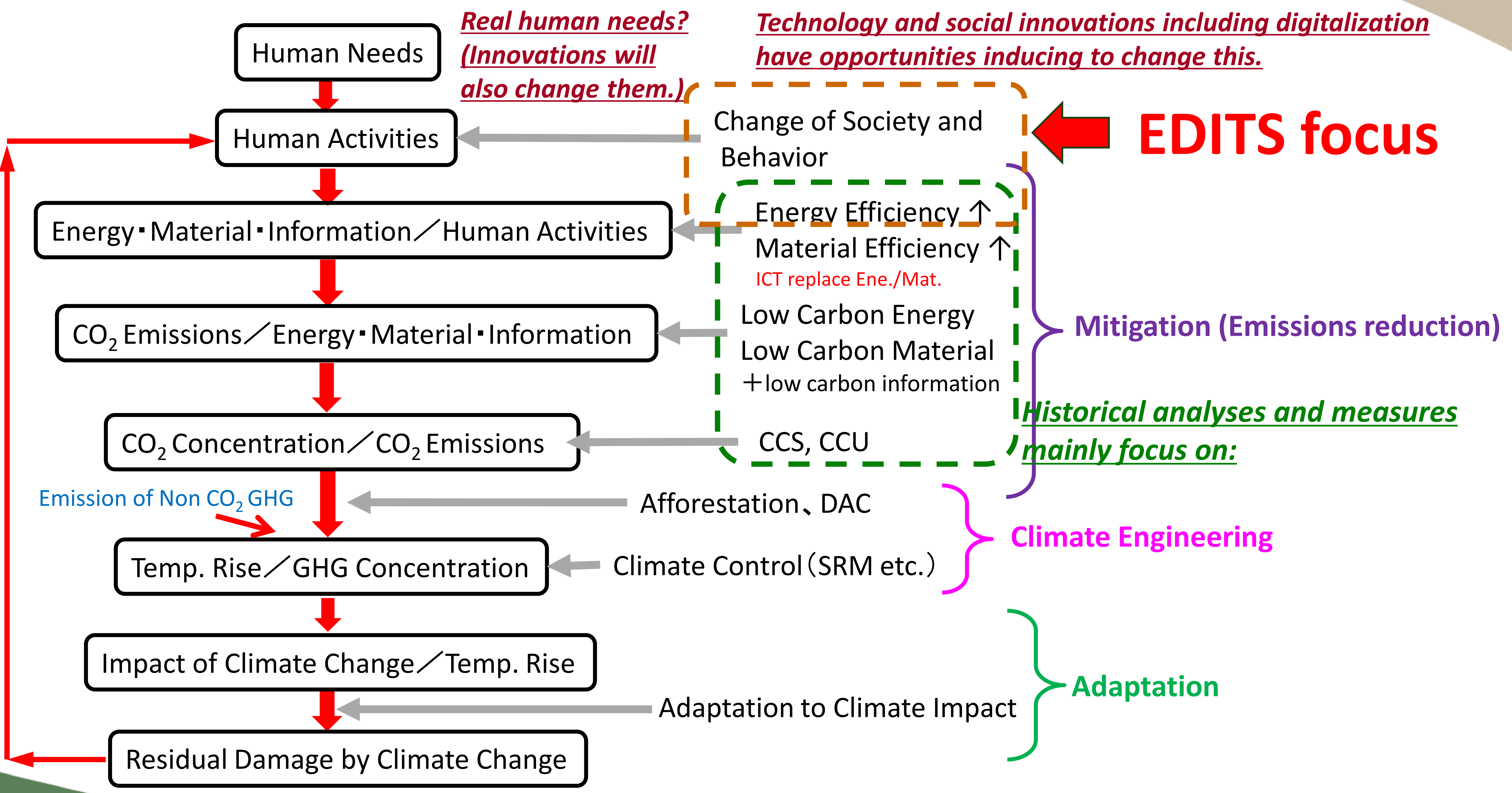
<u>The terms</u>: FY2020- (expectation: for five years and more)

<u>Participating research institutes or researchers</u>:
IIASA, AIT, LBNL, OECD/ITF, CMCC, Central European Univ., Univ. of Wisconsin, UCSB, UFRJ/COPPETEC, The Korean Society of Climate Change Research, The Univ. of Tokyo, Osaka Univ., RITE, and others
Nearly 100 researchers including many IPCC lead authors have been involved.

[Objectives]

- ✓ **To create a research community with a focus on end-use, demand-side perspectives that furthers dialogue and cross-fertilization of research and policy analysis through the sharing of novel data, novel concepts, methodologies and policy analyses.**
- ✓ **To improve the state-of-art of demand modeling in environmental and climate policy analysis, via methods and model intercomparisons and assisting the transfer of conceptual and methodological improvements across disciplines, sectors, and environmental domains.**
- ✓ **To better inform policy via structured model experiments and simulations that assess potential impacts, barriers, as well as synergies and tradeoffs to other SDG objectives of demand-side policy interventions, particularly in novel fields and service provision models such as digitalization, sharing economy, or the integration of SDG and climate objectives in synergistic policy designs.**

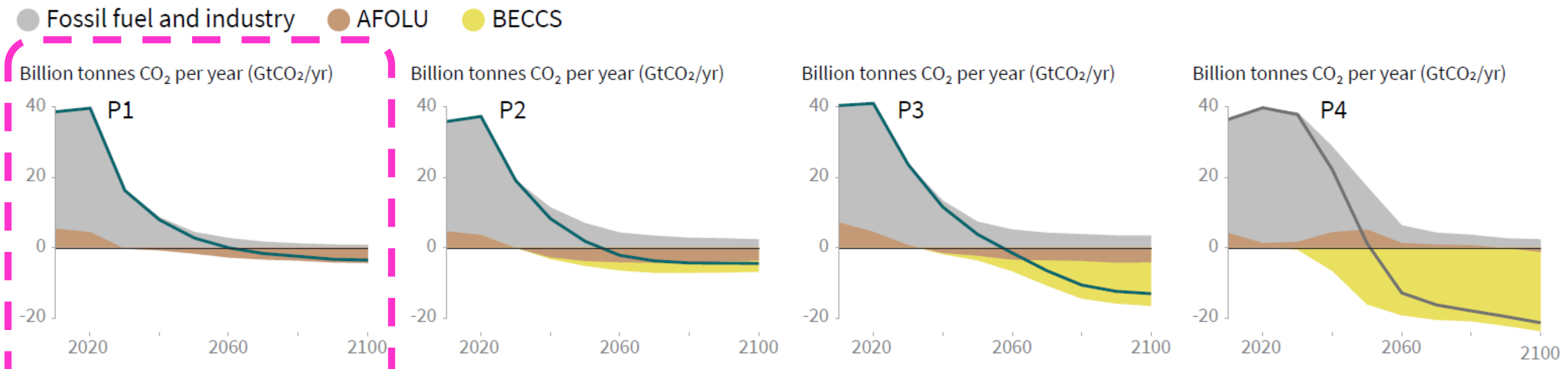
Response measures to climate change



Source：Kenji Yamaji, 2006：「Theory of 3E Systems Analysis」, Iwanami-Shoten (in Japanese) + modifications

Low Energy Demand (LED) scenarios

IPCC Special Report on 1.5 C (SR15)



P1: A scenario in which social, business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

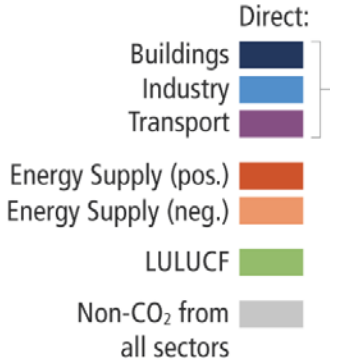
P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

LED

IPCC 6th Assessment Report (AR6)

LD



The IPCC reports show some scenarios of low energy demands, but more comprehensive and quantitative scenarios will be needed.

SDGs and a low energy demand society

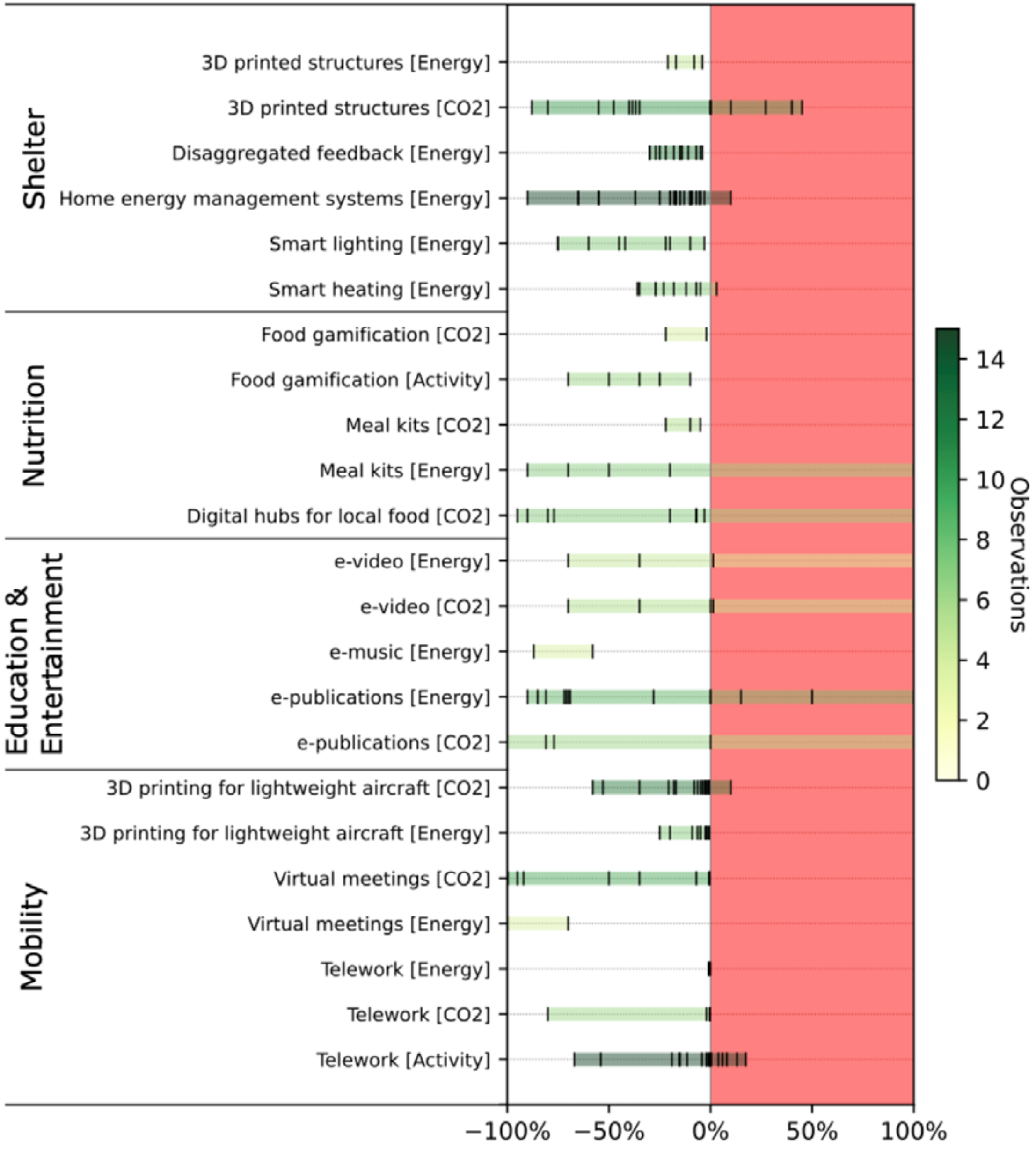
Achieving Goal 12 is well coordinated with achieving other eleven Goals

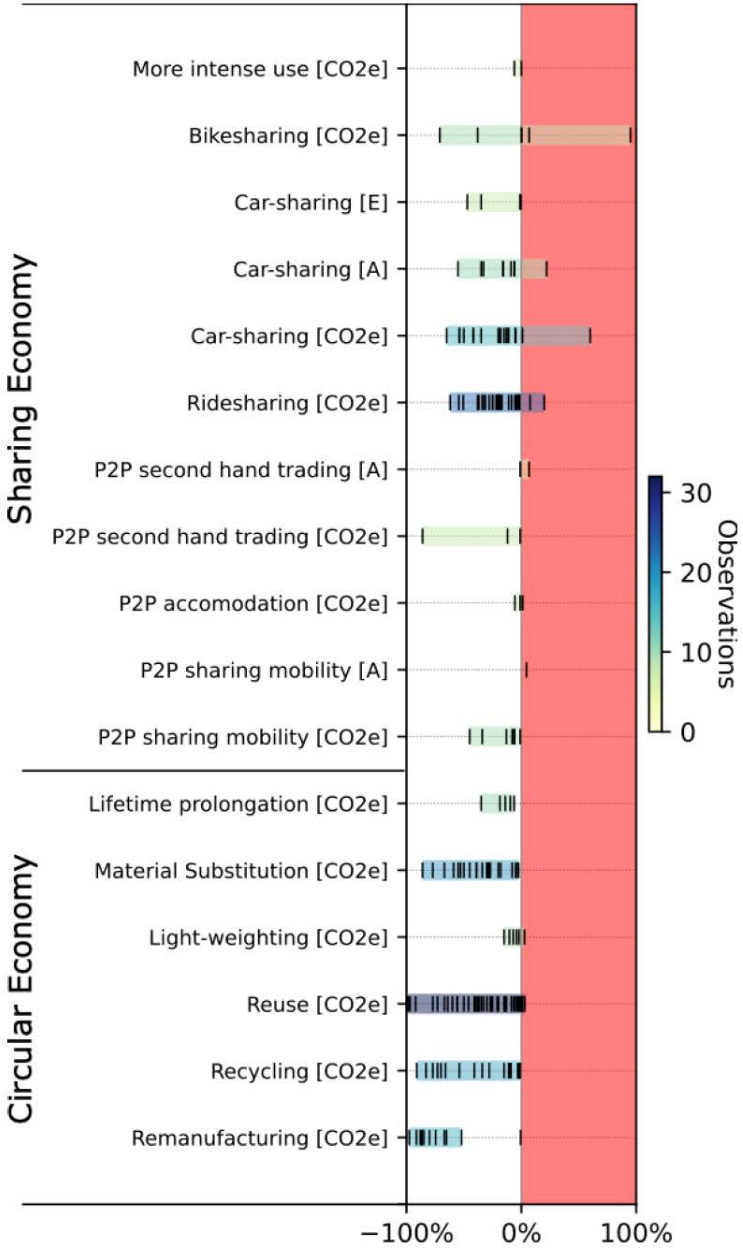
Responsible Consumption & Production:
End poverty, reduce overconsumption, minimize waste and environmental impacts

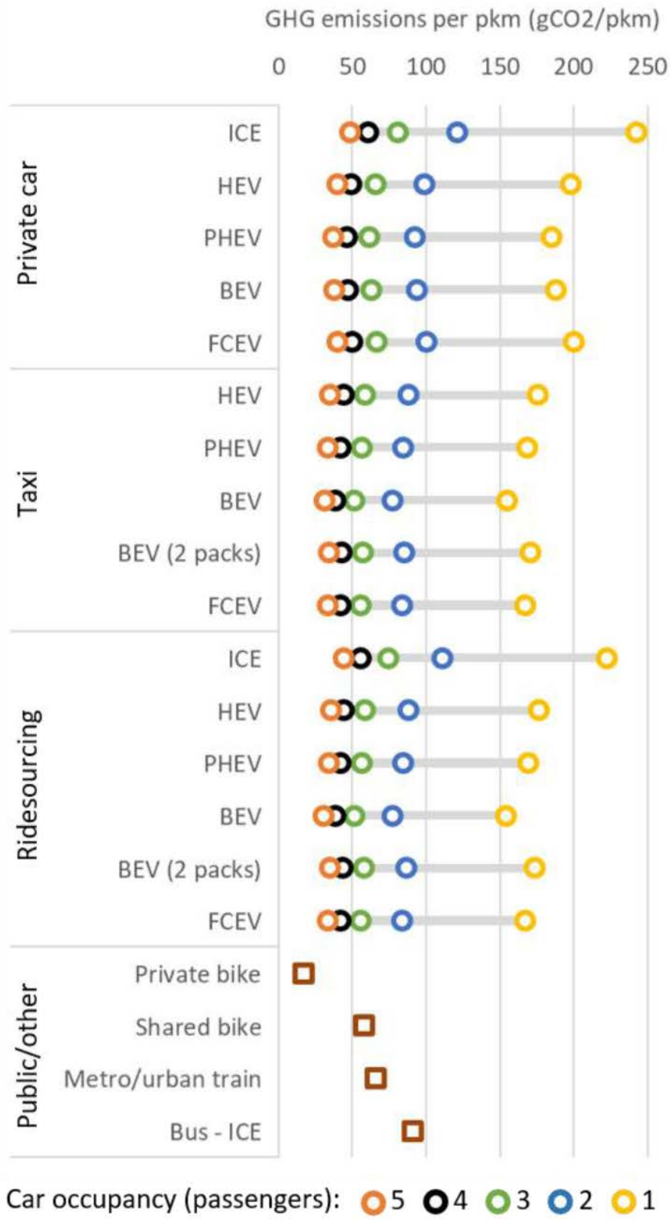
Source: IIASA, LED scenario

Deep emission reductions at affordable costs will be a key to achieving multiple SDGs, and digitalization, and the related other innovations will contribute to the achievement.

Digitalization impacts (IPCC AR5 Ch.5)







IPCC AR5 Ch.5 – Knowledge Gaps

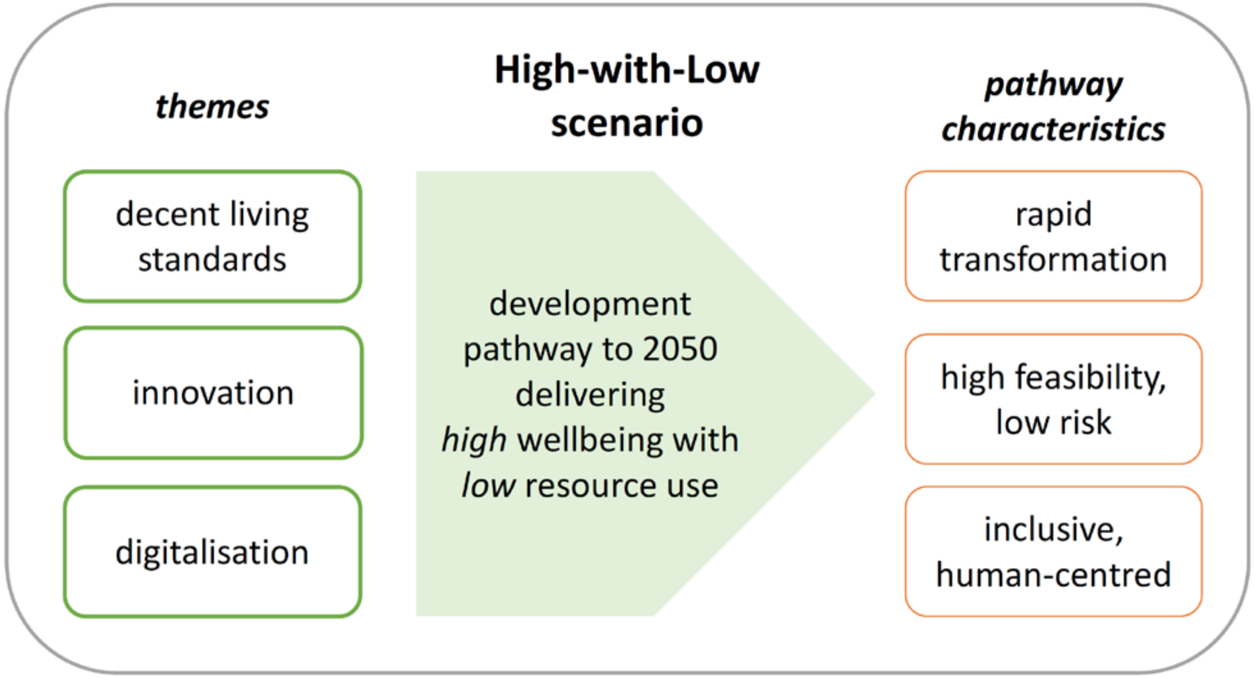
Authors: Felix Creutzig, Joyashree Roy, Arnulf Grubler, Eric Masanet, and others

1. **Better metric to measure actual human well-being**
2. **Evaluation of climate implication of the digital economy**
3. **Scenario modelling of services**
4. **Dynamic interaction between individual, social, and structural drivers of change**

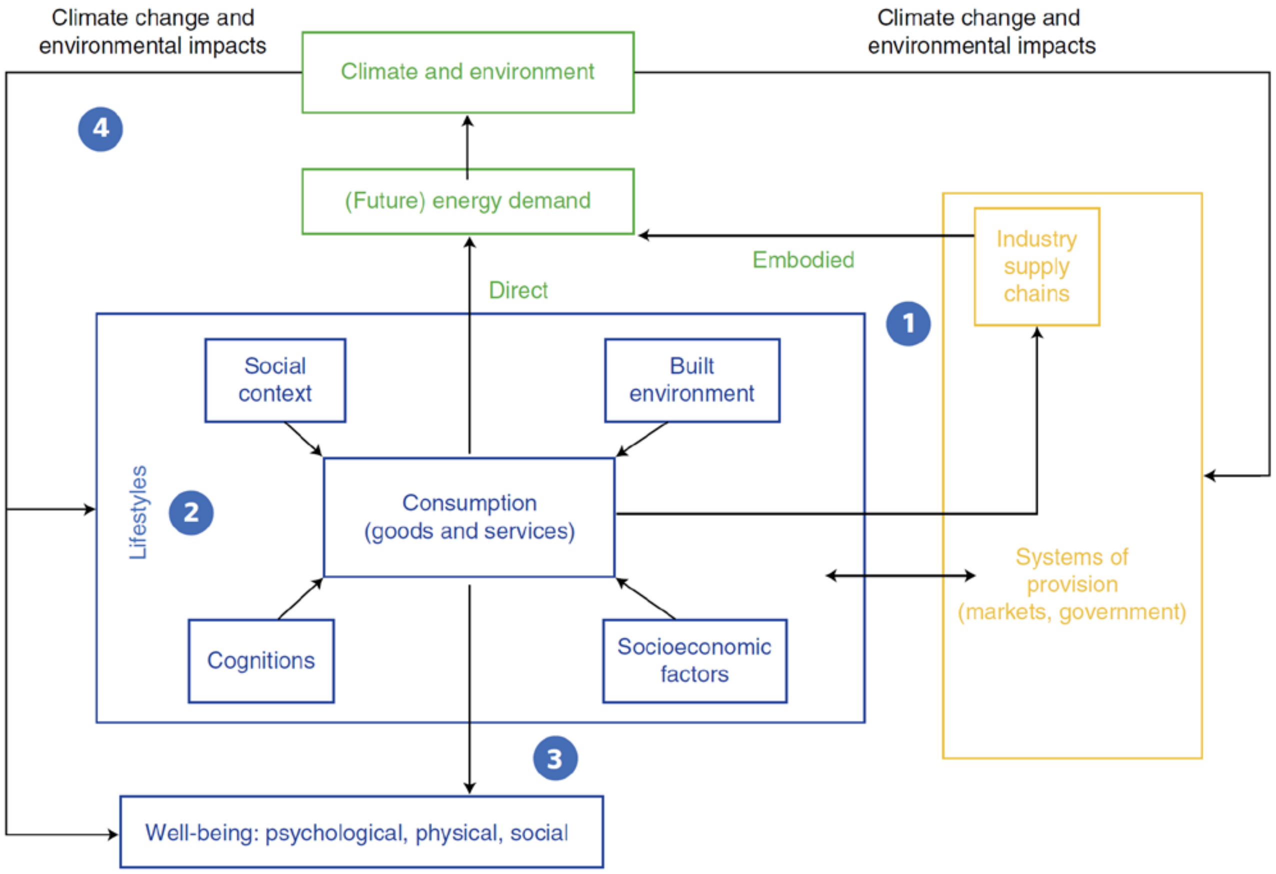
These gaps will also be tackled in the EDITS project.

‘High-with-Low’ Narrative Scenario

high wellbeing with **low** resource use



How can we approach this scenario from a modelling side?



Source: EDITS WG3 Narratives group (Arnulf Grubler, Greg Nemet, Shonali Pachauri, Charlie Wilson), The 'High-with-Low' Scenario Narrative: Key Themes, Cross-Cutting Linkages, and Implications for Modelling

Overview of DNE21+ model

- Linear programming model (minimizing world energy system cost; with 10mil. variables and 10mil. constrained conditions)
- Evaluation period: 2000-2100
  Representative time points: 2005, 2010, 2015, 2020, 2025, 2030, 2040, 2050, 2070 and 2100
- World divided into 54 regions
  Large area countries, e.g., US and China, are further disaggregated, totaling 77 world regions.
- Interregional trade: coal, crude oil/oil products, natural gas/syn. methane, electricity, ethanol, hydrogen, CO_2 (provided that external transfer of CO_2 is not assumed in the baseline)
- Bottom-up modeling for technologies on the energy supply side (e.g., power sector) and CCUS
- For the energy demand side, bottom-up modeling conducted for the industry sector including steel, cement, paper, chemicals and aluminum, the transport sector, and a part of the residential & commercial sector, considering CGS for other industry and residential & commercial sectors.
- Bottom-up modeling for international marine bunker and aviation.
- Around 500 specific technologies are modeled, with a lifetime of equipment considered.
- Top-down modeling for others (energy saving effect is estimated using long-term price elasticity.)

Scenario assumptions

Digitalization and innovations, and induced social changes – Demand reductions (1/2)

Changes due to digitalization	Direct impacts	Indirect impacts	Model assumptions (tentative)
1) Ride and car-sharing associated with fully autonomous cars	- Energy consumption reductions due to ride-sharing	- Reductions in consumption of basic materials, e.g., iron and steel, plastics, tire, glass, and concrete, due to reductions in number of cars associated with car-sharing - Reductions in freight shipping => 8)	- Iron and steel production: -4% compared with standard scenarios - Plastic production: -1% - Tire production (for cars): -28% - Glass production (for cars): -28% - Cement production: -1% (only for multi-storey car park)
2) Virtual meeting and teleworking	- Reductions in travel service demand and the associated reductions in energy consumptions in transport sector	- Potential reductions in numbers of commercial building, and the resulting reductions in iron and steel, concrete, and others *[Not yet considered]*	- Reductions in person-km travel by passenger cars, buses, and aircraft by 10%
3) E-publication etc.	- Reductions in paper consumptions due to large deployment e-publications etc.	- Potential reductions in freight services for papers. *[Not yet considered]*	- Reductions in paper/pulp by 20%
4) Recycling and reductions in apparels due to e-commerce and other digitalization	- Reductions in energy consumptions for apparel productions	- Potential reductions in energy consumption at shopping centers etc. *[Not yet considered]*	- Reduction in new productions of apparels by 20%. No explicit modeling for apparels in DNE21+, and corresponding reductions in energy consumption in textile and leather sector by 20%

Red: residential sector, **Green**: commercial sector, **Blue**: transport sector, **Purple**: industry sector , **Brown**: Non-CO2 GHGs etc.

Scenario assumptions

Digitalization and innovations, and induced social changes – Demand reductions (2/2)

Changes due to digitalization	Direct impacts	Indirect impacts	Model assumptions (tentative)
5) Longer life time of buildings due to improv. in city planning	- Potential Redductions in cement and steel due to longer life time of buildings		- Longer lifetime of building: +40%; the related reductions in cement (-3%) and steel (-3%) productions
6) Reductions in food losses due to better demand projection	- Reductions in nitrogen fertilizer, plastics, etc. and the resulting energy consumption reductions - Potential reductions in energy consumption at supermarkets etc. - Red. in CH4 and N2O	- Reductions in freight shipping services => 8) - *Pot. red. in construction for supermarkets etc., and the resulting reductions in steel, concrete, and others [Not yet considered]* - *Pot. increases in afforestation due to increase in rooms of land area [Not yet considered]*	- Reduction in petrochemical products including ammonia by 1% - Reduction in plastics by 1% - Reduction in paper and pulp by 0.5% - Reduction in transport services by 1% and others (according to I/O analysis results) - Reduction in CH4 and N2O emissions: -493 MtCO2eq/yr in 2050
7) AM (3D-printing) for applying aircraft	- Reduction in aluminum and steel production - Reduction in electricity for productions	- Energy efficiency improvements of aircraft and the energy consumption reductions - *Energy efficiency improvements of cars and the energy consumption reductions [Not yet considered]*	- Red. in aluminum and steel prod. by 1% and 0.02%, respectively - Reduction in elec. consumption by 1% - Increase in energy efficiency of aircraft by about 10%
8) Red. in freight shipping services due to reductions in basic materials and products	- Energy consumption reductions in freight shipping		- Reduction in freight shipping demand by 1%

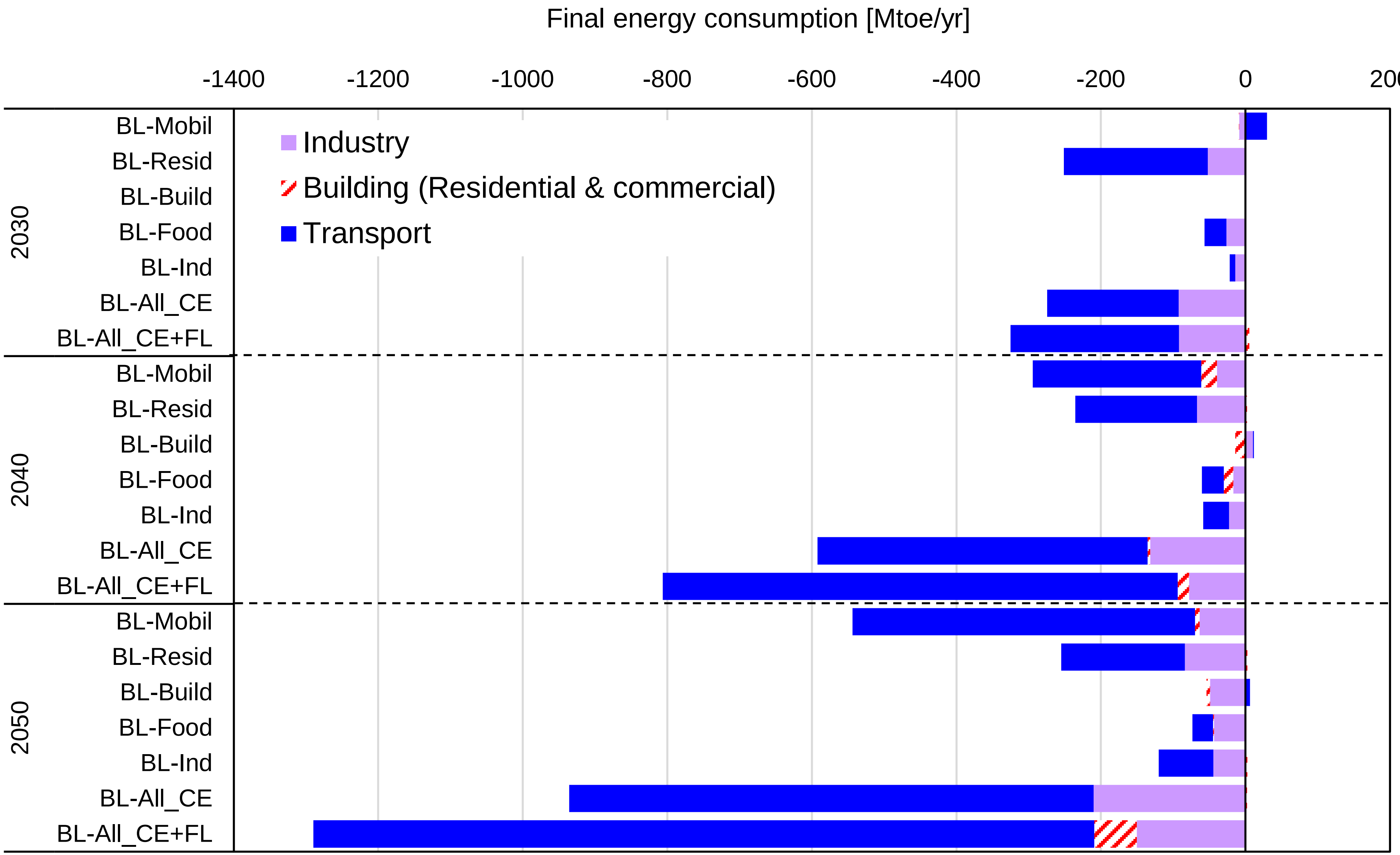
Red: residential sector, **Green**: commercial sector, **Blue**: transport sector, **Purple**: industry sector , **Brown**: Non-CO2 GHGs etc.

Scenario assumptions

	Emissions reduction	Energy demand reductions due to mainly digitalization						Rapid cost red. in granular tech's, e.g., PV, Wind, EV	Demand flexibilities in electricity (EV, HP, CGS)
		Transport 1)	Residential 2, 3, 4)	Building 5)	Food 6)	Industry 7)	Spill over 8)		
BL-Std	**Baseline** (non specific climate policies)	—	—	—	—	—	—	—	—
BL-Mobil		X							
BL-Resid			X						
BL-Build				X					
BL-Food					X				
BL-Ind						X			
BL-All_CE		X	X	X	X	X	X		
BL-All_CE+FL		X	X	X	X	X	X	X	X
B2DS-Std	**B2DS** (well below 2C; NDCs in 2030; CN by 2050 in G7 countries)	—	—	—	—	—	—	—	—
B2DS-Mobil		X							
B2DS-Resid			X						
B2DS-Build				X					
B2DS-Food					X				
B2DS-Ind						X			
B2DS-All_CE		X	X	X	X	X	X		
B2DS-All_CE+FL		X	X	X	X	X	X	X	X

Final energy consumption (preliminary)

Baseline (without additional climate policies)

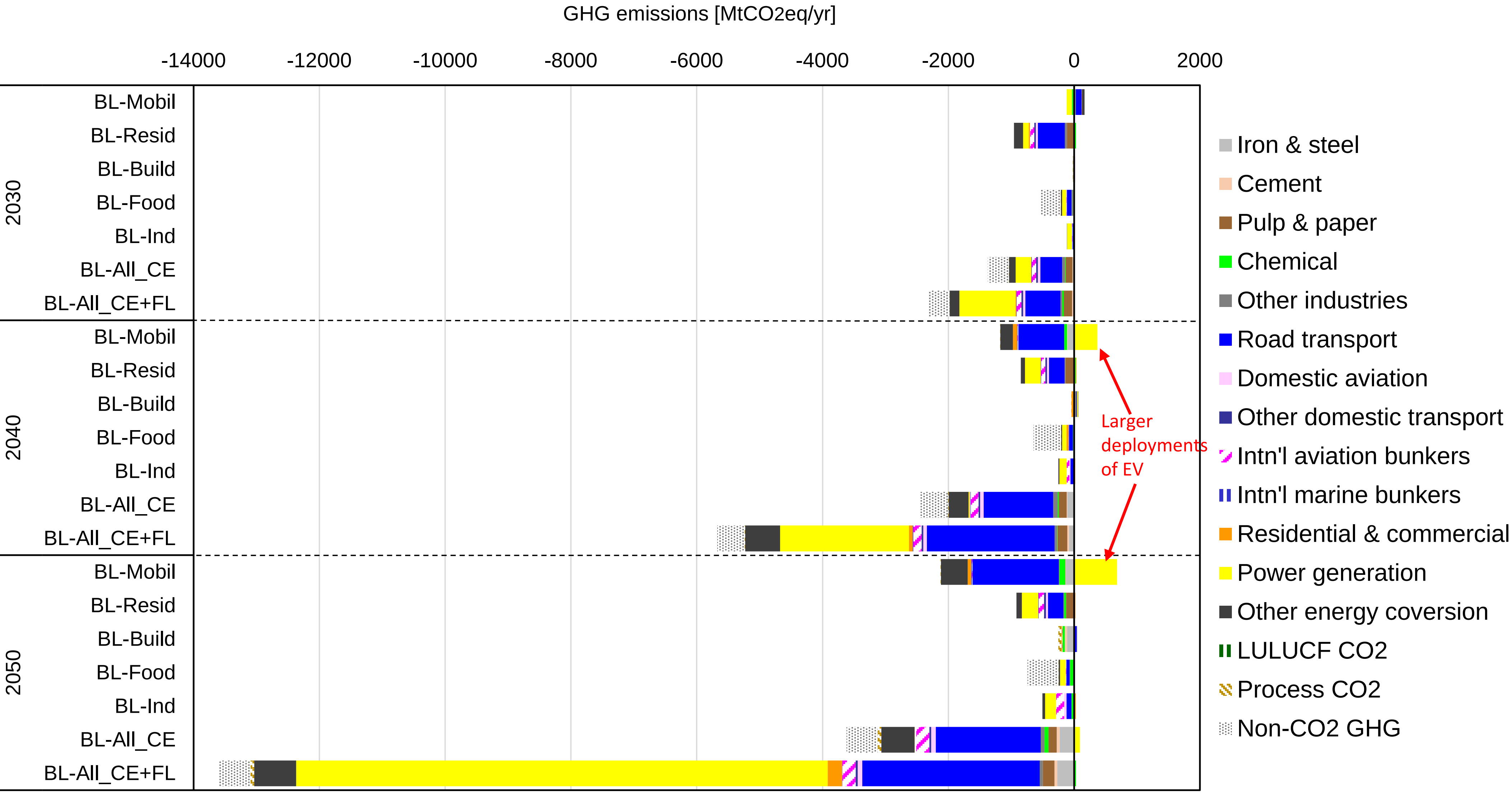


While this preliminary study assumes only limited impacts of circular/sharing economies due to digitalization mainly, significant reductions (by around 10%) in final energy consumptions are estimated.

Ref.) Global final energy consumption in 2019: 10 Gtoe/yr; baseline final energy consumption in 2050: 14 Gtoe/yr

GHG emissions (preliminary)

Baseline (without additional climate policies)

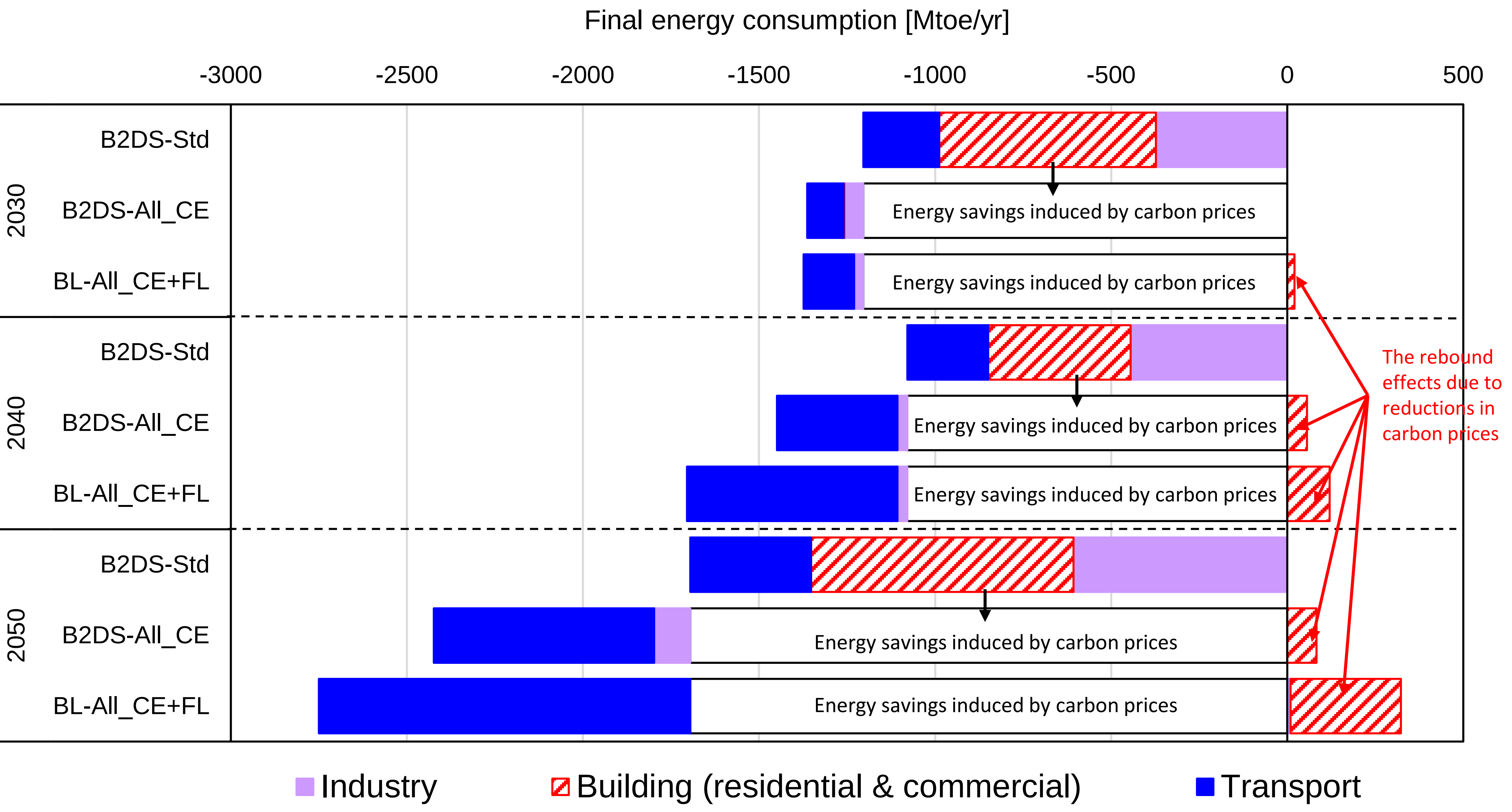


The assumed digitalization impacts in end-use sectors on entire GHG emissions are estimated to reduce the emissions by around 7%, and those plus the assumptions on rapid cost reductions in granular technologies and demand flexibilities could reduce the emissions by around 20%, even if limited factors are considered.

Ref) Global GHG emissions in 2019: 59 GtCO2eq./yr; Baseline GHG emissions in 2050: 73 GtCO2eq/yr

Final energy consumption (preliminary)

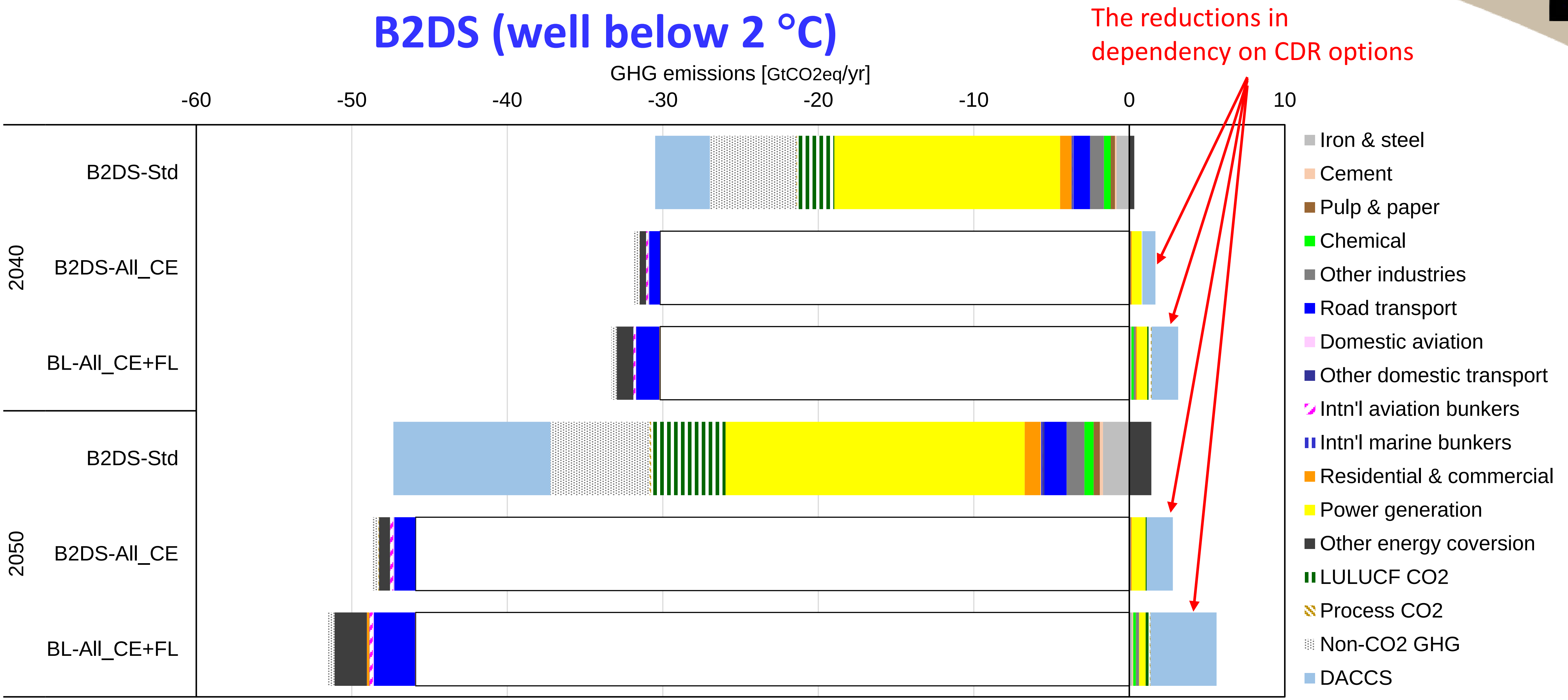
B2DS (well below 2 °C)



Final energy consumptions will be reduced by around 25% in B2DS with cheaper carbon prices, thanks to the impacts of end-use technological and social innovations.

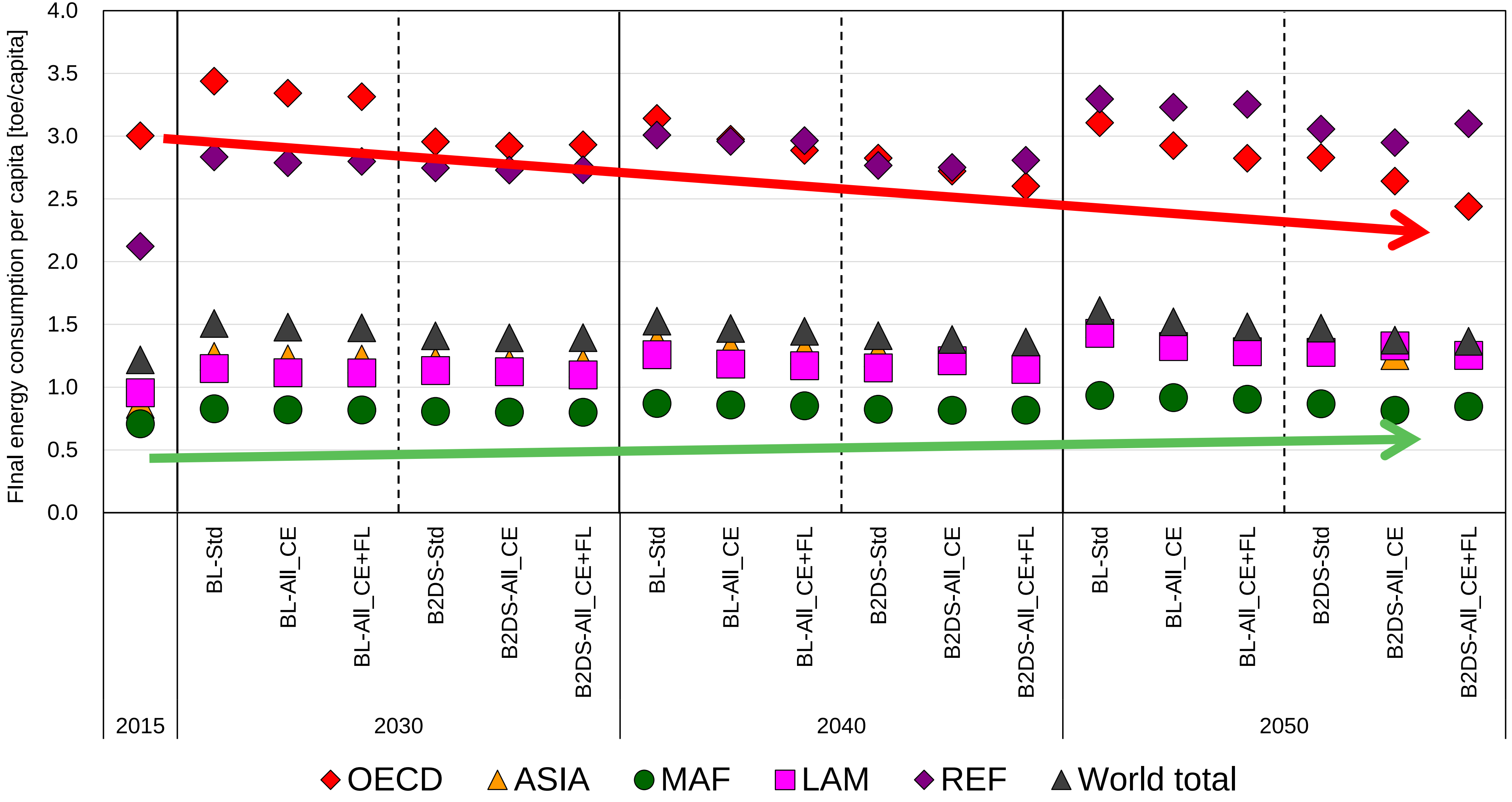
Ref.) Global final energy consumption in 2019: 10 Gtoe/yr; baseline final energy consumption in 2050: 14 Gtoe/yr

GHG emissions (preliminary)



The dependency on CDR options (e.g., BECCS and DACCS) will be reduced.

Final energy consumption per capita by region
(preliminary)



The 'High-with-Low' Scenario induces smaller differences in final energy consumption across regions.

Changes in emissions reduction costs (preliminary)

Total energy systems costs (unit: Billion USD/yr)

	The annual average in 2030-2040							The annual average in 2040-2050						
	Mobil	Resid	Build	Food	Ind	All_CE	All_CE +FL	Mobil	Resid	Build	Food	Ind	All_CE	All_CE +FL
Baseline	▲547	▲339	▲1	▲57	▲4	▲894	▲963	▲1601	▲459	▲1	▲74	▲7	▲1971	▲2085
B2DS	▲556	▲352	▲0	▲64	▲5	▲926	▲1038	▲1635	▲477	▲6	▲90	▲14	▲2037	▲2266

Note) The changes in the costs compared those in the standard scenarios for each emissions reduction targets.

CO2 marginal abatement costs (carbon prices) in B2DS (unit: USD/tCO2eq)

	2040			2050		
	B2DS-Std	B2DS_All-CE	B2DS_All-CE+FL	B2DS-Std	B2DS_All-CE	B2DS_All-CE+FL
Carbon prices for B2DS	68–310	57–238	50–195	146–739	123–524	60–364

Note) The cost ranges are those due to the differences in emissions targets across countries.

The emissions reduction costs can be reduced greatly through the assumed innovations in end-use sectors.
The affordable cost measures will also help increases in feasibility and achieve multiple SDGs.

Conclusions

- **EDITS project is developing comprehensive and quantitative scenarios of narrative 'High-with-Low' scenario (high well-being with low resource use) with DNE21+ model and other several models.**
- **Digitalization and the related innovations could induce rapid changes in our society, reduce several resources and the embedded energy consumptions through circular and sharing economy, and achieve cheaper cost for deep emissions reduction.**
- **Our EDITS project members believe that better understandings on the potential changes and great contributions to emissions reduction as well as achievements of multiple SDGs through comprehensive analyses will induce the movements in all people including consumers, industrial people, and policymakers.**

Thank you very much for your attention!

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