• Title	**A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies (LED)**	**A Societal Transformation Scenario for Staying Below 1.5C (STS)**	**Providing decent living with minimum energy: A global scenario (DLE)**	**Net Zero by 2050 - A Roadmap for the Global Energy Sector**
• Carrying organisation		Heinrich Böll Foundation		IEA - international Energy Agency
• Authors	Grubler et al	Kuhnhenn et al	Millward-Hopkins et al	Lead authors: Bouckaert, Fernandez Pales, McGlade and Remme
Resources				
• Date of publication number of editions or frequency of updating	June 2018	November 2020	August 2020	
• Documentation provided	Article published in Nature Several supplementary information documents Database access	Detailed report	Article published in Elsevier	Detailed report (393 pages) No executive summary
• Language(s)	English	English	English	English
Inclusion in the public debate				
• Type of organisation (institutional, academic, industrial, NGO)	Academic	Academic	Academic	Institutional
• Purpose(s) of the scenario	To present a transition scenario based on the strong decrease in final energy demand which differs from most scenarios proposing solutions related to energy supply and production To show that such a future is not unrealistic and what it implies To inform policy-makers	To present a sustainable, safe and participatory path to preventing a runaway climate crisis (compared to most progressive climate mitigation scenarios presenting a bias on economic growth and not adressing behavioural change - except LED)	"To estimate a practical minimal threshold for the final energy consumption required to provide decent material livings to the entire global population"	To show what is needed across the main sectors by various actors, and by when, for the world to achieve net-zero energy-related and industrial process CO2 emissions by 2050. To urge "governments to act, and act decisely to accelerate the clean energy transformation" To show that "the IEA [is] fully committed to leading those efforts"
Ambition				
• Climate (**objective**, consideration of the objective - neutrality, carbon budget compliance, other -, % of reduction compared to a year of reference, other)	Carbon budget compliance with 1.5°C increase with probability greater than 60% (390GtCO2 budget between 2020-2100 with lower sequestration than SSP19 - 169GtCO2 according to Kuhnhenh et al)	Carbon budget compliance with 1.5°C increase (320GtCO2 budget between 2020-2100 with lower sequestration than SSP19 - 232GtCO2)	Any	CO2 neutrality by 2050. Minimase other GHG emissions from the energy sector. "Consistent with around a 50% chance of limiting the long- term average global temperature rise to 1.5°C without a temperature overshoot".
• Final energy demand (quantified evolution in % or TWh compared to a historical year of reference, quantified evolution compared to a reference scenario, other)	Final Energy demand (including feedstock): North: -55%, South: -34% by 2050 compared to 2020* *extension from 2018 to 2020 (w/o Covid-19 impact) Global: -40% by 2050 compared to 2020* reaching 68.000TWh (-42% excl. feedstock)	Final energy demand: Annex I: -75%, Non-Annex I: -20% by 2050 compared to 2018 Global final energy demand: -55% in 2050 compared to 2020* reaching 51.700TWh and -26% compared to Grubler 2050 *2020 equal to 2020 Grubler (2018) estimation	Final Energy demand: Global: -63% in 2050 compared to 2020* reaching 41.700TWh and -39% compared to Grubler 2050 and -62% compared to IEA SDS 2050 *2020 equal to 2020 Grubler (2018) estimation	Final Energy demand: -21% by 2050 compared to 2019 reaching 95.600TWh Electricity demand: +106% by 2050 compared to 2019 reaching 47.000TWh
• Renewable energy sources share (%)	> 90% in 2050	> 90% in 2050		> 65% in 2050
General approach and comprehensiveness				
• Geographical perimeter and level of desagregation of the represented regions (multiregional, regional, national, local, etc)	**International** **World** Assumptions and results given for the world and North/South distinction	**International** **World** Assumptions generally given for the world and North/South distinction	**International** **World**	**International** **World**
• Time horizon(s)	2050 (extension to 2100)	2050	2050	2050

• Scenarios / Variants (isolated/central/alternative scenario)	isolated	isolated	isolated	isolated
• Comparison to a scenario of reference (yes/no, type, construction, other)	No (but yes for some assumptions in the supplementary tables - e.g. number of appliances or mobility assumptions with GEA efficiency scenario or IPCC SSPs or ETP 2DS as industry's baseline scenario)	Only for results on final energy demand in Annex I countries and global CO2 emissions (w/o reductions in consumption) Comparison to LED	Energy demand compared to IEA strated, IEA SDS and LED scenario	No
• **Vision / Pathway** (considering a trajectory or not)	Pathway	Pathway		Pathway
• **Modelling** (yes*/no, *model name, supply-demand model, analytical approach (macro-economic, technico-economic, other), number of models composing the model, etc)	Yes Main model: MESSAGE Supply-demand model Hybrid approach (techno-economic approach for the supply and macro-economic approach for the demand) Optimisation model (maximisation of agents' surplus in cost-benefit analysis over the period) Model coupled with: GLOBIOM (hybrid techno-economic and macro-economic, Optimisation model (dynamic recursive)	Yes The Global Calculator Supply-demand model Techno-economic approach Simulation model	Yes Buttom-up energy-model upon the existing framework of Rao and Min (2018a)	Yes Main models: WEM and ETP Supply-demand model Hybrid approach (techno-economic approach for the supply and macro-economic approach for the demand) Optimisation model Models coupled with: GAINS for air polluants and health impacts, GIMF model for investments and GDP spending share
• **Energy scope** (systemic approach of energy covering all energy usages or limited to some sectors, electricity only, etc)	Systemic approach of energy covering all energy usages	Systemic approach of energy covering all energy usages	Systemic approach of energy covering all energy usages	Approach coverring most of energy usages (Agriculture and forestry not included)
• **Sector detail** (strong/weak, breakdown, etc.)	Strong Sectors covered: Buildings, Transport, Industry, Forestry, Agriculture	Strong Sectors covered: Buildings, Transport, Industry, Forestry, Agriculture	Strong Sectors covered: Buildings, Transport, Industry, Agriculture	Strong Sectors covered: Buildings, Transport, Industry
• **Climate impact: quantification, GHG scope**, accounting approach (strict national territory approach aslo called "production", footprint approach also called "consumption", other)	Carbon neutrality by 2050 and budget compliance (1.5°C pathway P>60%) GHG: CO2, CH4, N2O, F-gases	Carbon neutrality by 2050, carbon budgert compliance with 1.5°C increase GHG: CO2, CH4, N2O, F-gases	Not calculated	CO2 neutrality by 2050 GHG: CO2 mainly (CH4, N2O, F-gases also studied in order to minimise emissions)
• Other environmental impacts (materials use, land use, water, air pollutants, etc)	air pollution		Planetary boundaries, water consumption,	
• Socio-economic impacts (growth, costs, purchase power, jobs, etc.)	GDP: 2.8% increase per year between 2020 and 2050, Average annual energy investment over the period 2020-2050 (1.000 G€), Poverty-eradication among others (Supplementary Note 12 on impcats on relevant SDGs)		Decent living standarts	Energy investments, Health impacts of air pollutants
• Level of transparency (strong/weak, number of supportive documents, access to the model and assumptions, etc)	Very Strong - Scenario: http://pure.iiasa.ac.at/id/eprint/15301/ - Base data associated: https://db1.ene.iiasa. ac.at/LEDDB - several supplementary information documents	Strong - Model: http://tool.globalcalculator.org/	Strong	Medium ?
Role of Sufficiency				
• Level of details of sufficiency parameters (strong/weak, breakdown, etc)	Fair (but some very agregated)	Fair/Strong	Strong	
• Integration of an SSH approach in the construction of the sufficiency vision (yes/no, other) Integration of lifestyles as elements of the trajectory	Yes Main drivers of change in narrative: Increase of quality of life, Urbanisation, Novel Energy Services, Information innovation, End-user roles Other elements: Rapid transformation, Use value from services, Granularity, Decentralised serfice provision, Digitalisation of daily life, Rapid transformation	Yes	No	Yes
• Coupling of sufficiency levers with policy proposals and measures (yes/no, other)	Yes	Yes	No	Yes ?
• Sectors in which SSH and Policy & Measures are considered and level of detail (strong/weak, breakdown, etc)	All	All		All

• Transparency and details of the scenario narratives, values, principles, and vision underpinning the sufficiency assumptions	UN SDGs Main drivers of change in narrative: Increase of quality of life, Urbanisation, Novel Energy Services, Information innovation, End-user roles	UN SDGs, Cooperation, Care, Solidarity, Sustainability, Democracy	Sustainability, Respect of planetary boundaries ("demand-side solutions are an essential part of staying within planetary boundaries")	UN SDGs, Co-opération (not specifically underpinning sufficiency assumptions)
• Specific quantification of the energy saving potentials from sufficiency levers by sectors (yes/no, approach, quantified potential by sector on the energy demand, GHG emissions or other)	Yes	No (but should be possible with the online open model)		Yes "Cities are important to the behavioural changes in the NZE. Urban design can reduce the average city dweller's carbon footprint by up to 60% by shaping lifestyle choices and influencing day-to-day behaviour." "In countries with low rates of car ownership or energy service demand in buildings, many of the behavioural changes in advanced economies in NZE would not be relevant or appropriate. As a result, around half of the emissions savings from behavioural changes are in emerging market and developing economies, despite around 95% of activity growth in buildings and road transport between 2020 and 2050 occurring there." Total: 8% of CO2 savings CO2 and energy saving per sector in Figure 2.15 p69 (and global in Figures 4.16 and 4.22) Buildings: Avoided residential energy demand from behaviour: -12% by 2030 and -14% by 2050 (heating and cooling)
• **Main sufficiency levers** (per sector, specific quantification, identification of those with greater impact, other)	Transport: overall reduction of distance travelled, reduction of distances travelled by car, car sharing, change in the modal split, reduction of plane transport, reduction of ground freight (volume and distances) Buildings: reduction of the living space per person in the Global North when higher than 30m2/cap and incrase in the Global South (+32%)(common target 30m2/cap), reduction of appliances per person (-14% in the Global North and -2% in the Global South compared to GEA Efficiency scenario taken as reference) Diet: stabilisation of meat consumption in the Global North despite incrase of GDP/cap and increase in the Global South, decrease of ruminant meat consumption in the Global North and in the Global South Industry: Stabilisation of consumer goods in the GN and increase in the GS inducing a reduction of industry production (commodities, etc), increase of products lifetime and share of recycled components	Transport: overall reduction of distance travelled, increase of car occupancy, change in the modal split, reduction of plane transport, reduction of ground freight Housing: reduction of the living space per person (reaching 30m2/cap), reduction of appliances per person Food: reduction of food, and specially meat, consumption Industry: Longer life span of products	In general : High-quality, low-energy housing, widespread public transport, and diets low in animal-based foods Buildings: Decease of the average household floor area (15m2/cap in 2050 as in Rao et al and compared to 30m2/cap in Grubler et al), increase of the number of persons per household (4 persons), decrease of water heating temperature (50°C instead of 65°C currently), decrease of water consumption (50L/cap/day) Transports: Lower mobility levers (4.900 to 15.000 pkm/cap compared to 10.000 pkm/cap in Rao et al and 9.544 to 17177 pkm/cap in Grubler et al), modal shift to soft (4kpm/cap/day) and public transport (strong role of train and bus), 1000km/cap/year of air Diet: 7% of animal-based and 93% of plant-based instead of 13% and 87% of the "omnivore recommended diet" (energy basis) includong a significant reduction of red meat consumption compared to the "omnivore recommended iet but also to World 2005 average Industry: increase of products lifetime (5 years cellphone, 10 years for a laptop)	Transport: reduction of car's speed (eco-driving, etc), modal shift from air to rail for regional trips, limitation of businees and leisure air travel Buildings: moderation of space heating and cooling, reduce of excessive hot-water Industry: Circular economy via an increase of collection rates, reduction of cars weight

• **Main sufficiency drivers and/or policies** (per sector, per type - infrastructures-related, social, political, etc -)	Buildings: New construction multi-family dwellings in the Global South (p21/122), higher urbanisation in the Global North (from single-family homes in low density suburbs to multi-family dwellings in denser urban core areas), sharing appliances in the Global North (p32/122) Transport (p44/122): Higher degree of urbanisation reducing motorised and individual modes demand in cities to save time, inbconvenience and exposure to pollution, cycling and walking infrastructures, developement of virtual reality (personal + profesional) enables a reduction of long-distances mobility, development of a flexible and user-responsive public transports, developement of sharing economies and dematerialisation (reduce of freight), development of distrubuted manufactures (reduce freight distances) social driver: consideration of mobility as a service integration public transport (pay-per-use services) Industry: quality culture (vs quantity), digitalisation, service provision culture (less packaging)	Transport: Ground mobility (p38): ST: improvements of cycling infrastructure, cheaper public transport, more pedestrian zones, disincentives for car ownership and travel such as fewer and more costly parking spaces, increased taxation of ownership and fuel, access restriction and road pricing. MT: expansion of public transport systems, subsidies for local businesses, subsidisation of car-sharing services, introduction of co-working spaces in rural areas, synchronisation of day structures in rural areas to improve occupancies, curtailing of car production, car-free cities and village centres. LT: changes in city and settlement structures, conversion of the car industry Air mobility (p43): bans on short-distance flights, education on the environmental impact of flying, reduction of working hours/increase in holidays - so that more time can be spent on trains and buses, increasing ticket prices through taxation, levies and abolishing subsidies in the aviation sector, increasing attractiveness of long-range train and bus rides by reducing prices, increasing comfort, reliability and interconnectedness including (re)opening of night trains and a better coordination of international train schedules and booking systems, introduction of quotas for flights per person, moratoria on new infrastructure and scaling down of airports stricter environment and health policies in relation to noise and air pollution (e.g., implementation of the WHO		"Around three quarters of behavioural changes in the NZE can be directly influenced or mandated by government policies.[...]Behavioural changes made by citizens and companies play a roughly equal role in reducing emissions in the NZE" Examples: transport: speed limits of 100km/h introduced, high-speed railways development, companies promoting the use of public transport by employees that commute or encouraging working from home
• **Main sufficiency indicators** (per sector, by level - micro, meso or macro-, by type - equipment, use, etc -)	Transport: pkm/person/year by mode, pkm car/person/year, number of cars/person, tkm/cap Buildings: m2/person for housing and commercial/public, appliances/person Diet: total kCal/cap/day, meat kCal/cap/day, ruminant meat kCal/cap/day Industry: Mt of commodities produced (steel, cement, paper, etc), units of consumer goods	Transport: pkm/person/year, modal share (%) in urabn and rural areas, people/vehicle, flights/person, Gt/km/year Housing: m2/person, appliances/person, Diet: kcal/person/year, kcal meat/person/year, ruminants meat share	Buildings: person/hh, m2/cap, L water/cap/day, ° of water heating temperature Transport: pkm/cap/year, modeal share (%) Diet: kcal/person/year, share of meat (per type) in diet (%), share of plant in diet (%) Industry: products lifetime	