Desafíos de la Transición Energética

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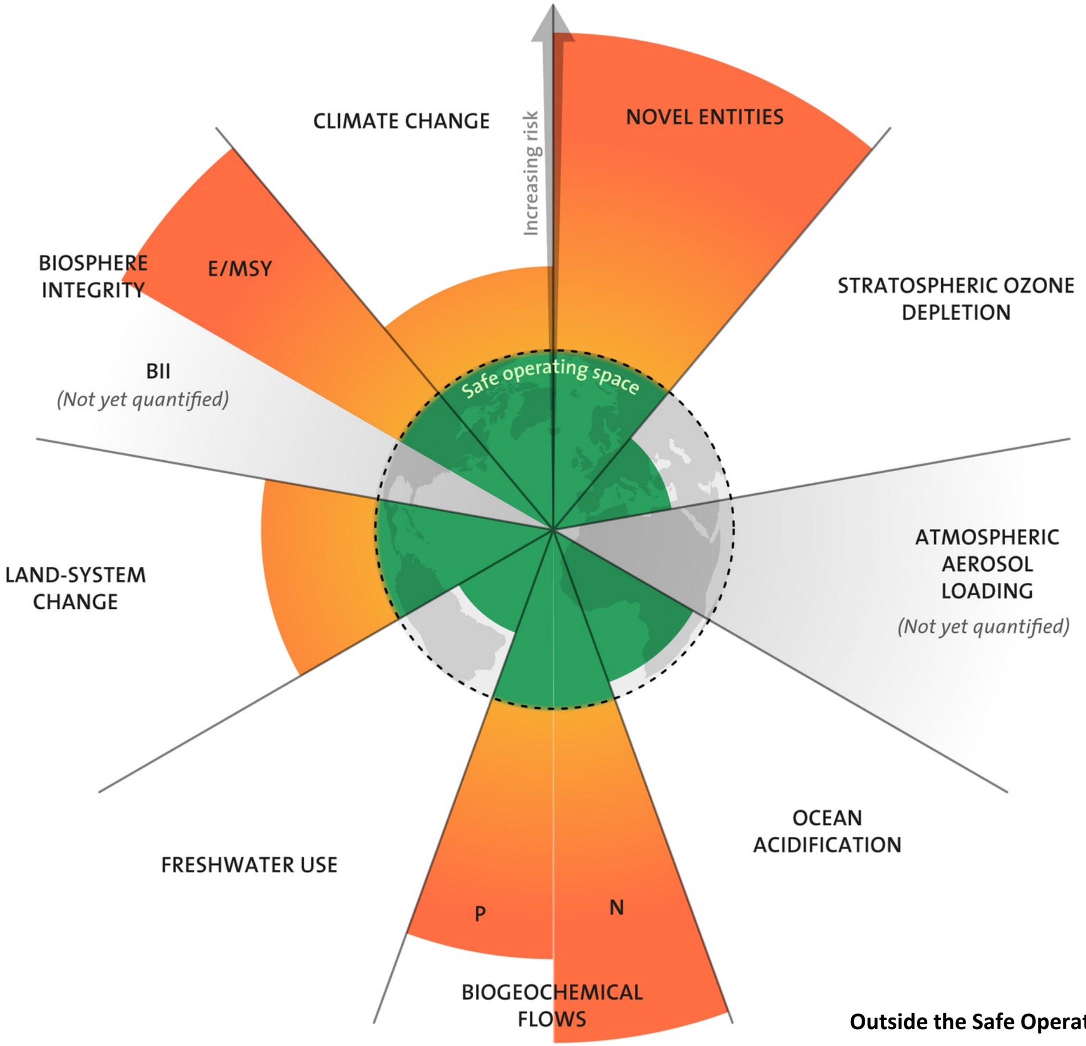
X SEMINARIO DE AUTOMÁTICA
27 AL 30 DE SEPTIEMBRE

194 Años
Universidad del Cauca

¿Cuál es la situación?

Las fronteras planetarias

The planetary boundaries framework represents the boundaries for nine biophysical processes that regulate life support systems and the planet's habitability. They define the space within which humanity can operate safely for generations to come. Today, we have transgressed four of the boundaries.

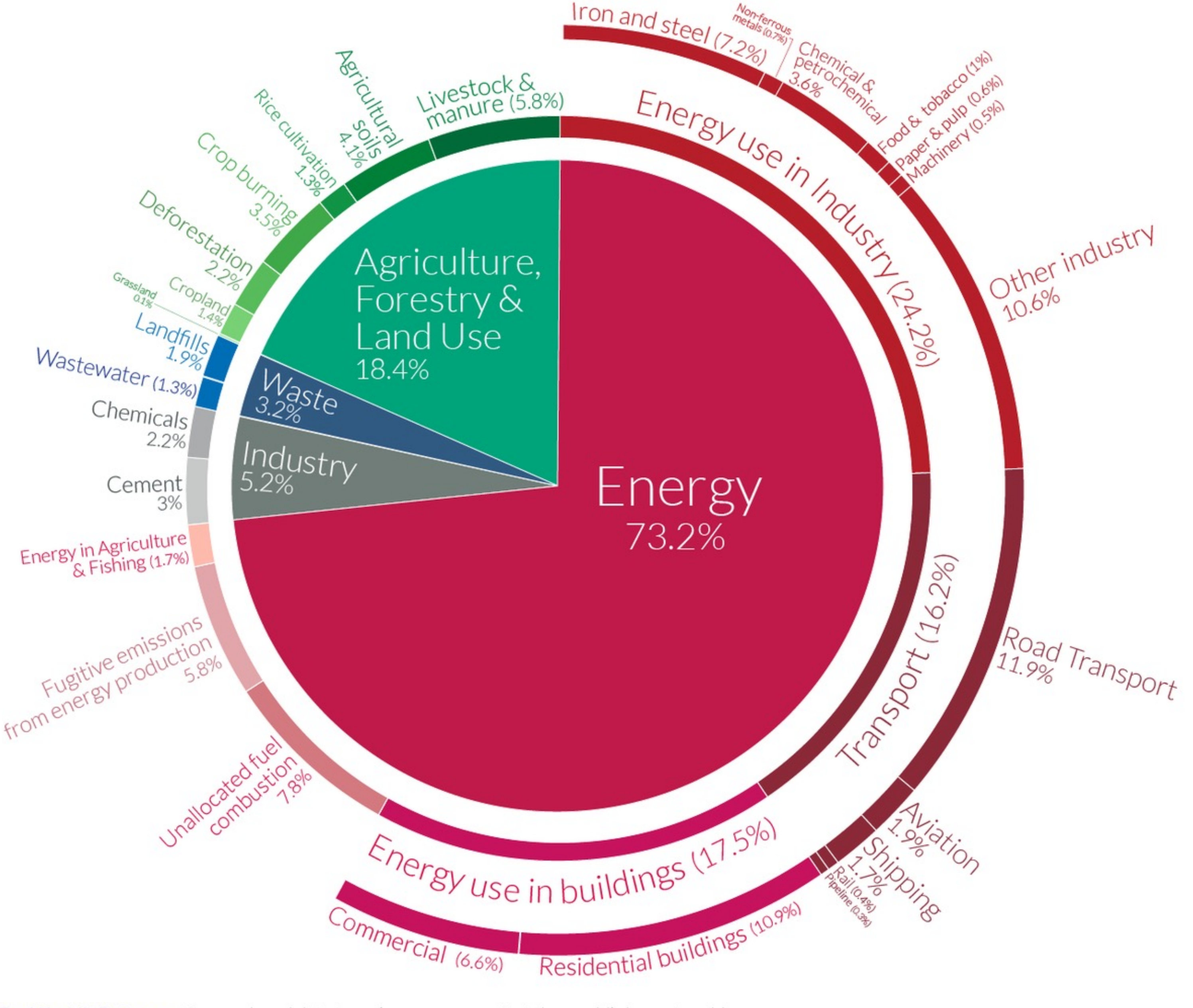


The Planetary boundaries concept defines the safe operating space we should stay within to avoid large-scale and abrupt environmental degradation. It was developed in 2009 by a group of internationally renowned scientists led by Food Planet Prize Jury co-chair **Johan Rockström**. They identified nine biophysical processes that regulate the stability of the planet's climate, habitability, and life support systems.

Outside the Safe Operating Space of the Planetary Boundary for Novel Entities, *Environmental Science & Technology* **2022** *56* (3), 1510-1521

Global greenhouse gas emissions by sector

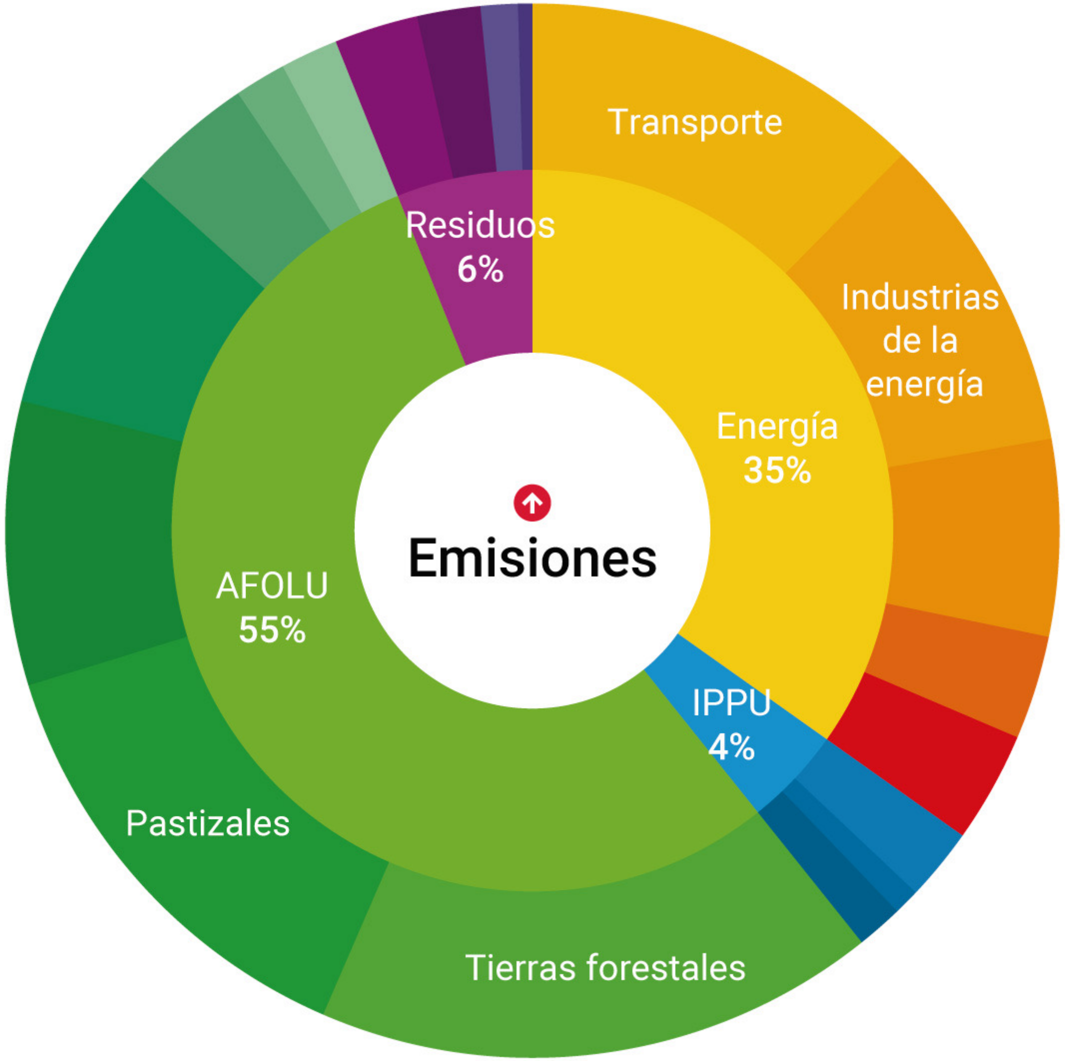
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.



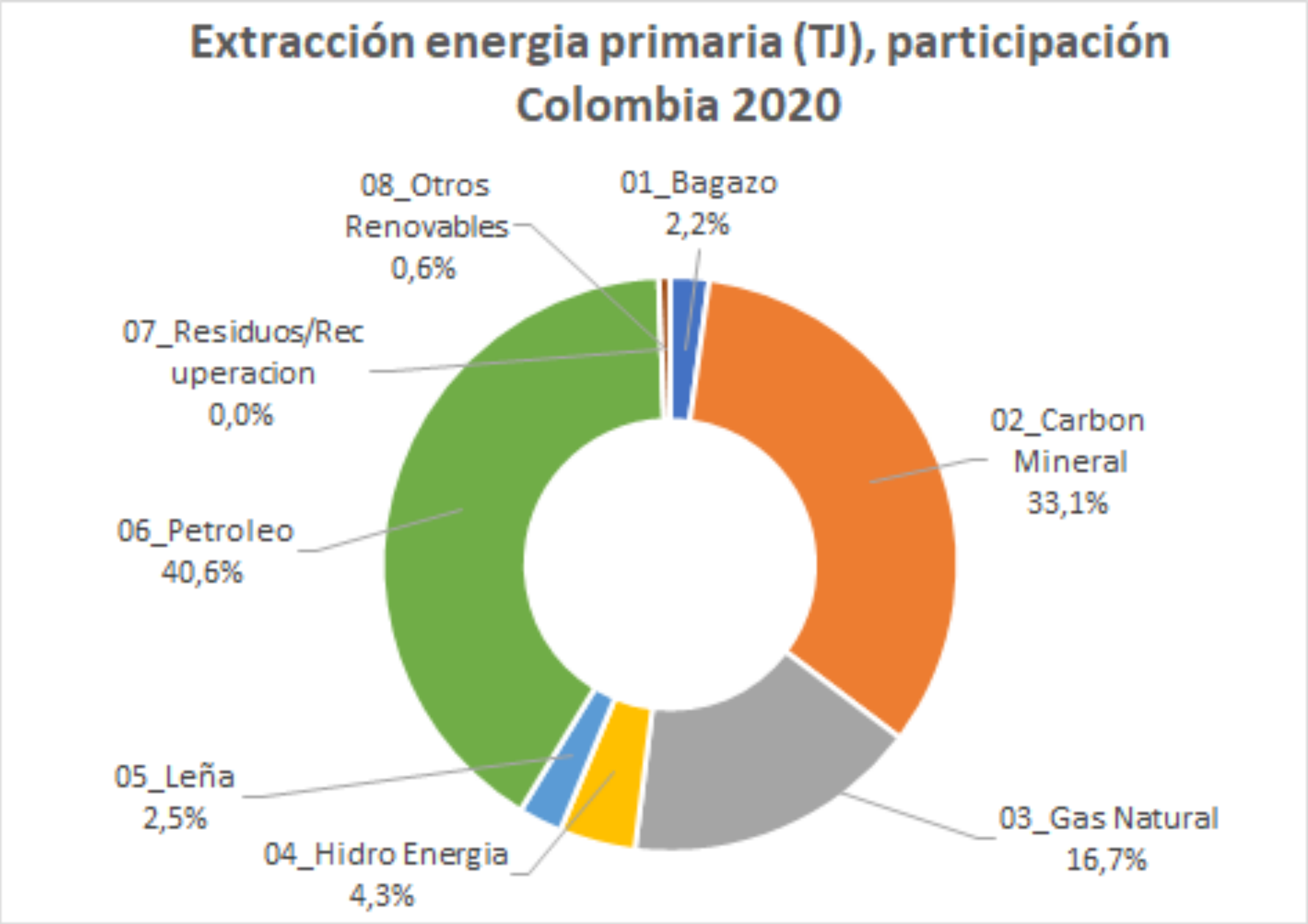
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Climate Watch, the World Resources Institute (2020).

Emisiones en Colombia



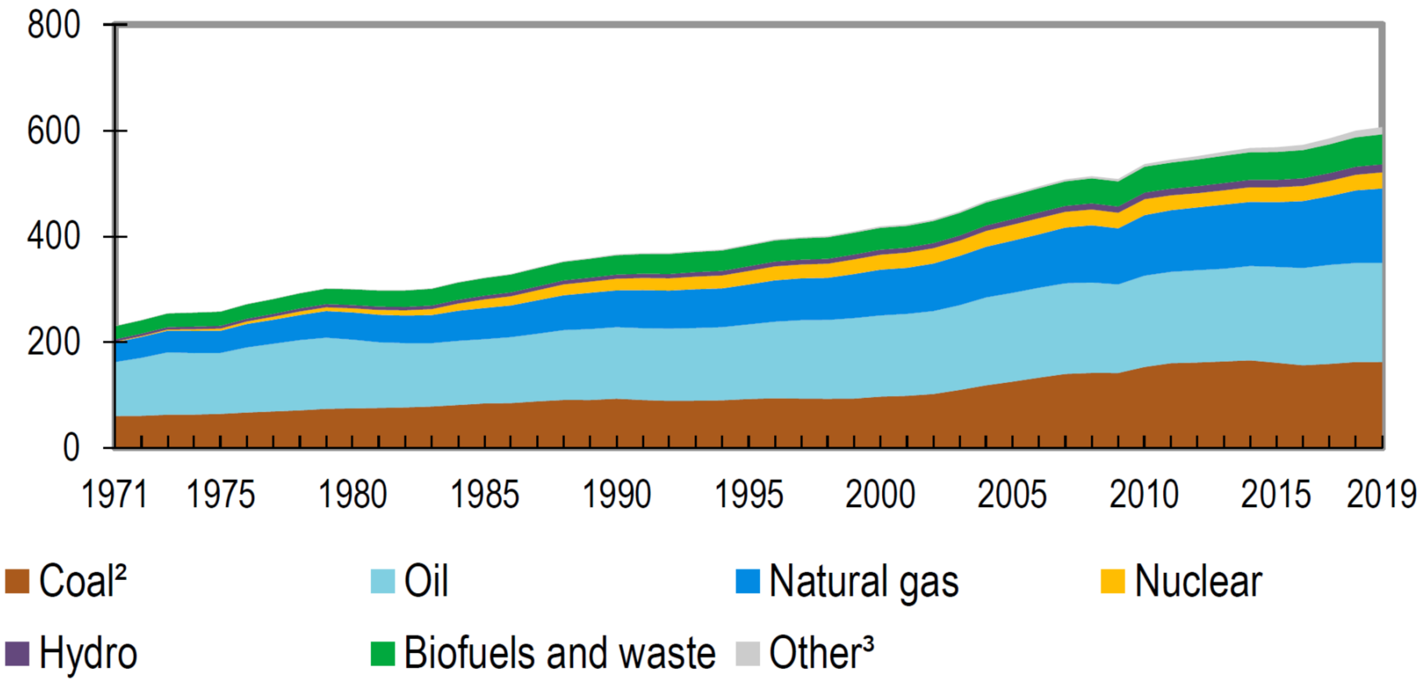
Energía primaria en Colombia



Fuente: Unidad de Planeación Minero-Energética UPME, Colombia

World total energy supply (TES) by source

World[1] total energy supply by source, 1971-2019 (EJ)



Total energy supply (TES)

Total energy supply (TES) is made up of production + imports – exports – international marine bunkers – international aviation bunkers ± stock changes. For the world total, international marine bunkers and international aviation bunkers are not subtracted from TES.

1. World includes international aviation and international marine bunkers.

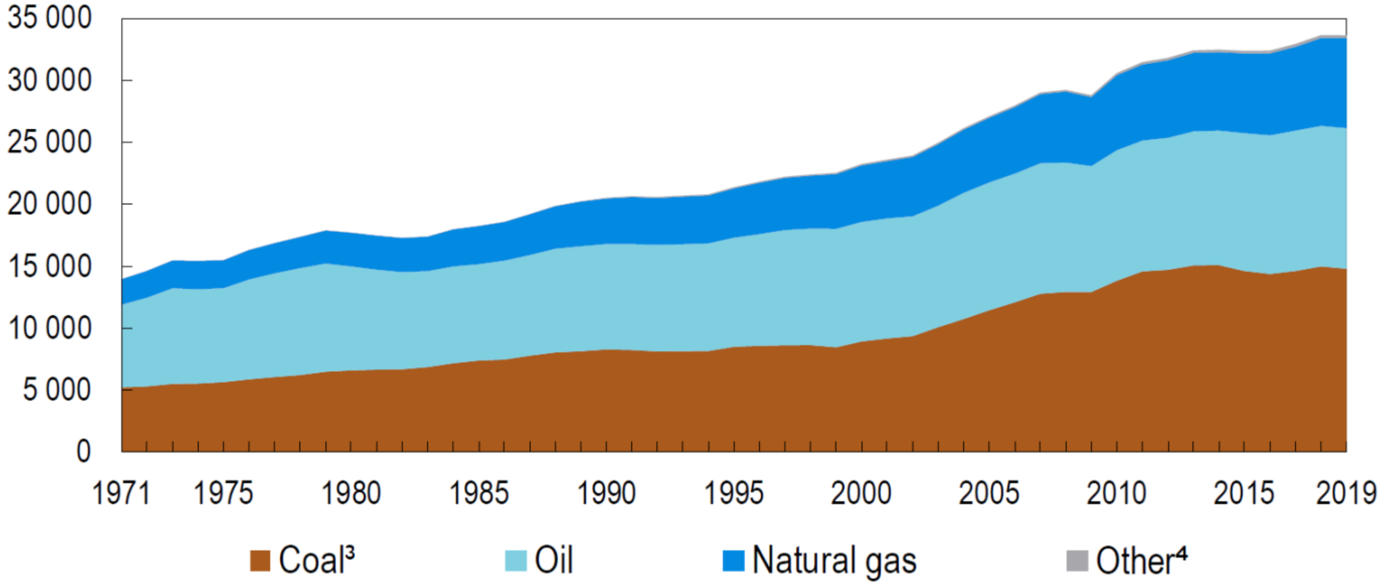
2. In these graphs, peat and oil shale are aggregated with coal.

3. Includes geothermal, solar, wind, tide/wave/ocean, heat and other sources.

Source: IEA, World Energy Balances, 2021.

CO_2 emissions by fuel

World[1] CO_2 emissions from fuel combustion[2] by fuel, 1971-2019 (Mt of CO_2)



Carbon emissions

- Carbon emissions from energy use fell by 6.3%, to their lowest level since 2011. As with primary energy, this was the largest decline since the end of World War II.

Statistical Review of World Energy
2021 | 70th edition

1. World includes international aviation and international marine bunkers.
2. CO_2 emissions from fuel combustion are based on the IEA World energy balances and the 2006 IPCC Guidelines for national greenhouse gas inventories, and exclude emissions from non-energy use. 3. In these graphs, peat and oil shale are aggregated with coal.
4. Includes industrial waste and non-renewable municipal waste.
Source: IEA, CO_2 Emissions from Fuel Combustion, 2021.

¿Cómo vamos?

Si bien es cierto que el tráfico vehicular y aéreo, así como la actividad industrial, se han reducido drásticamente en la mayoría de las partes del mundo desde enero de 2020, este no es el caso con nuestro suministro de electricidad: el 64% de la combinación global de energía eléctrica proviene de los combustibles fósiles (carbón 38%, gas 23%, petróleo 3%), según el informe Perspectivas de la energía en el mundo 2019 de la Agencia Internacional de Energía. Los sistemas de calefacción han seguido funcionando como antes de la COVID-19. Ninguno de los asuntos clave ha cambiado (como la transición hacia las energías renovables, el transporte público o la deforestación).

Los incendios forestales, que han aumentado en probabilidad y gravedad debido al cambio climático, continúan afectando áreas de Brasil, Honduras, Myanmar, Tailandia y Venezuela, y cada uno de esos fuegos emite grandes cantidades de CO_2 adicionales.

"Sin cambios fundamentales en la producción mundial de energía, no tenemos razones para esperar una reducción duradera de las emisiones", dice el experto en cambio climático del PNUMA Niklas Hagelberg.

Monday, June 7, 2021

Carbon dioxide peaks near 420 parts per million at Mauna Loa observatory

Atmospheric carbon dioxide measured at NOAA's Mauna Loa Atmospheric Baseline Observatory peaked for 2021 in May at a monthly average of 419 parts per million (ppm), the highest level since accurate measurements began 63 years ago, scientists from NOAA and Scripps Institution of Oceanography at the University of California San Diego announced today.

Scripps' scientist Charles David Keeling initiated on-site measurements of carbon dioxide, or CO_2, at NOAA's weather station on Mauna Loa in 1958. NOAA began measurements in 1974, and the two research institutions have made complementary, independent observations ever since.

Forbes

SCIENCE

Carbon Dioxide Peaked In 2022 At Levels Not Seen For Millions Of Years

David Bressan Contributor
I deal with the rocky road to our modern understanding of earth

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Jun 5, 2022, 07:44am EDT

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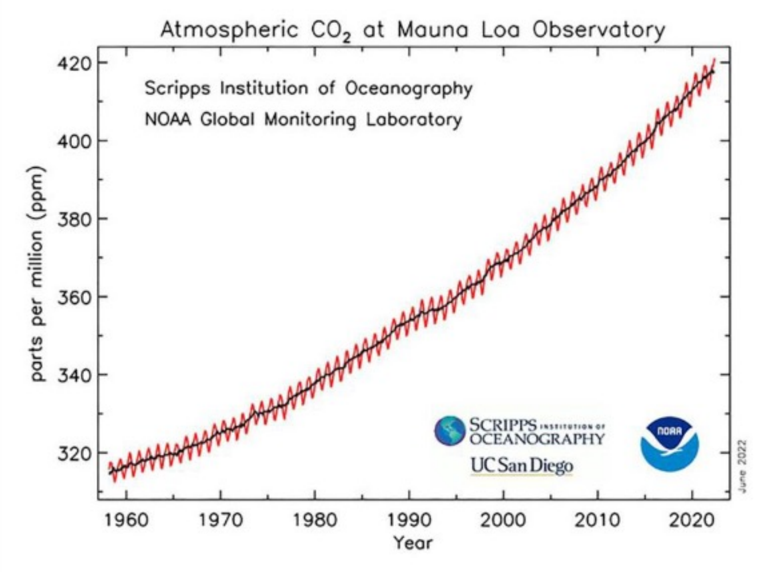
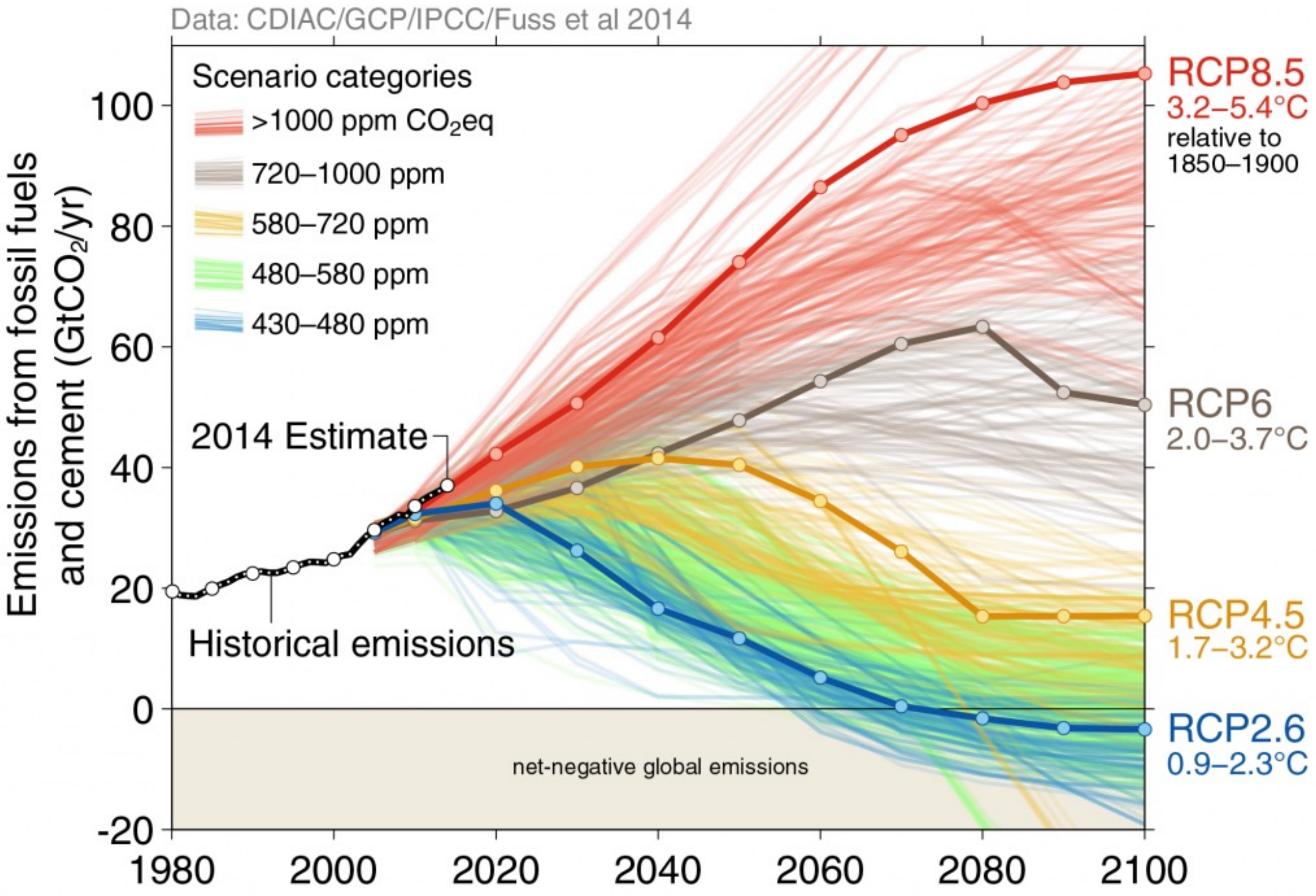


Carbon dioxide measured at NOAA's Mauna Loa Atmospheric Baseline Observatory peaked for 2022 at 421 ... [+] NOAA

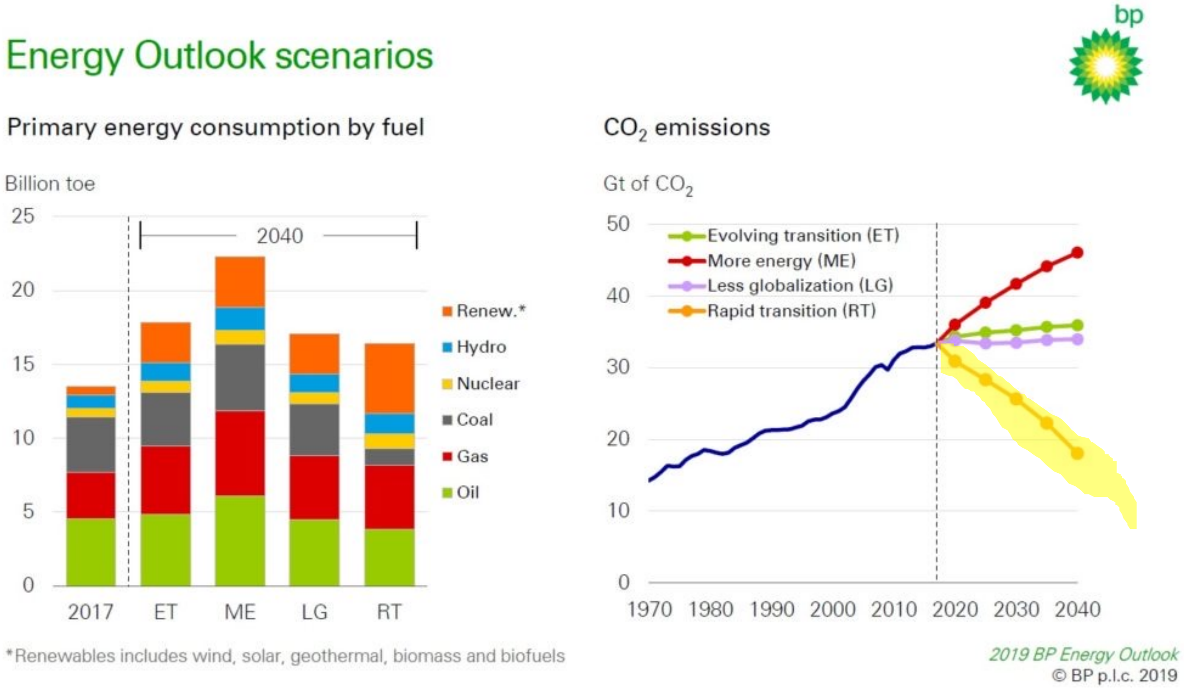
¿Cuáles son los escenarios?

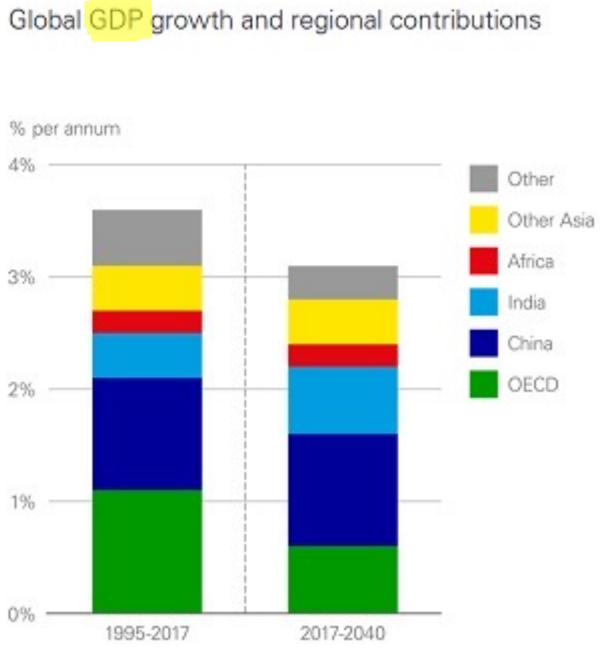
Trayectorias de concentración representativas (RCP)



The RCPs try to capture these future trends. They make predictions of how concentrations of greenhouse gases in the atmosphere will change in future as a result of human activities. The four RCPs range from very high (RCP8.5) through to very low (RCP2.6) future concentrations. The numerical values of the RCPs (2.6, 4.5, 6.0 and 8.5) refer to the concentrations in 2100

BP Energy Outlook 2019



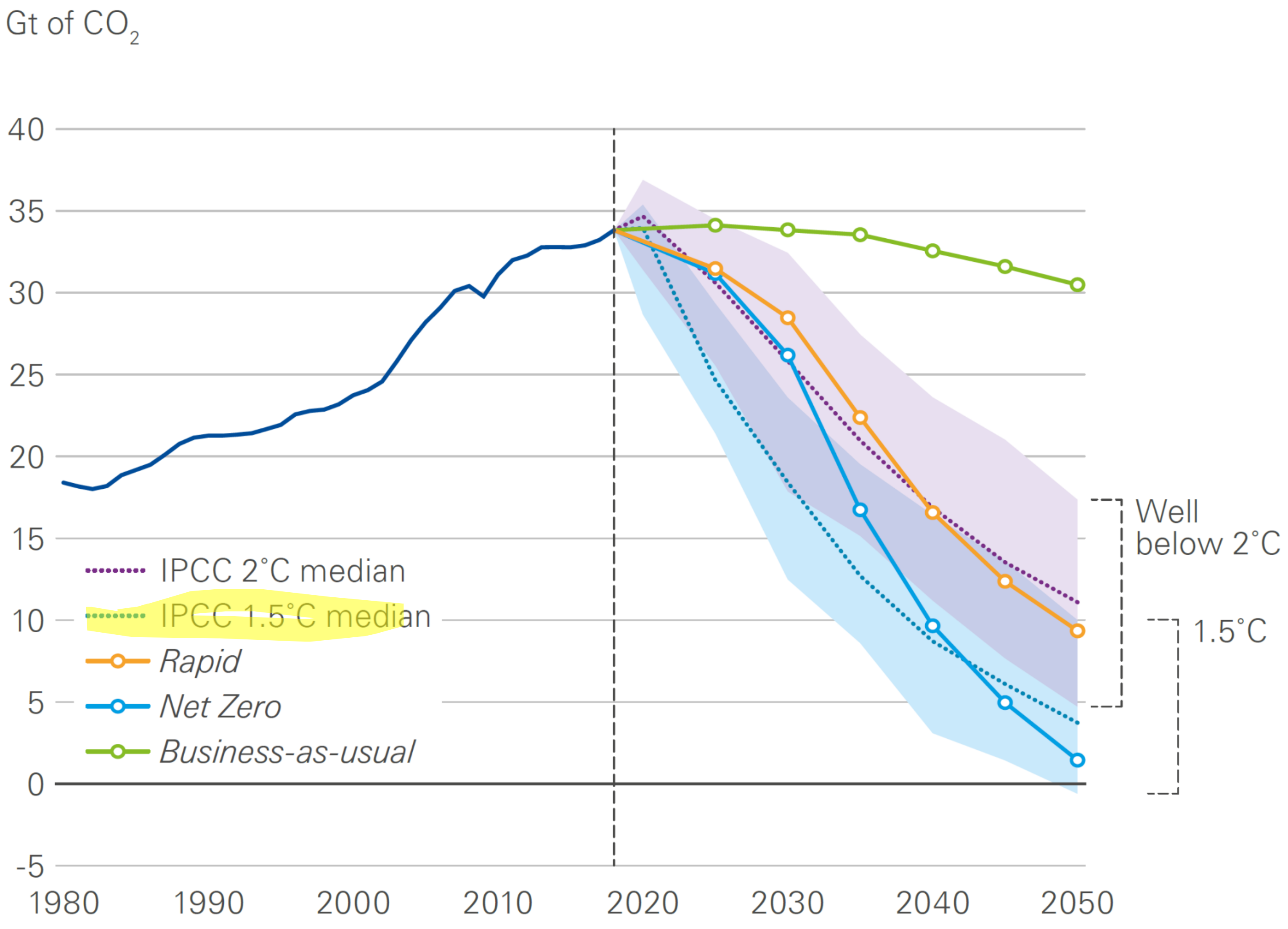


El sistema energético mundial enfrenta un doble desafío, la necesidad de más energía y menos carbón.

El escenario ET no es consistente con el logro de cualquiera de estos desafíos: la demanda de energía aumenta en un tercio, pero dos tercios de La población mundial en 2040 vive en países en los que el consumo promedio de energías que siendo inferior a 100GJ por cabeza; Emisiones de CO2 del uso de la energía continúan hacia arriba, aumentando en casi el 10% para 2040, en lugar de caer sustancialmente.

El escenario de "transición rápida" representa un similar Paso intermedio sobre las emisiones de carbono: reduciendo las emisiones de CO2 en alrededor 45% para 2040, casi a mitad de camino para reducir completamente las emisiones de carbono del uso de energía

Global carbon emissions from energy use



Ranges show 10th and 90th percentiles of IPCC scenarios, see pp 150-151 for more details

- Carbon emissions from energy use in *Rapid* fall by around 70% by 2050 to a little over 9 Gt CO_2. This fall in emissions is broadly in the middle of the range of 'well below 2-degree' scenarios contained in the 2019 IPCC Report. See pages 150-151 for details on the construction of the IPCC scenario ranges.
- In *Net Zero*, carbon emissions fall by over 95% from their 2018 levels to around 1.5 Gt CO_2 by 2050. The initial pace of decline is slower than the range of IPCC 'below 1.5-degree' scenarios, but by the second half the Outlook the emissions pathway in *Net Zero* is close to the middle of the IPCC range.
- The carbon emissions remaining in 2050 in *Net Zero* could be reduced further by either additional changes in the energy system or using negative emissions technologies (NETs). Alternatively, the emissions could be offset by increased deployment of natural climate solutions (NCS) (see pp 130-131). This will partly depend on the costs of NETs and of abating GHGs emitted from outside the energy system, neither of which are explicitly considered in this Outlook.

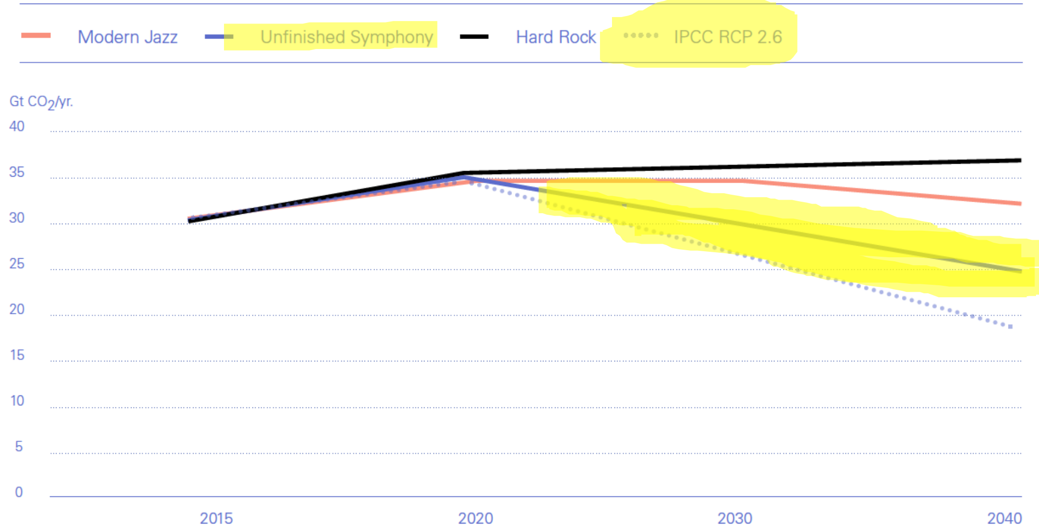
WEC

https://www.worldenergy.org/transition-toolkit/world-energy-scenarios/long-term-world-energy-scenarios

	Modern Jazz	Unfinished Symphony	Hard Rock
Productivity / Economic Growth	▪ GDP 3.3% p.a. (2015–2060) ▪ Digital boost ▪ Tech innovation ▪ GDP per capita 2060 US$ 30,600	▪ GDP 2.9% p.a. (2015–2060) ▪ Sustainable growth ▪ Circular economies ▪ GDP per capita 2060 US$ 25,200	▪ GDP 1.7% p.a. (2015–2060) ▪ Fragmented markets ▪ Local content ▪ GDP per capita 2060 US$ 14,700

Figure 6 — Global carbon emissions

Source: The World Energy Council, Paul Scherrer Institute, Accenture Strategy



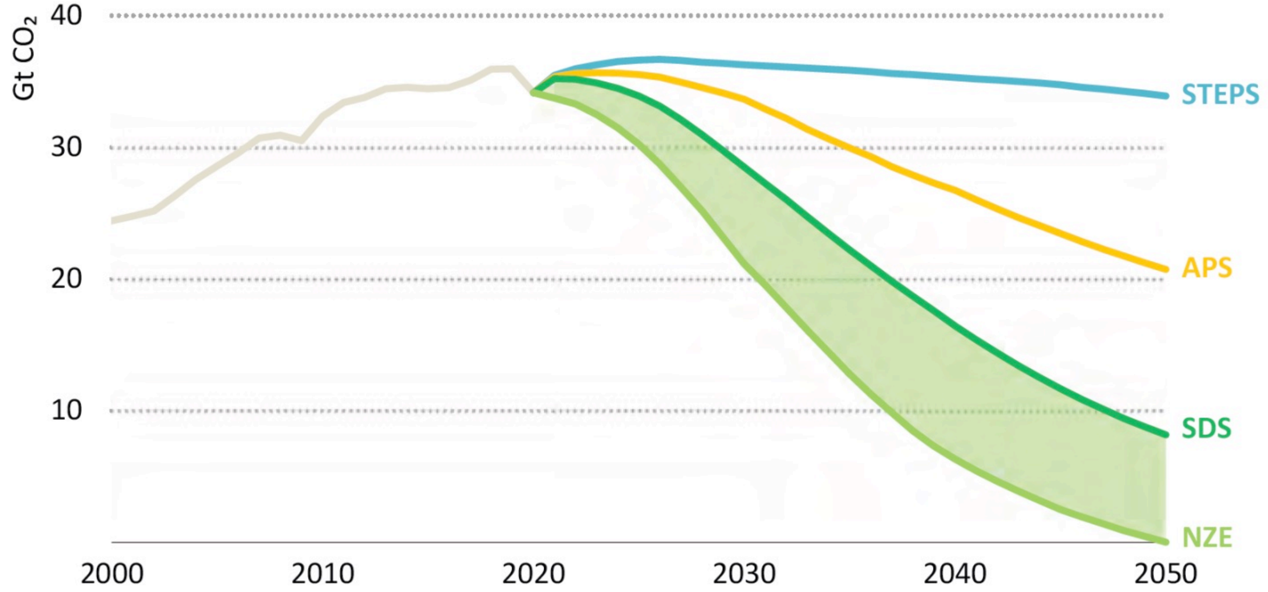
Note: The Council's scenario emissions forecasts do not include emissions from non-energy industrial uses and from land-use. The IPCC RCP 2.6 scenario presented represents the median of the IPCC AR5 data from within the 2.6 CO_2 equivalent band (430-480ppm).

According to the IPCC, RCP 2.6 requires that carbon dioxide (CO2) emissions start declining by 2020 and go to zero by 2100. It also requires that methane emissions (CH4) go to approximately half the CH4 levels of 2020, and that sulphur dioxide (SO2) emissions decline to approximately 10% of those of 1980-1990. RCP 2.6 requires negative CO2 emissions (such as CO2 absorption by trees). RCP 2.6 is likely to keep global temperature rise below 2 degrees C by 2100

WORLD ENERGY SCENARIOS | 2019: EXPLORING INNOVATION PATHWAYS TO 2040

World Energy Outlook

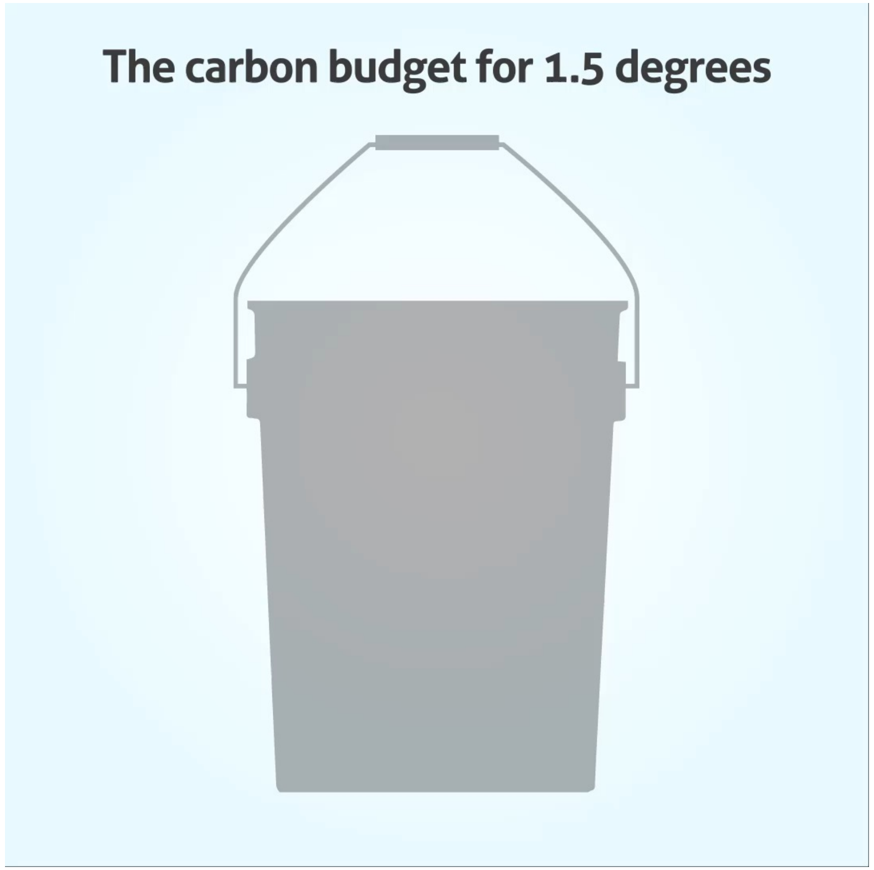
Figure 1.4 ▷ CO_2 emissions in the ***WEO-2021*** scenarios over time



The APS pushes emissions down, but not until after 2030; the SDS goes further and faster to be aligned with the Paris Agreement; the NZE delivers net zero emissions by 2050

Note: APS = Announced Pledges Scenario; SDS = Sustainable Development Scenario; NZE = Net Zero Emissions by 2050 Scenario.

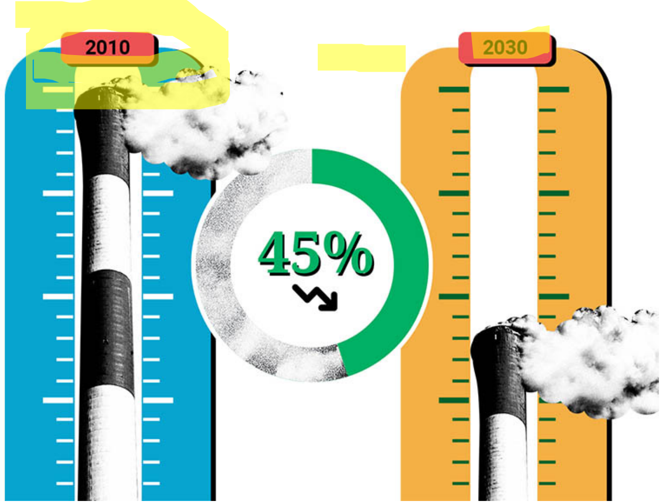
Carbon budget



Naciones Unidas | Acción por el Clima

¿Estamos en la senda correcta para alcanzar el cero neto en 2050?

No, los compromisos adquiridos por los gobiernos hasta la fecha se han quedado cortos para lo que es necesario. Los planes nacionales por el clima actuales, y para el total de las 193 partes adheridas al Acuerdo de París, nos llevarían a un aumento considerable de casi el 14 % en las emisiones globales de gases de efecto invernadero EN para 2030, en comparación con los niveles de 2010. Lograr el cero neto hace necesario que los gobiernos, en primer lugar, los mayores emisores, refuercen significativamente sus contribuciones determinadas a nivel nacional (CDN) y que emprendan fases enérgicas e inmediatas para la reducción de las emisiones actuales. El Pacto de Glasgow por el Clima EN hizo un llamamiento a todos los países para que revisaran y reforzaran los objetivos de 2030 dentro de sus CDN y para finales de 2022, a fin de alinearse con el objetivo de temperatura del Acuerdo de París.



¿Cómo responder ante los desafíos de la transformación del mundo de la energía?

Transición energética

Definiciones

International Renewable Energy Agency

The energy transition is a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. At its heart is the need to reduce energy-related CO_2 emissions to limit climate change. Decarbonisation of the energy sector requires urgent action on a global scale, and while a global energy transition is underway, further action is needed to reduce carbon emissions and mitigate the effects of climate change. Renewable energy and energy efficiency measures can potentially achieve 90% of the required carbon reductions.

The energy transition will be enabled by information technology, smart technology, policy frameworks and market instruments.

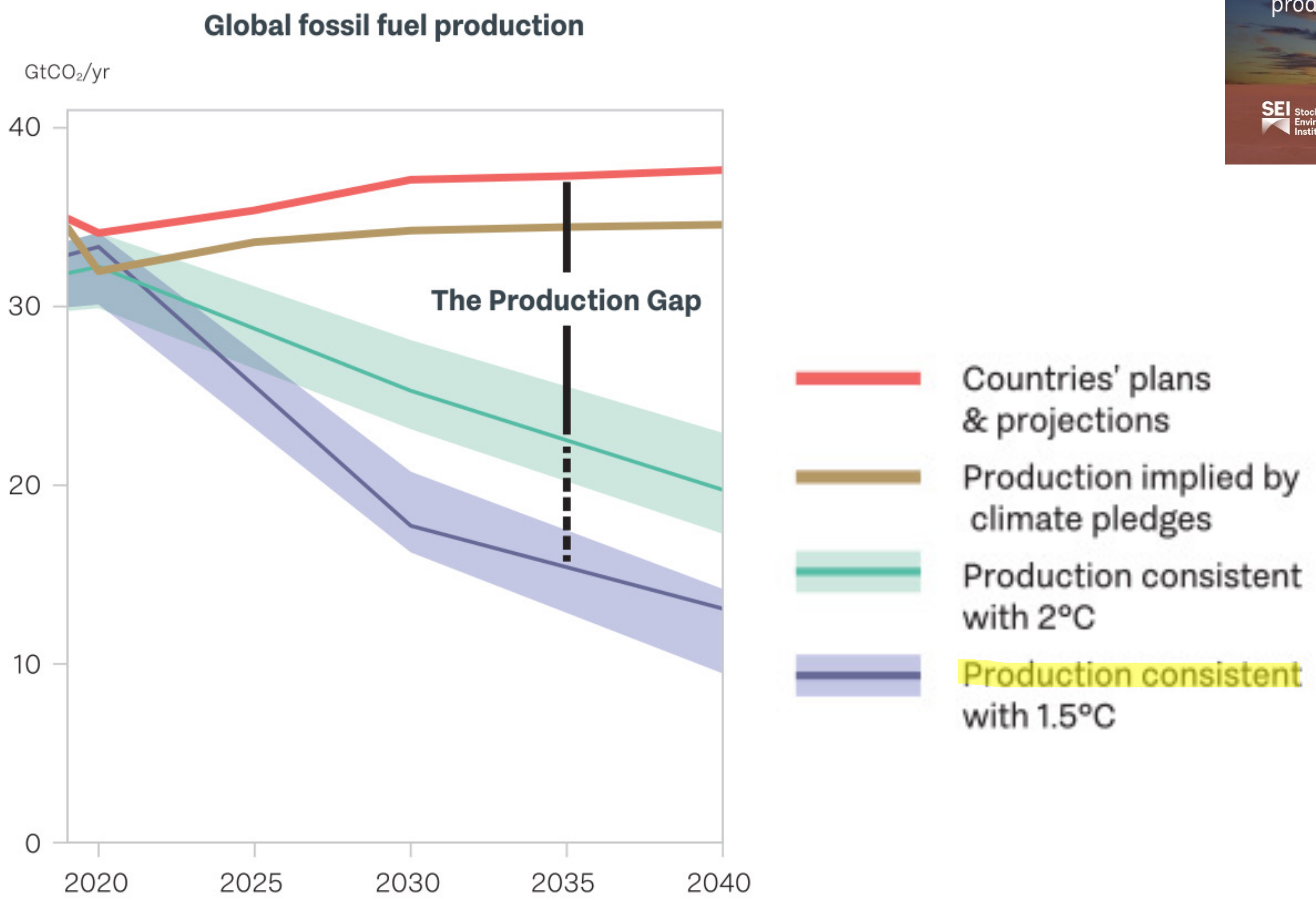
Definiciones

Green Power

In December 2015, at COP 21 in Paris, an international agreement was signed that set the target of limiting global warming by the end of this century to below 2 degrees compared with pre-industrial levels and preferably limiting it to 1.5 degrees.

In order to achieve this goal, our main tool is the energy **transition**, i.e., the shift from an energy mix based on fossil fuels to one that produces very limited, if not zero, carbon emissions, based on renewable energy sources.

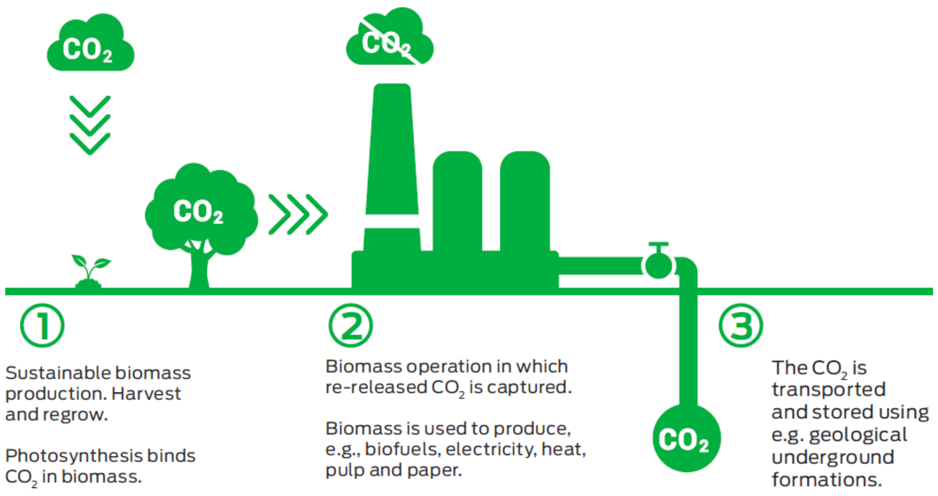
Production Gap



Asunciones para estos escenarios (Hickel & Kallis, 2019):

- AR5 warns, however, that these scenarios ‘typically involve temporary overshoot of atmospheric concentrations’ and ‘**typically rely on the availability and widespread deployment of bioenergy with carbon capture and storage** (BECCS)’ (2014, p. 23)
- BECCS is highly controversial among climate scientists. It was first proposed by Obersteiner et al. (2001) and Keith (2001) at the turn of the century. IPCC modelling teams began including it in their scenarios from 2005, **despite having no firm evidence of its feasibility**. With the publication of AR5, BECCS was enshrined as a dominant assumption

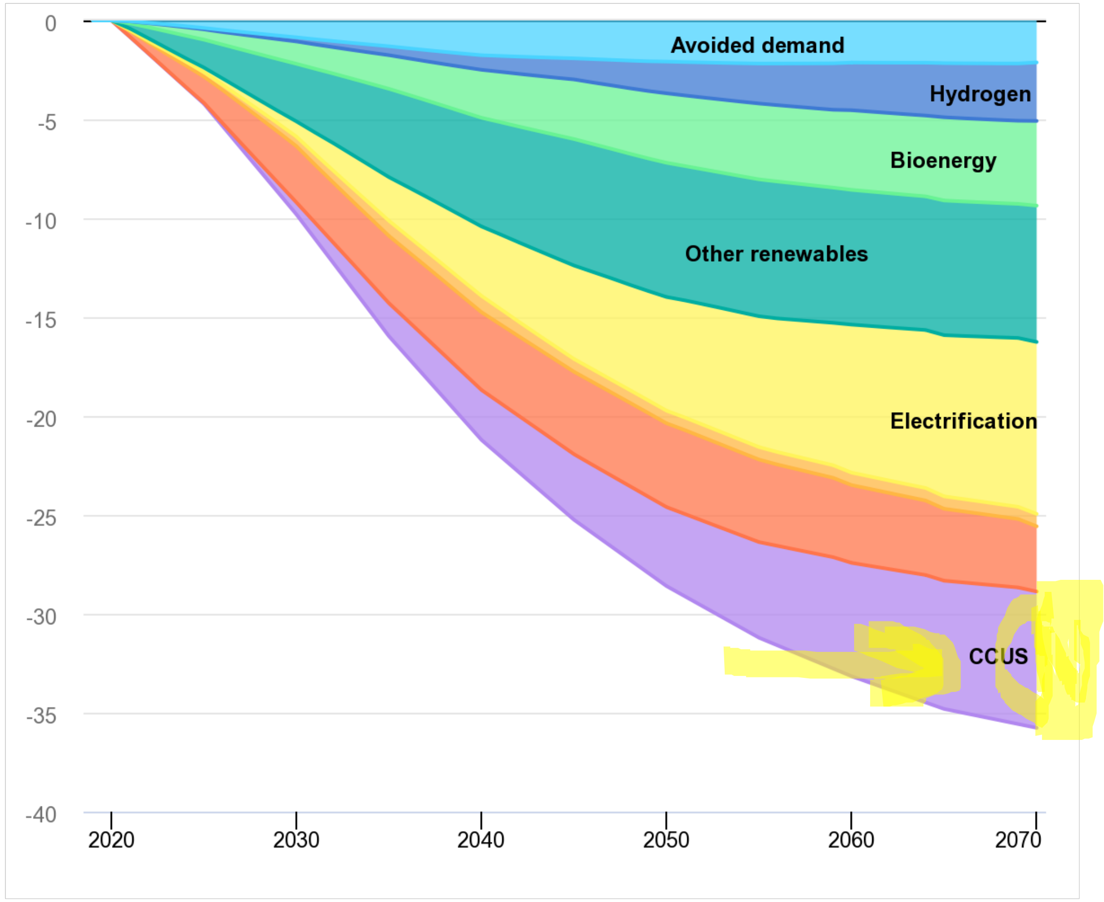
Figure 1-1 | Principle of bioenergy with carbon capture and storage (BECCS).



IEA

https://www.un.org/en/climatechange/net-zero-coalition

An energy sector transition to net-zero CO_2 emissions by 2070 of the kind depicted in the Sustainable Development Scenario requires a radical technological transformation of the energy sector. Energy efficiency and renewables are central pillars, but additional technologies are needed to achieve net-zero emissions. Four technology value chains contribute about half of the cumulative CO_2 savings: technologies to widely electrify end-use sectors (such as advanced batteries); carbon capture, utilisation and storage (CCUS); hydrogen and hydrogen-related fuels; and bioenergy.



nature energy

ARTICLES

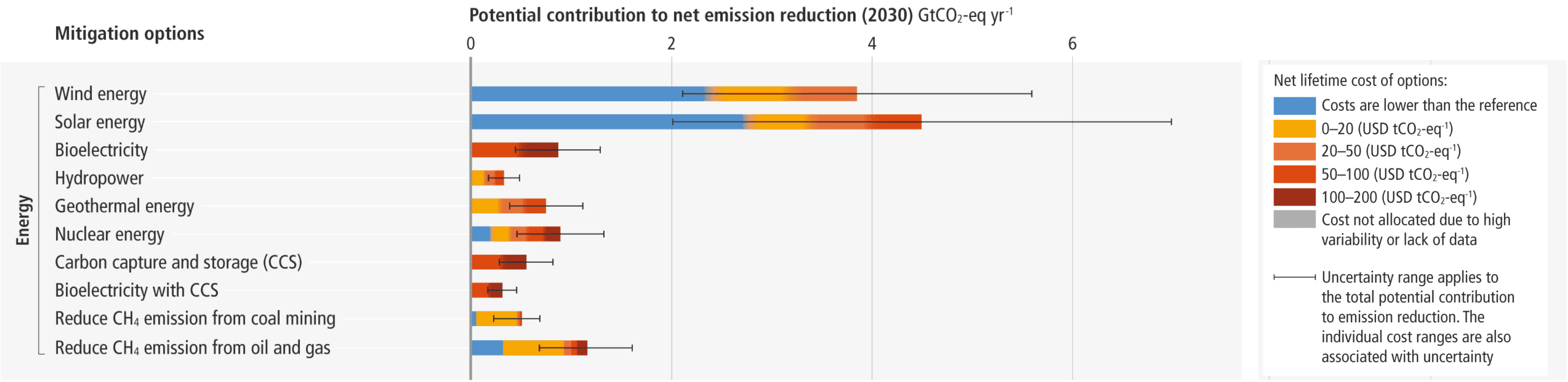
https://doi.org/10.1038/s41560-019-0365-7

Comparative net energy analysis of renewable electricity and carbon capture and storage

Sgouris Sgouridis[1*], Michael Carbajales-Dale[2], Denes Csala[3], Matteo Chiesa[1,4] and Ugo Bardi[5]

Carbon capture and storage (CCS) for fossil-fuel power plants is perceived as a critical technology for climate mitigation. Nevertheless, limited installed capacity to date raises concerns about the ability of CCS to scale sufficiently. Conversely, scalable renewable electricity installations—solar and wind—are already deployed at scale and have demonstrated a rapid expansion potential. Here we show that power-sector CO_2 emission reductions accomplished by investing in renewable technologies generally provide a better energetic return than CCS. We estimate the electrical energy return on energy invested ratio of CCS projects, accounting for their operational and infrastructural energy penalties, to range between 6.6:1 and 21.3:1 for 90% capture ratio and 85% capacity factor. These values compare unfavourably with dispatchable scalable renewable electricity with storage, which ranges from 9:1 to 30+:1 under realistic configurations. Therefore, renewables plus storage provide a more energetically effective approach to climate mitigation than constructing CCS fossil-fuel power stations.

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.

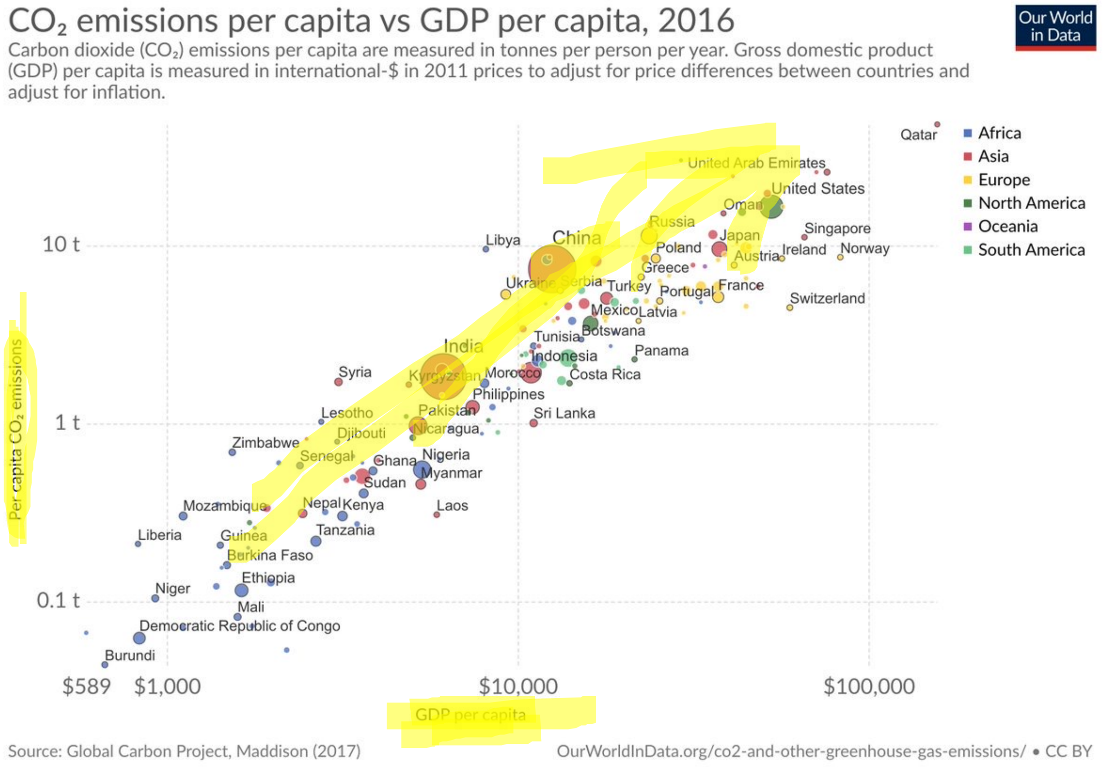


¿Qué retos existen?

> **Green Growth**: the fostering of economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies.
>
> **- Organization for Economic Co-operation and Development**

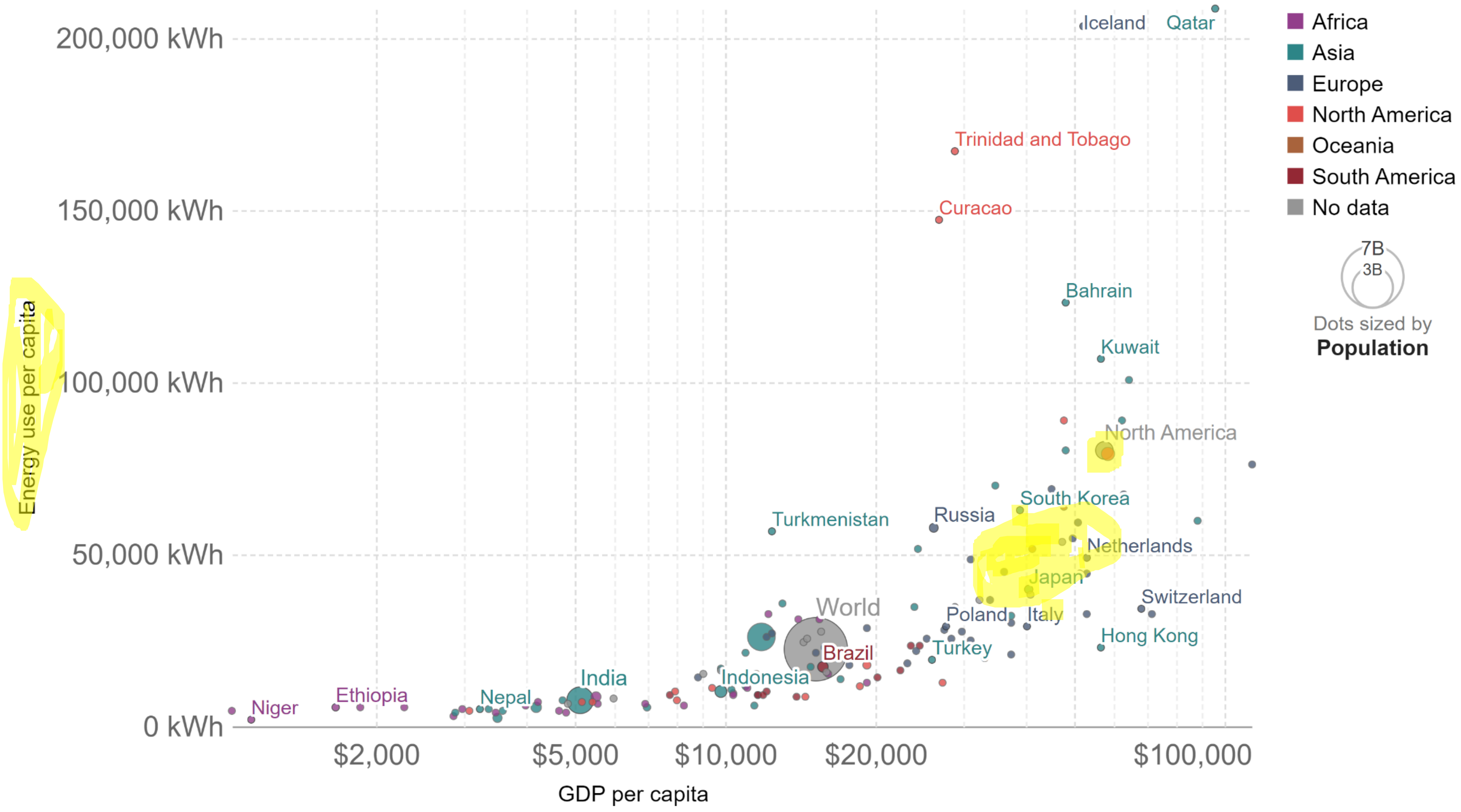
Preocupación: El PBI

- Se calcula con base en las cuentas nacionales… es simple
  - Sumar ingresos de agentes económicos: salarios, ingresos de capital, financieros, rendimientos, etc.
  - Sumar todos los gastos de agentes: Consumo, inversiones, gasto público, etc.
- No mide actividades no monetarizadas, no es un buen medidor de prosperidad o bienestar.
- No mide desigualdad, PIB es un indicador de flujo y no de stock (capital natural), excluye externalidades ecológias
- Desconoce la pérdida de recursos finitos, biodiversidad, cambio climático
- No mide adecuadamente desarrollo cualitativo y necesidades humanas



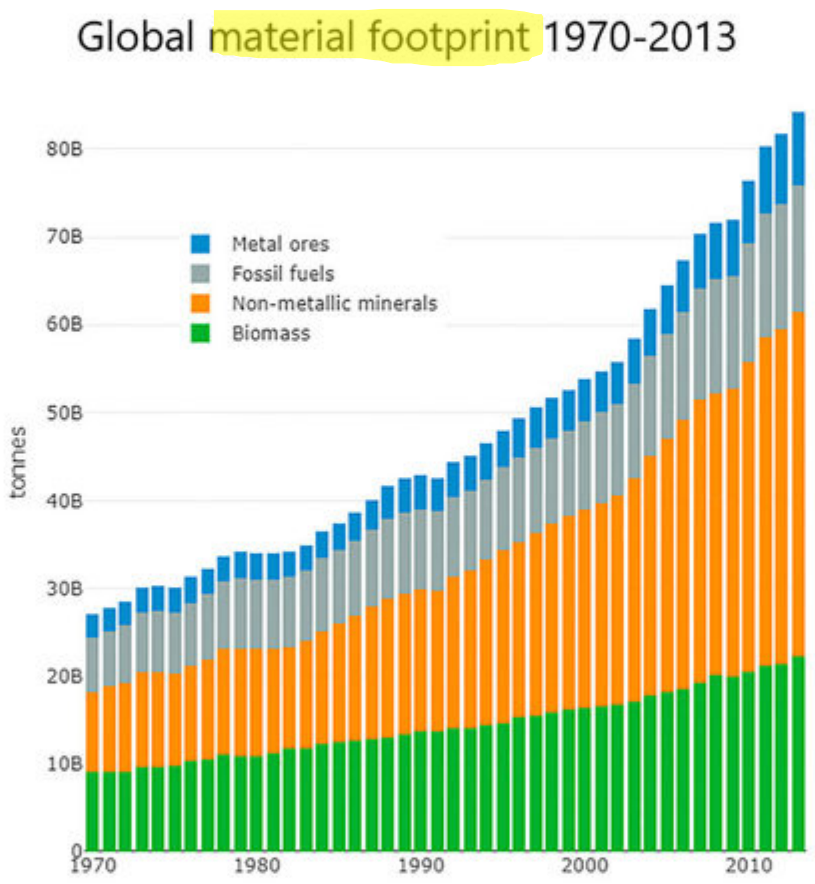
GDP per capita vs. energy use, 2015

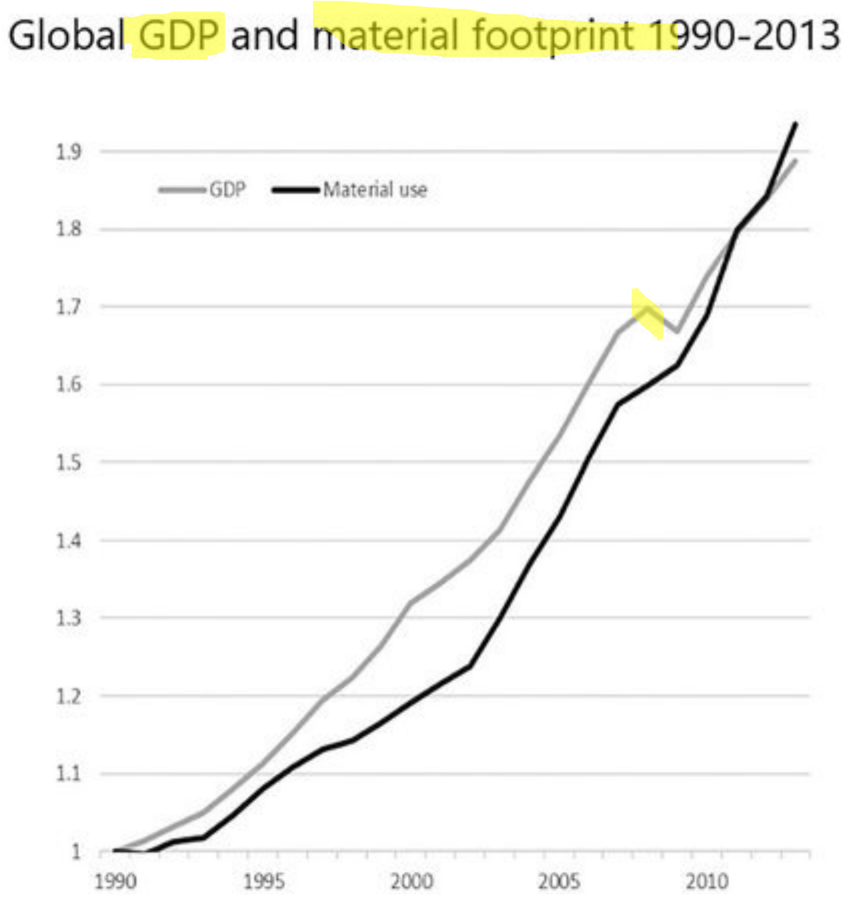
Annual energy use per capita, measured in kilowatt-hours per person vs. gross domestic product (GDP) per capita, measured as constant international-$.



Source: Data compiled from multiple sources by World Bank

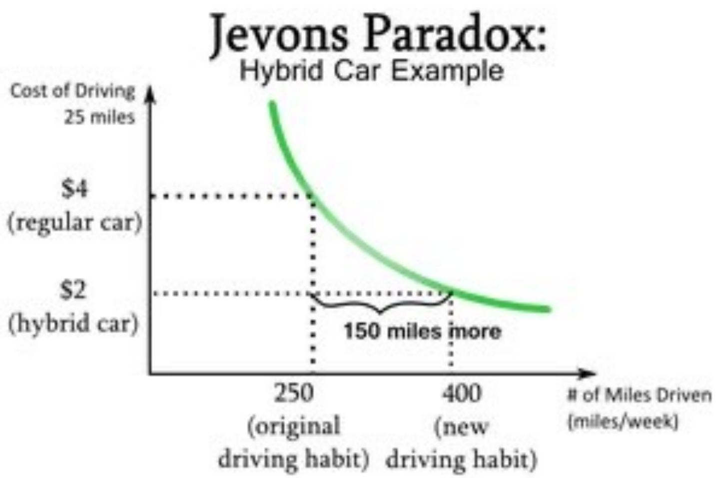
El crecimiento verde y su (in)compatibilidad con los límites del planeta

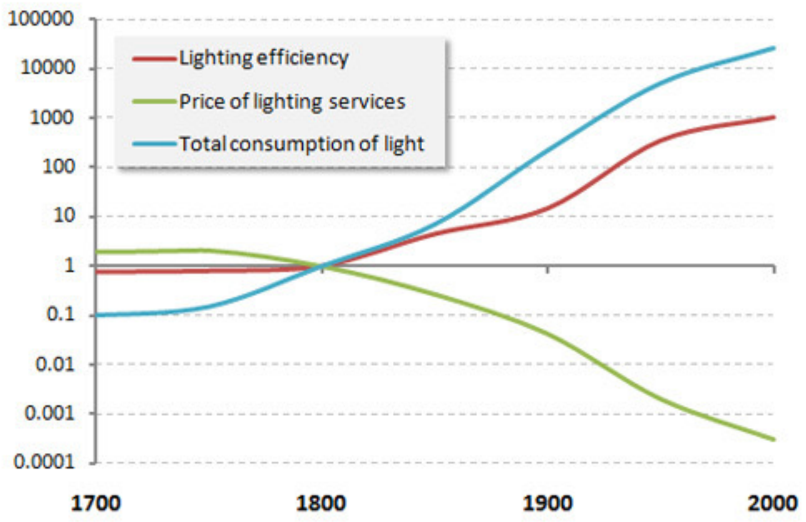


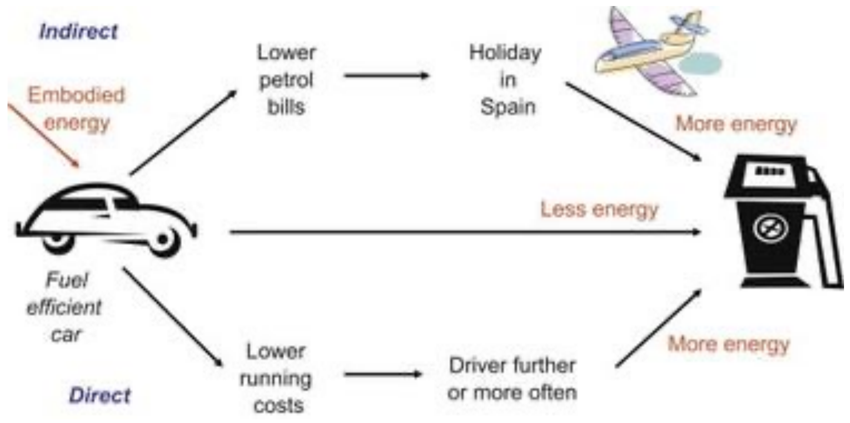


Preocupación: Eficiencia y Paradoja de Jevons

an increase in efficiency in using a resource leads to increased use of that resource rather than to a reduction





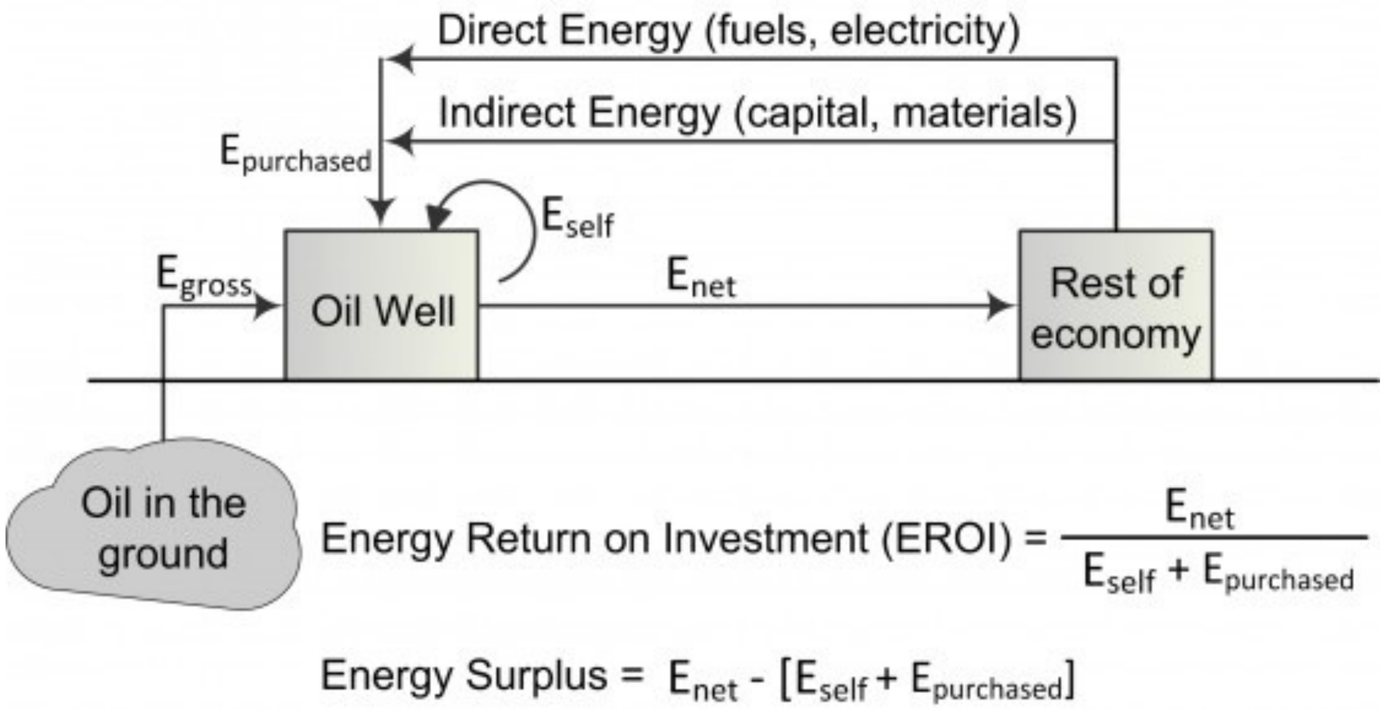


“Jevons’ Paradox and the myth of technological liberation”, J. Polimeni, R. Iorgulescu. Ecological Complexity, 2006.

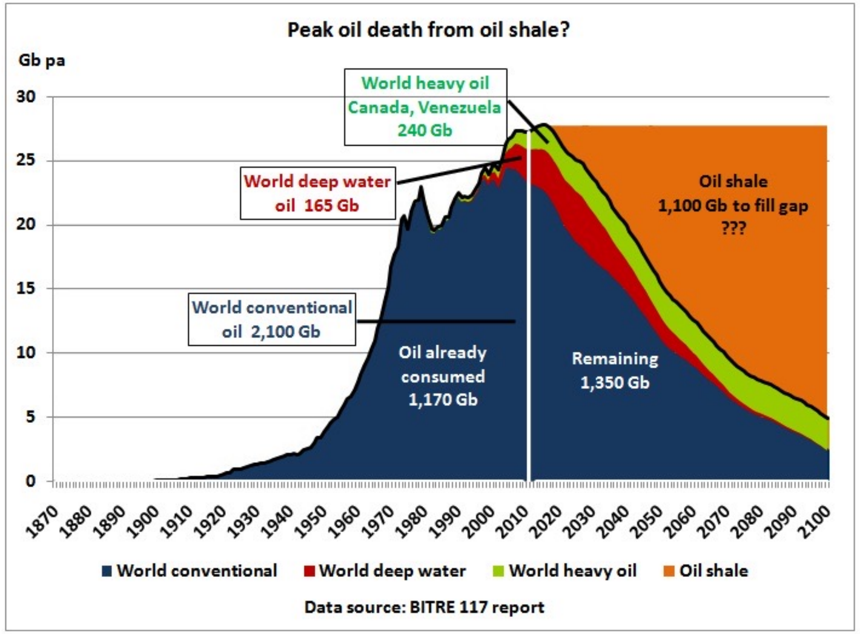
Preocupación: Enegy Return On Investment

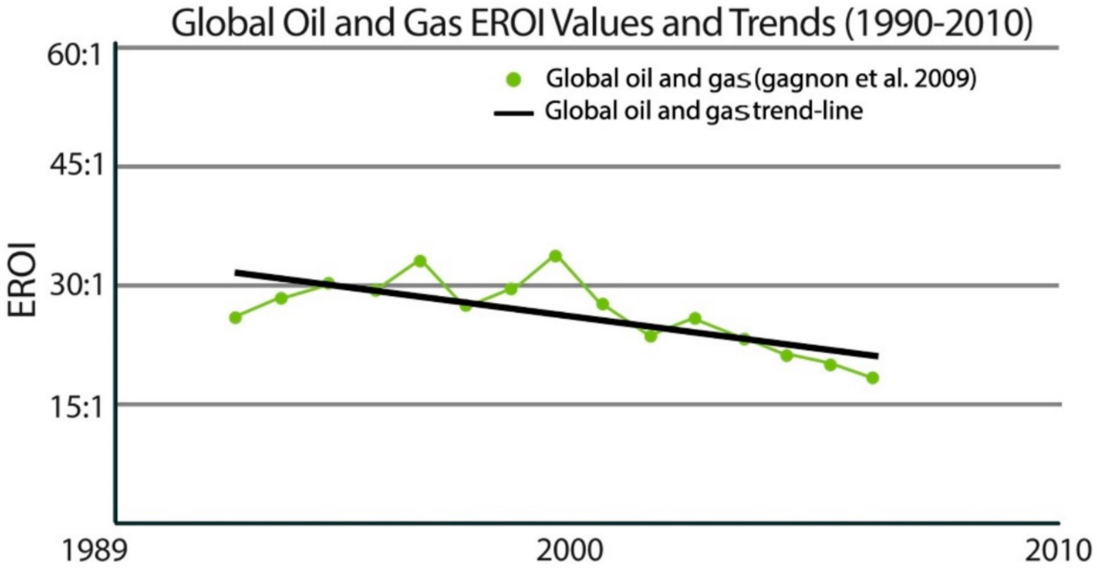
$$\text{EROI} = \frac{\text{Energy returned from an energy gathering activity}}{\text{Energy used to get that energy}}$$

Enegy Return On Investment

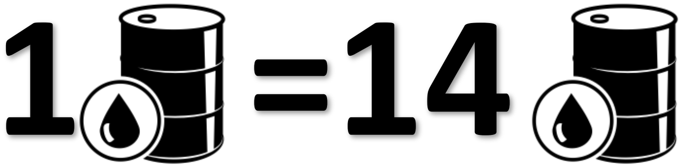


Peak oil y EROI (tasa de retorno energético – *Energy Return on Investment*)



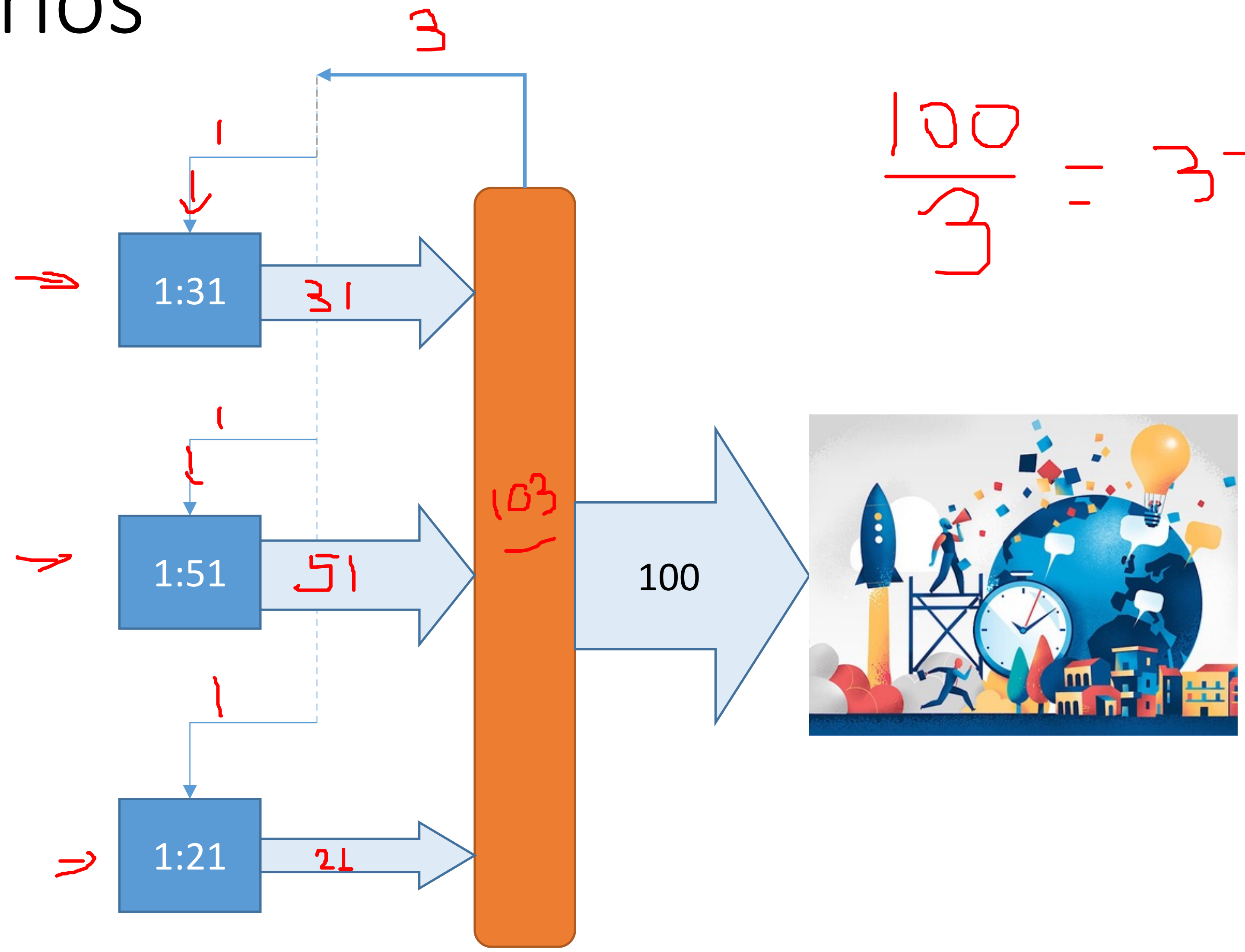


Vaferi, M.; Pazouki, K.; Klink, A.V. Declines in EROI of Main Fuels and the Implications on Developing LNG as a Marine Fuel. *J. Mar. Sci. Eng.* **2020**, *8*



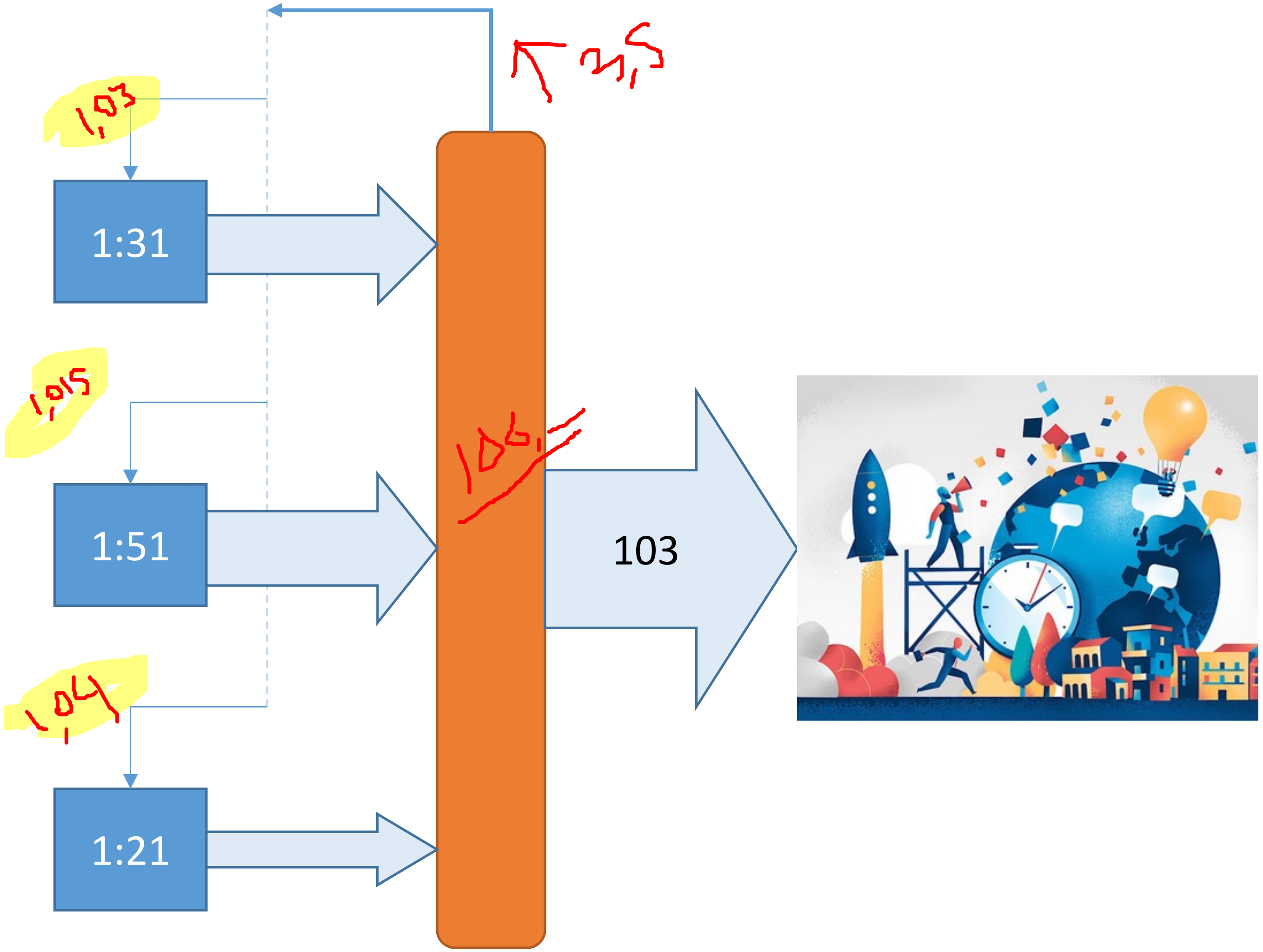
Adrien Fabre, "*Evolution of EROIs of electricity until 2050: Estimation and implications on Prices*", Ecological Economics, 164 (2019)
Sgouridis, S., Carbajales-Dale, M., Csala, D. et al. Comparative net energy analysis of renewable electricity and carbon capture and storage. Nat Energy 4, 456–465 (2019).

Escenarios

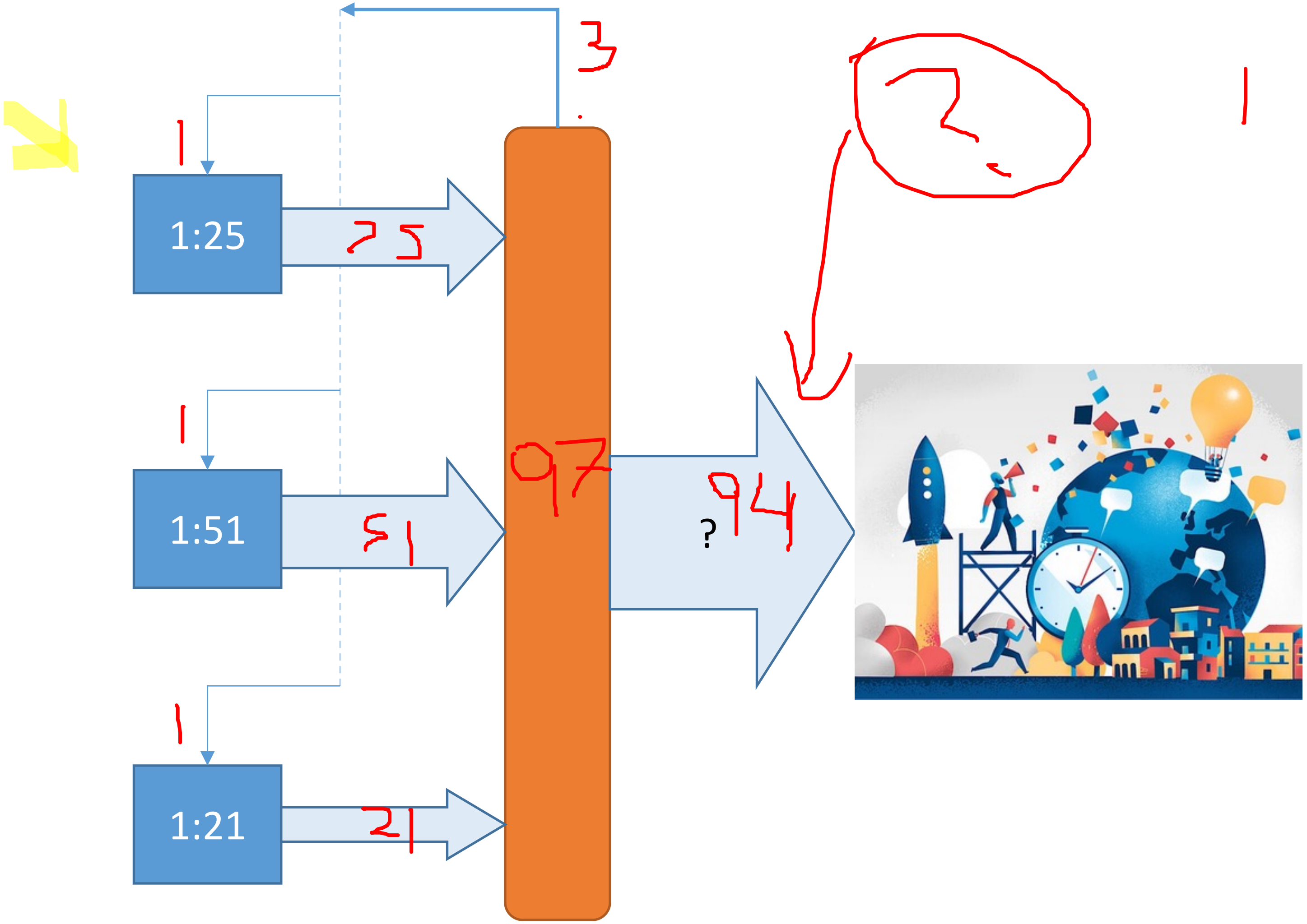


$$\frac{100}{3} = 33{,}3$$

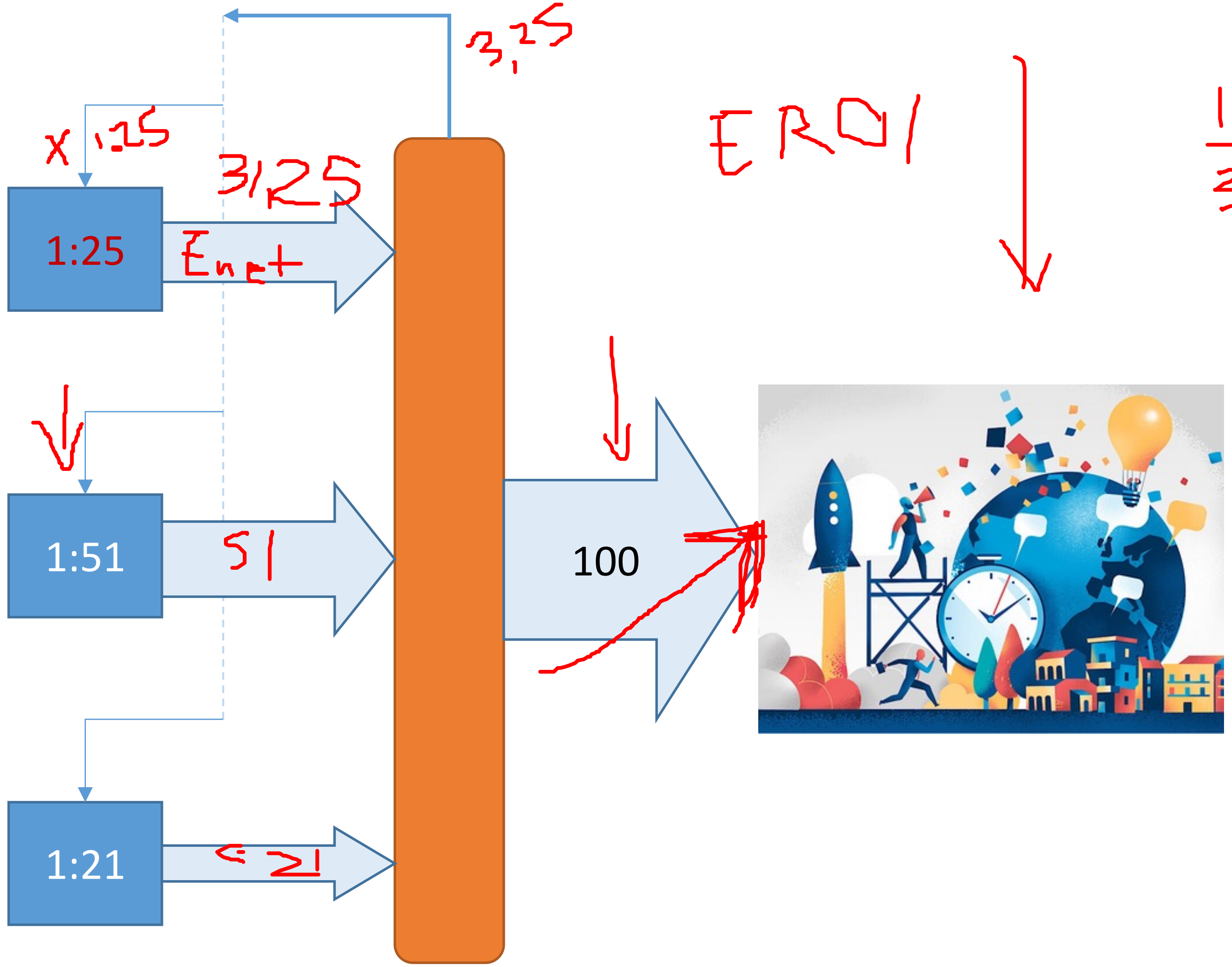
Escenario 1: Aumenta demanda – igual EROI



Escenario 2: Baja EROI – igual E_{in}



Escenario 2: Baja EROI – igual E_{social}



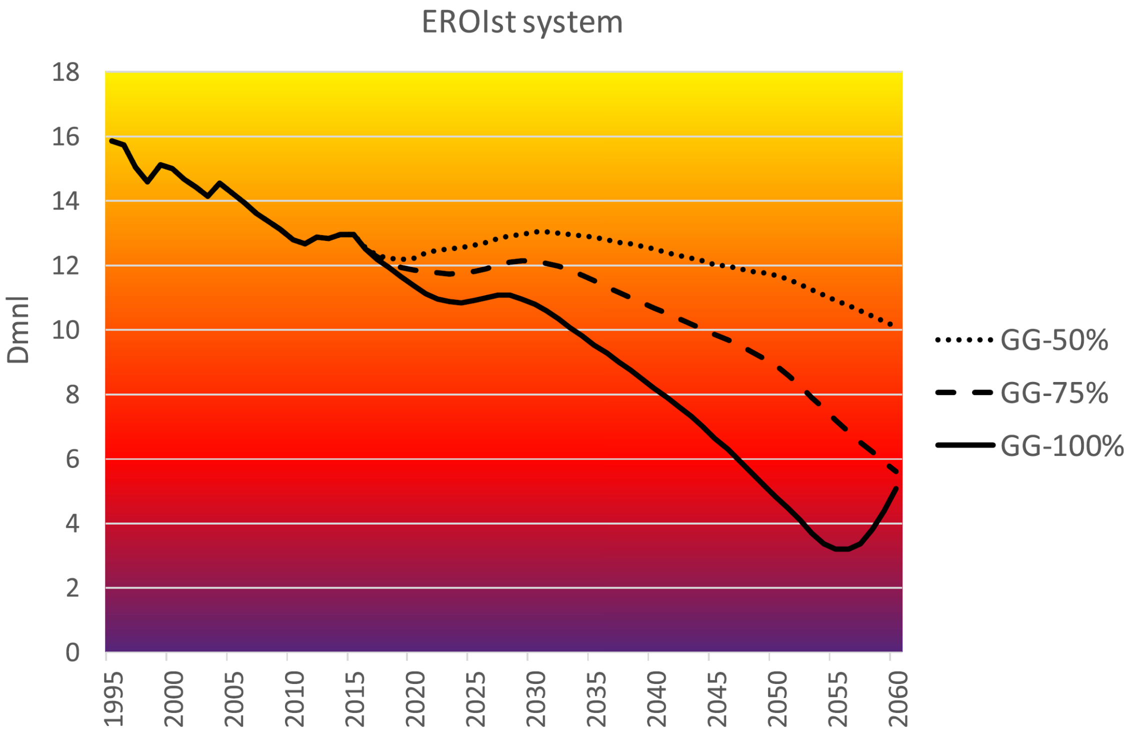
EROI ↓

$$\frac{100}{3,25} = 30,8$$

Typical EROEI values (derived from Hall and Klitgaard, 2011).

Primary energy production technologies	Approximate EROEI
Hydropower	> 100:1
Historic oil and gas	100:1
Coal	80:1
Current global oil and gas	20:1
Wind (no storage)	20:1
Nuclear	15:1
Current US oil and gas	10:1
Solar (no storage)	10:1
Unconventional oil and gas	5:1
Biofuels	2:1

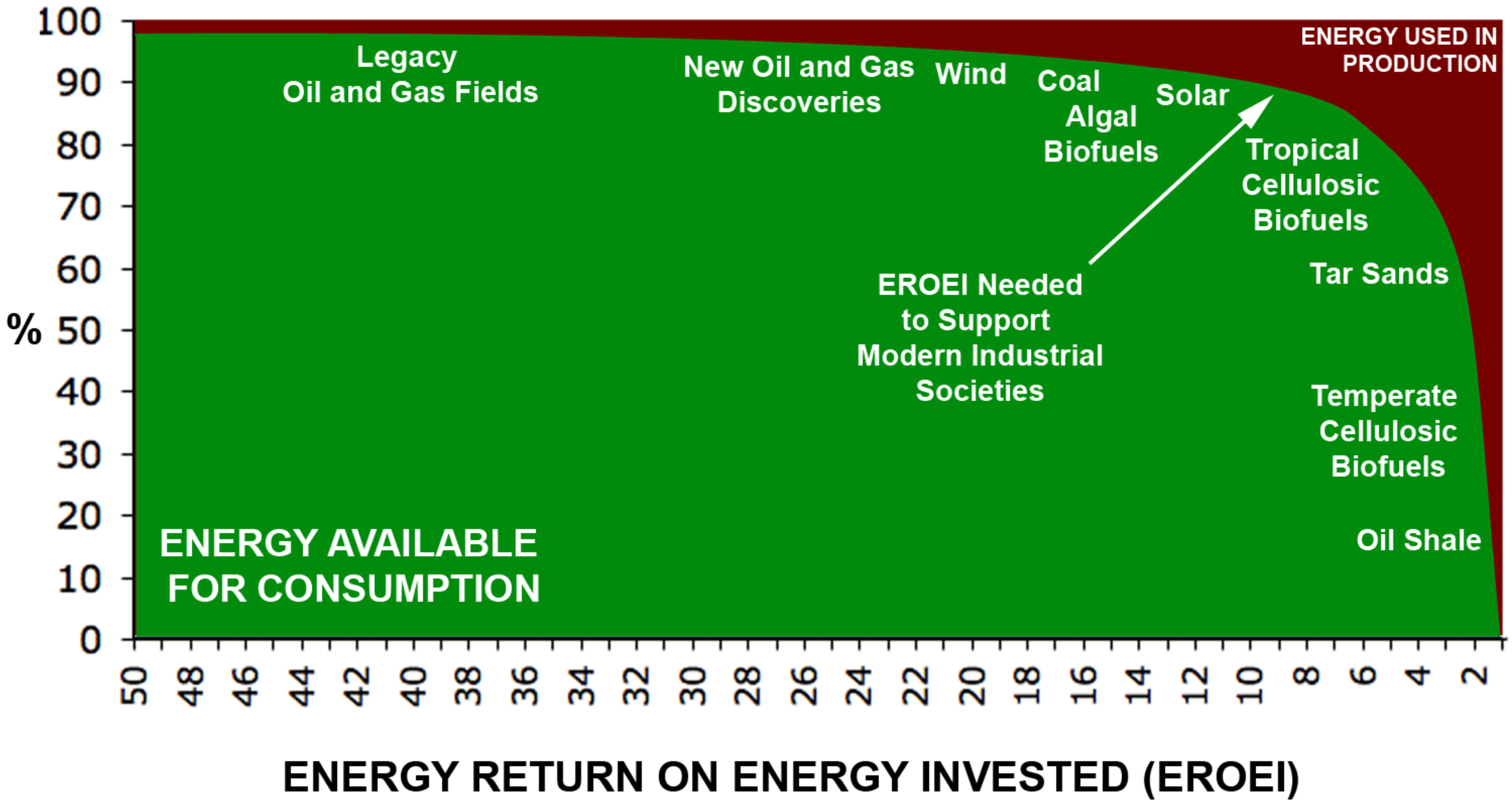
Green growth 2060



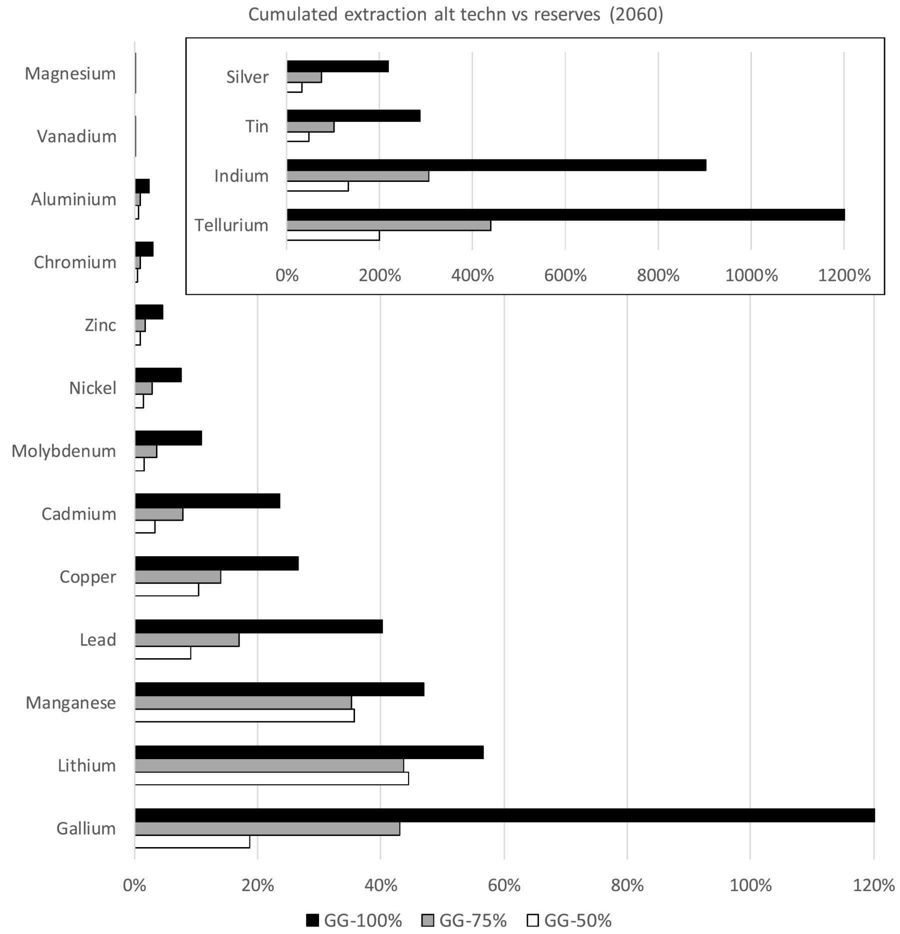
“the aforementioned factors such as the resulting EROIst of the system being well below the range of the thresholds identified in the literature as necessary to sustain high levels of development in current industrial and complex societies, as well as the evidence of the strong re-materialization required to perform the transition towards RES energies in the electricity sector (instead of absolute decoupling), put into question the consistence and soundness of the Green Growth paradigm as it is being currently presented ***[76–81].”***

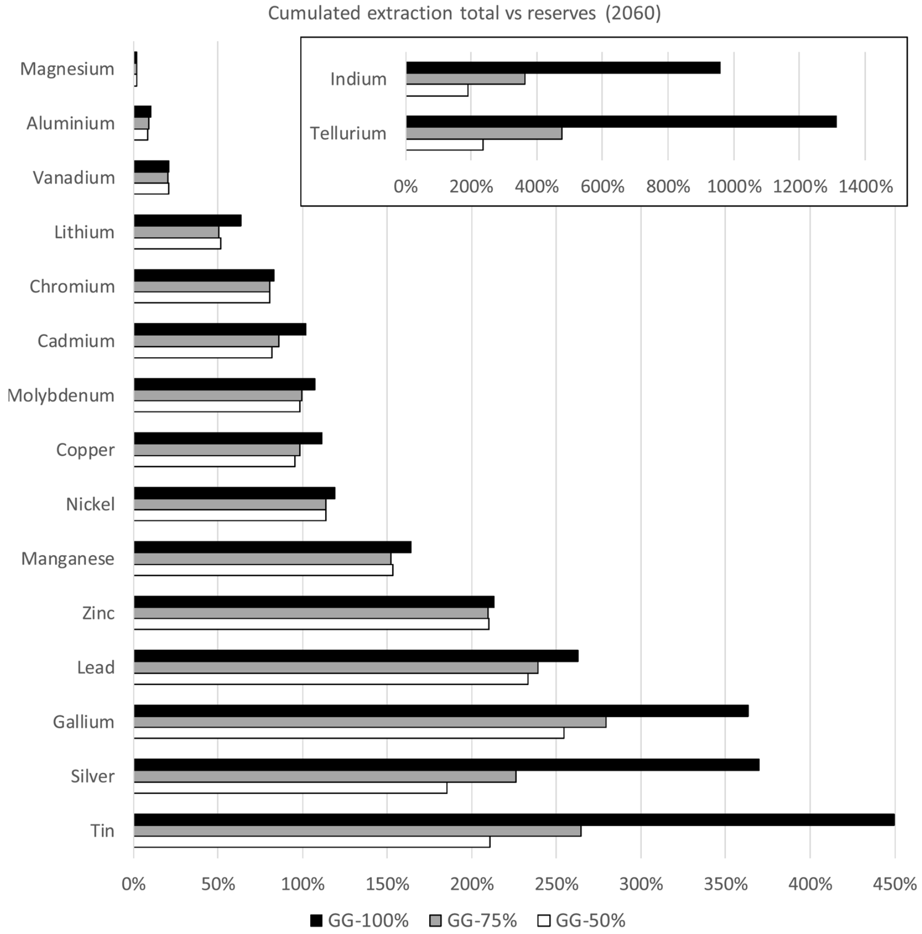
Iñigo Capellán-Pérez, Carlos de Castro, Luis Javier Miguel González, “Dynamic Energy Return on Energy Investment (EROI) and material requirements in scenarios of global transition to renewable energies,” Energy Strategy Reviews, Volume 26, 2019

Net Energy Cliff



Preocupación: Disponibilidad de materiales





Iñigo Capellán-Péreza, Carlos de Castroa, Luis Javier Miguel Gonzáleza, “Dynamic Energy Return on Energy Investment (EROI) and material requirements in scenarios of global transition to renewable energies”, Energy strategy reviews, 2019

nature sustainability
ARTICLES
https://doi.org/10.1038/s41893-021-00842-z

Check for updates

Impacts of poverty alleviation on national and global carbon emissions

Benedikt Bruckner[1], Klaus Hubacek[1]✉, Yuli Shan[1]✉, Honglin Zhong[2] and Kuishuang Feng[3]

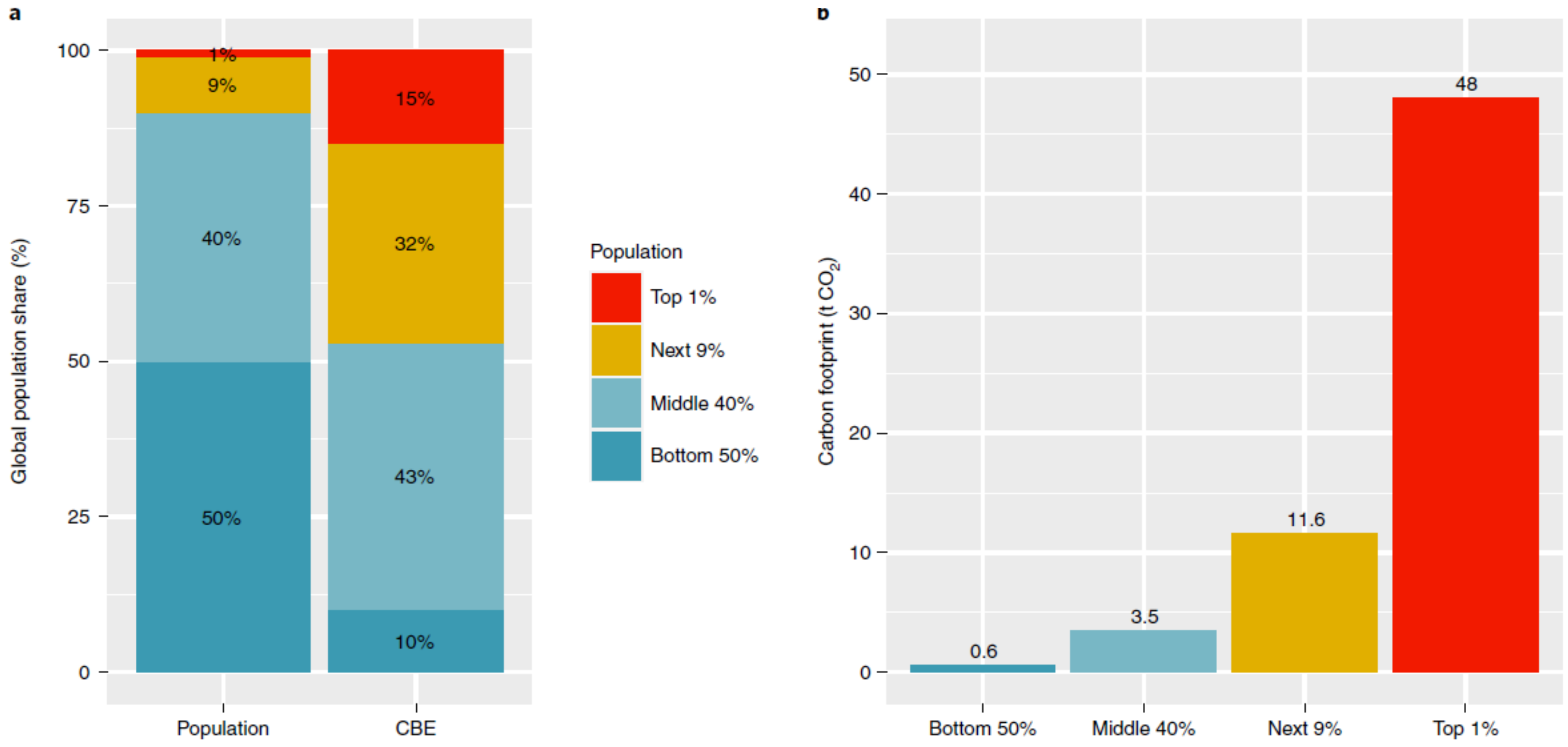


Fig. 3 | Global distribution of carbon emissions and carbon footprints. a, Global population shares (left) and corresponding shares of total global carbon emissions (CBE, right). **b**, Average carbon footprints of the top 1%, top 10%, middle 40% and bottom 50% of the global population.

DLS dimension	Material requirements and services
Nutrition	Food
	Cooking appliances
	Cold Storage
Shelter and living conditions	Sufficient housing space
	Thermal comfort
	Illumination
Hygiene	Water supply
	Water heating
	Waste management
Clothing	Clothes
	Washing facilities
Healthcare	Hospitals
Education	Schools
Comms' and information	Phones
	Computers
	Networks + data centres
Mobility	Vehicle production
	Vehicle's propulsion
	Transport infrastructure

- La humanidad tendrá que vivir con menos energía y menos materiales.
- Se muestra que es posible vivir en un mundo con menos energía, y con un modo de vida decente, generoso y universalizado, para una población de ~10000 millones de habitantes.
- Aunque el progreso tecnológico y los cambios individuales son componentes esenciales de la solución, dichas posturas incrementales alineadas con la narrativa del crecimiento verde y el consumo verde, son inadecuadas e insuficientes.
- Se requieren cambios RADICALES del consumo de energía en TODOS LOS SECTORES.
- Los conceptos de suficiencia, umbrales materiales e igualdad económica que se usaron en el estudio, son incompatibles con las normas económicas del presente, en las que el desempleo y la inequidad son requerimientos sistemáticos, los desechos y la basura es considerada económicamente eficiente y la persecución de crecimiento económico infinito es necesario para la estabilidad política y económica.
- En los países especialmente pobres y en vías de desarrollo, el consumo del sector más rico de la población ha superado enormemente los niveles de suficiencia, mientras cientos de millones permanecen en la pobreza.
- Esta investigación está en línea con planteamientos que aceptan que los cambios económicos y socio-políticos necesarios para enfrentar los retos ecológicos actuales, son enormes, a pesar de que las soluciones tecnológicas ya existen.
- Los sacrificios materiales son, en teoría, mucho más pequeños que lo que muchas narrativas sugieren. De hecho, sucede justo lo contrario a un sacrificio para 4000 millones de personas actualmente viviendo en la pobreza.

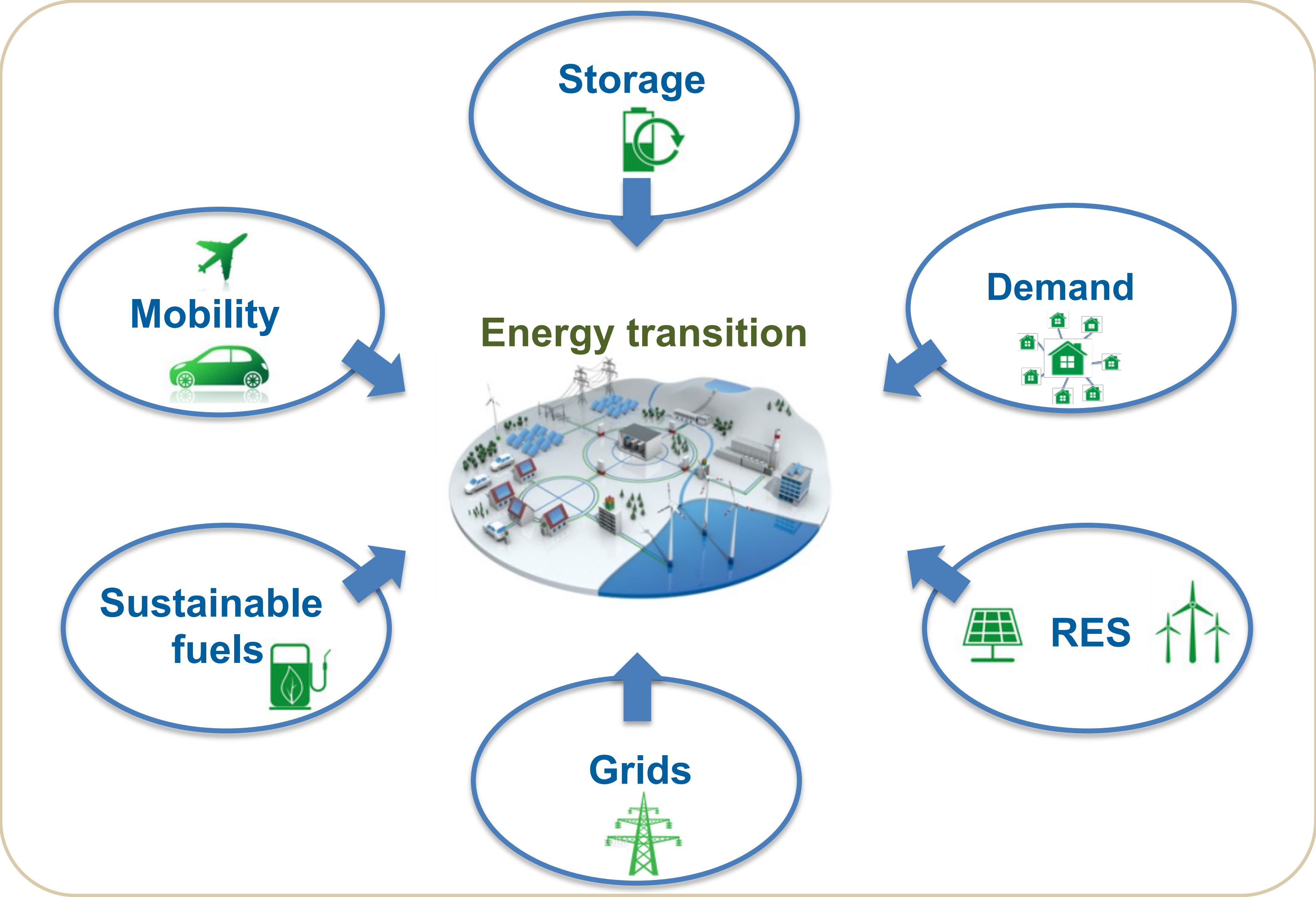
Joel Millward-Hopkins, Julia K. Steinberger, Narasimha D. Rao, Yannick Oswald, Providing decent living with minimum energy: A global scenario, Global Environmental Change, Volume 65, 2020.

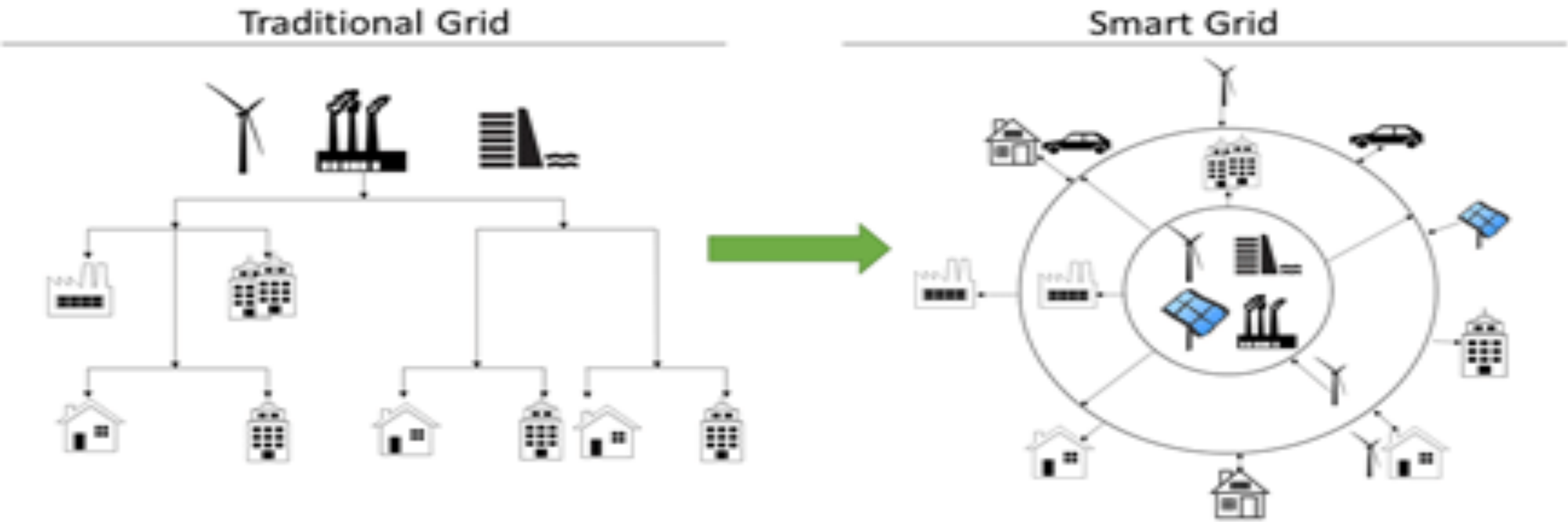
Algunas conclusiones

- En lo económico
- En lo ambiental
- En lo termodinámico
- En huella material
- En lo societal

GRACIAS

Integración hacia la transición

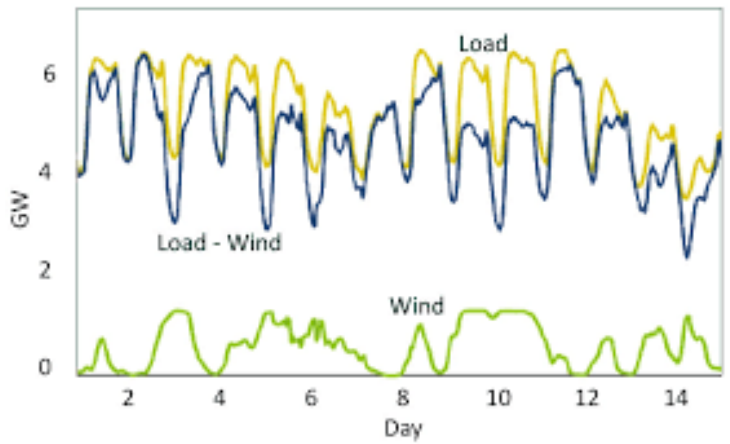


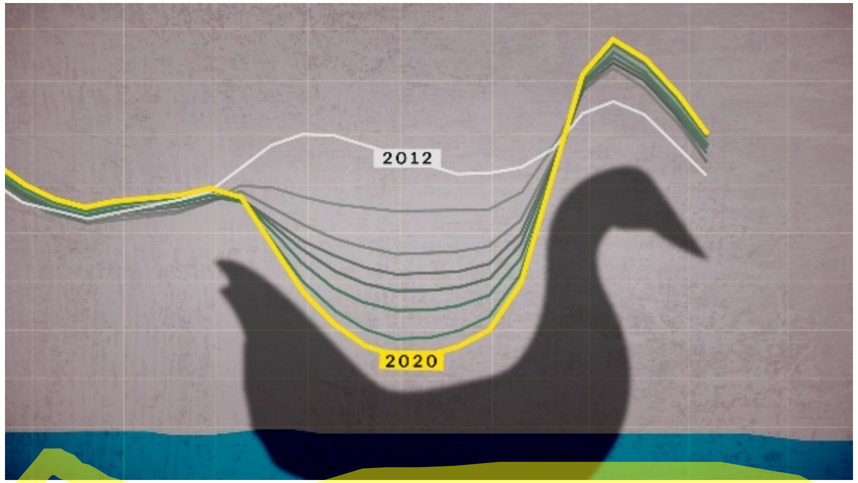


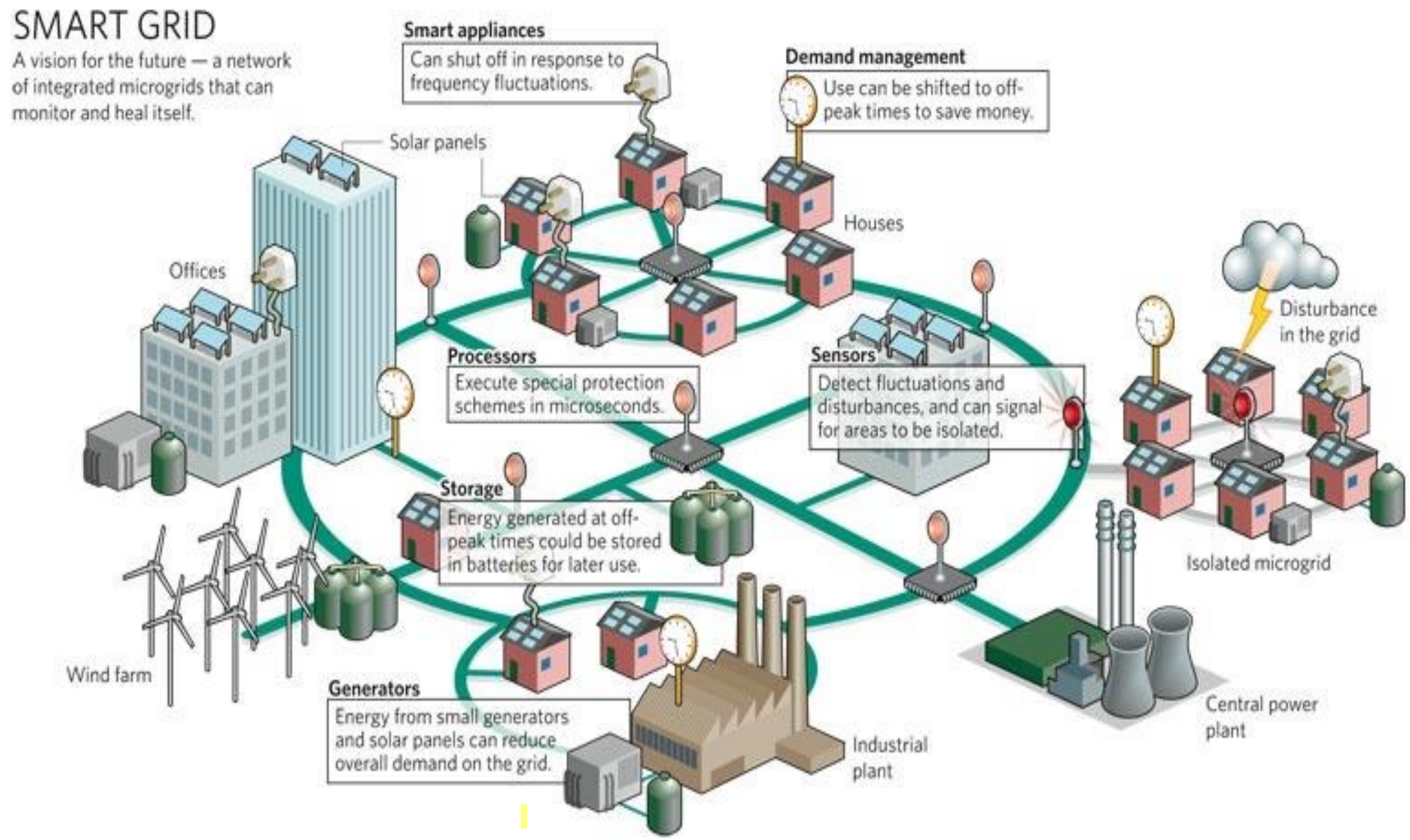
Maquinaria eléctrica	Digital
Comunicación de una vía	Comunicación bidireccional
Generación centralizada	Generación distribuida
Pequeño número de sensores	Despliegue de sensores en toda la red
Monitoreo manual	Monitoreo automático
Restauración manual	Restauración automática
Fallas y cortes	Adaptivas y aisladas
Pocas opciones para el usuario	Más opciones

Preocupaciones

- Picos y cambios en la demanda
- Variabilidad de la generación renovable
- Modelo de mercado jerárquico
- Diversidad espacial y temporal
- Herencia del mundo de las TIC

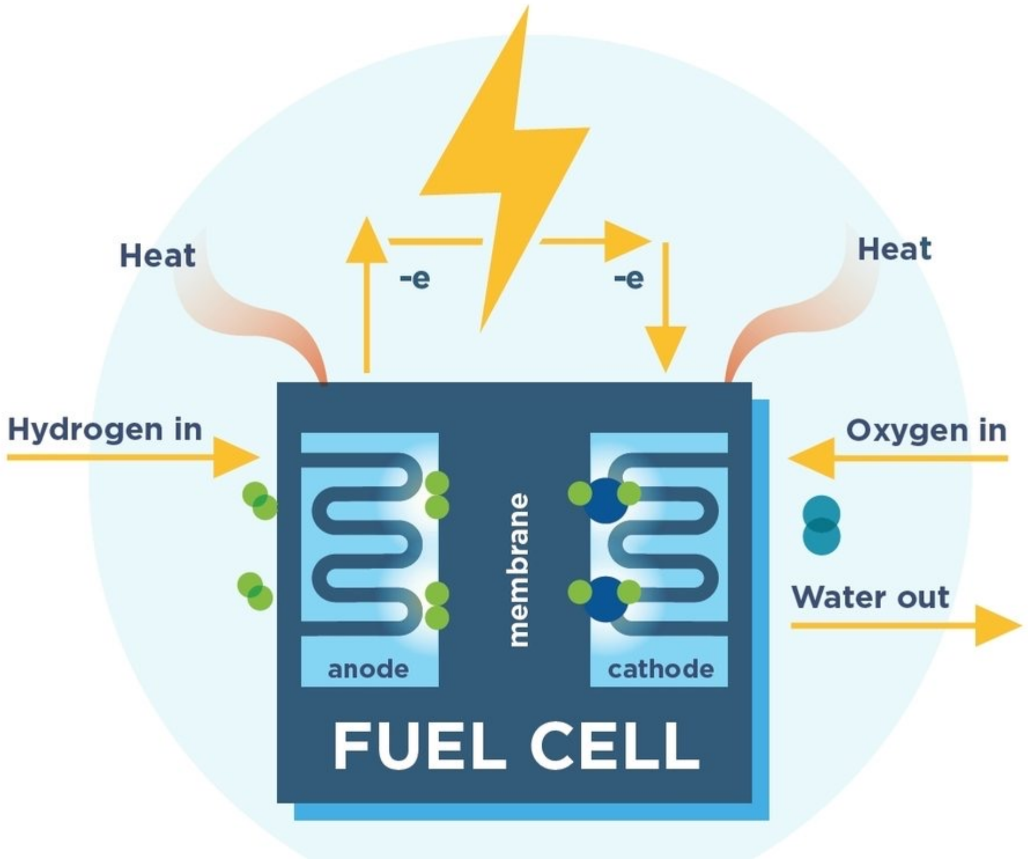






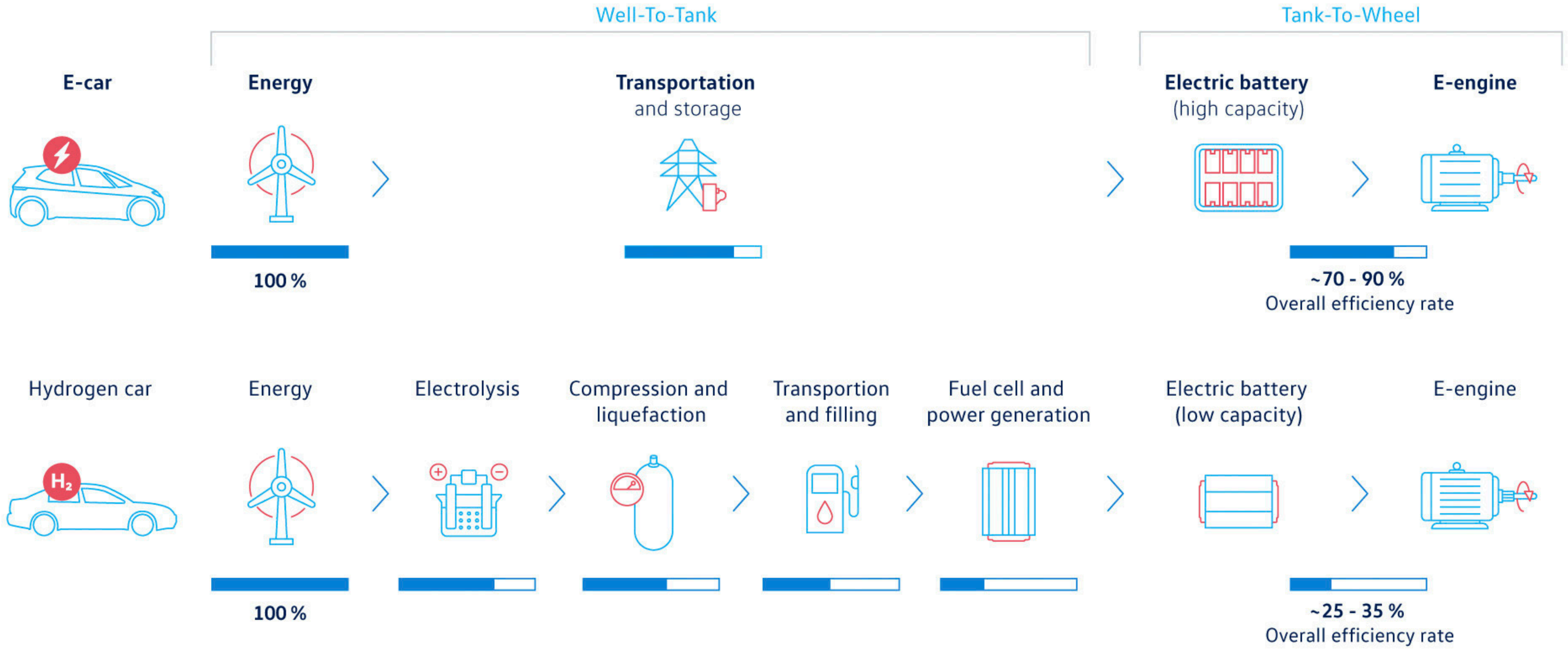
- https://www.youtube.com/watch?v=riwgz7WXmXA

Celdas de combustible – pilas de hidrógeno



Hydrogen **and electric drive**

Efficiency rates in comparison using eco-friendly energy



Source Volkswagen

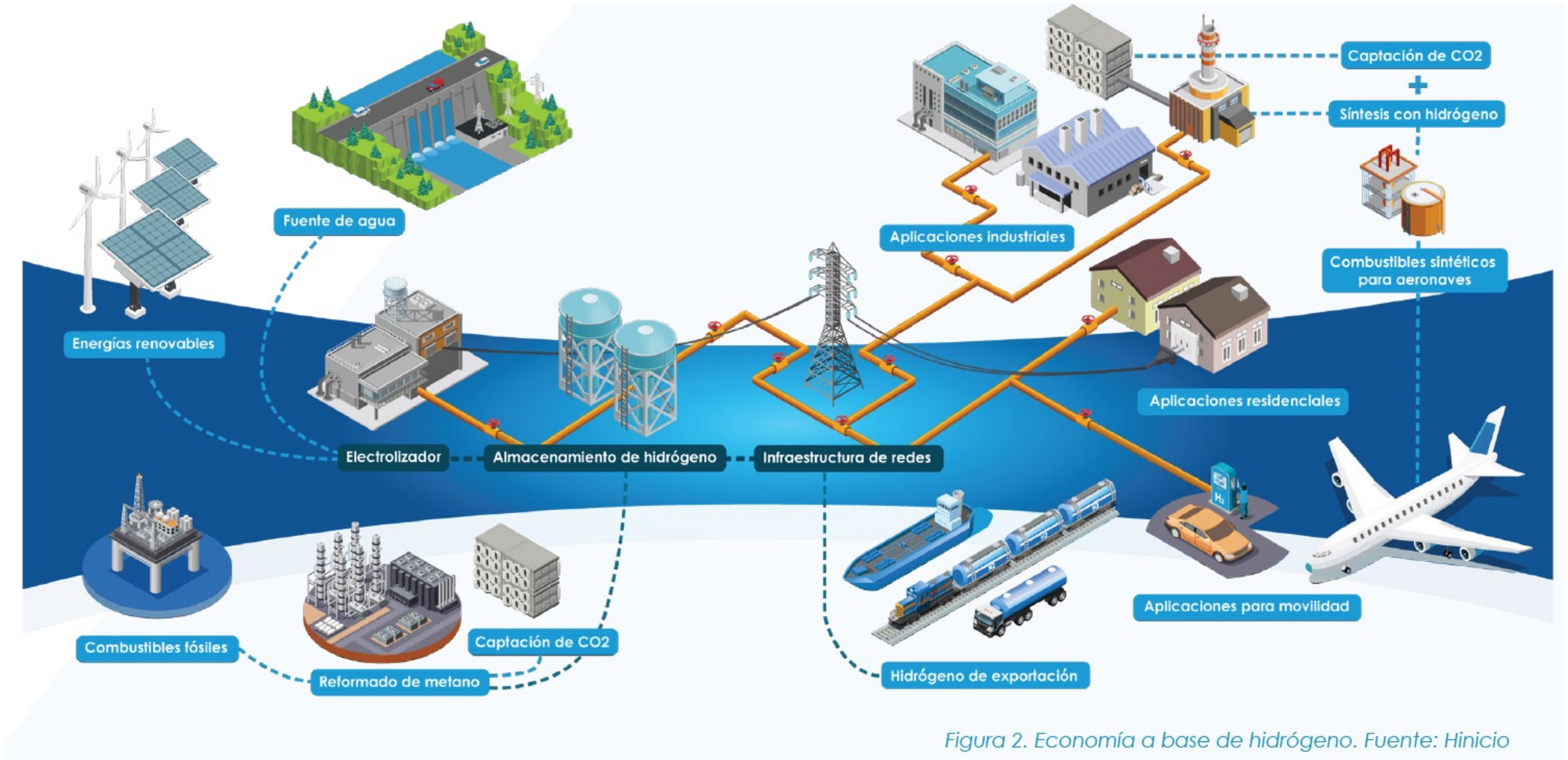
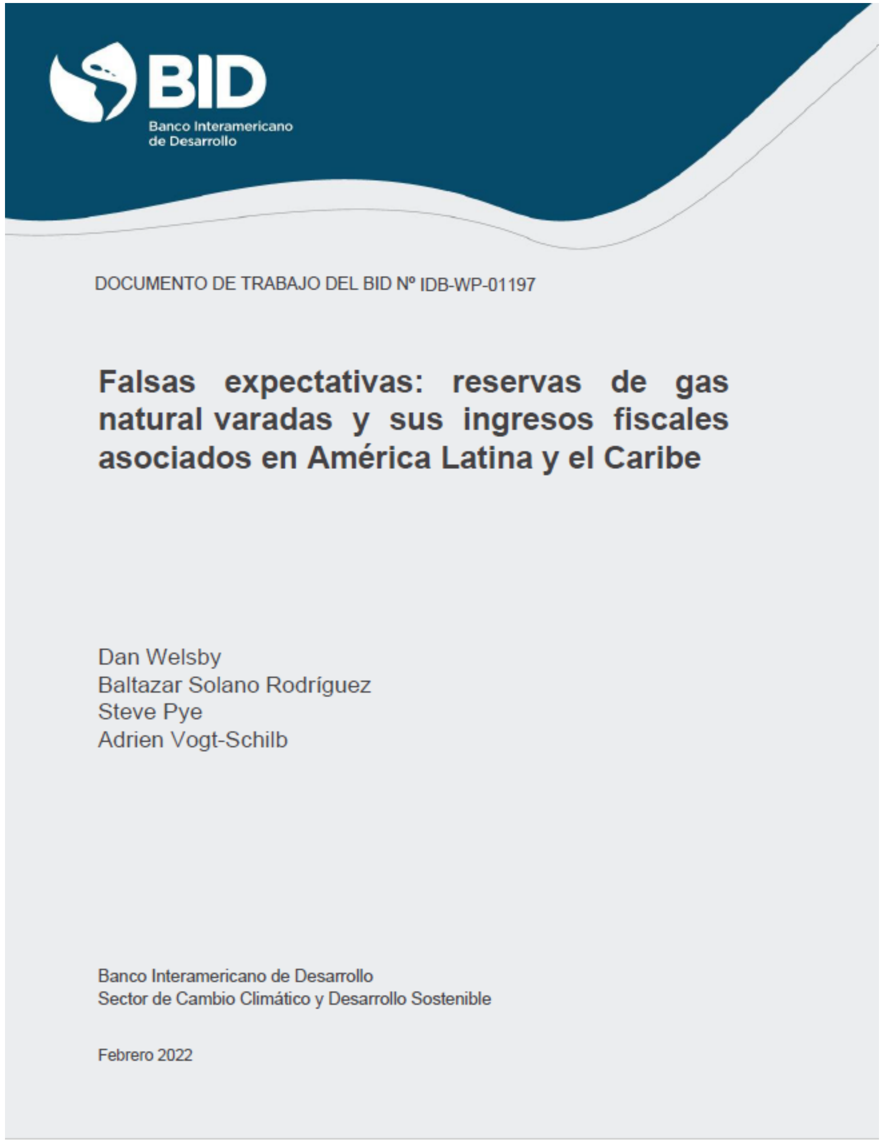


Figura 2. Economía a base de hidrógeno. Fuente: Hinicio

Preocupación: El gas natural (y el petróleo)


Banco Interamericano de Desarrollo

DOCUMENTO DE TRABAJO DEL BID Nº IDB-WP-01197

Falsas expectativas: reservas de gas natural varadas y sus ingresos fiscales asociados en América Latina y el Caribe

Dan Welsby
Baltazar Solano Rodríguez
Steve Pye
Adrien Vogt-Schilb

Banco Interamericano de Desarrollo
Sector de Cambio Climático y Desarrollo Sostenible

Febrero 2022

- Los planes de los gobiernos para cumplir con el Acuerdo de París crea incertidumbre con respecto a la futura demanda de gas, sus precios y los ingresos públicos asociados
- Evaluamos las perspectivas de la producción de gas natural y los ingresos públicos procedentes de regalías y de los impuestos sobre la producción de gas en América Latina y el Caribe bajo diferentes niveles de ambición climática global
- Gas natural como un combustible puente potencial hacia un sistema de energía con cero emisiones netas, ya que emite menos dióxido de carbono durante la combustión que el carbón, el cual históricamente ha sido la fuente dominante en la producción de electricidad a nivel mundial*
- Simulamos varios escenarios de producción y demanda energética mundial. Combinamos supuestos sobre los futuros impulsores de la demanda de energía a nivel mundial
- Con presupuestos de carbono diseñados para representar políticas climáticas coherentes con las actuales NDC, que se sabe que son incompatibles con el logro de los objetivos de temperatura a largo plazo del Acuerdo de París, un objetivo de calentamiento de 2 °C, un objetivo de 1,75 °C, o ninguna política climática.

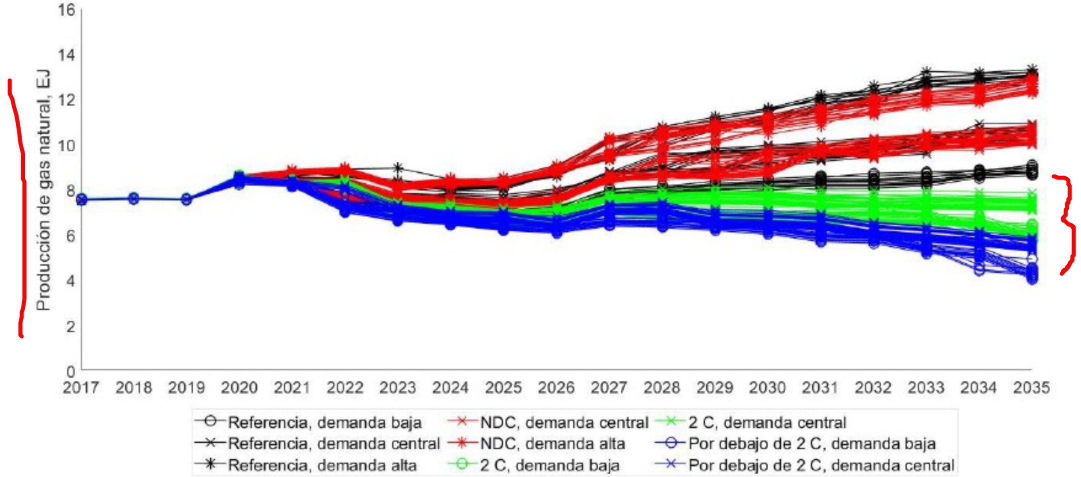


Gráfico 7: Producción agregada de América Latina y el Caribe en cada una de las rutas enumeradas en el cuadro 2

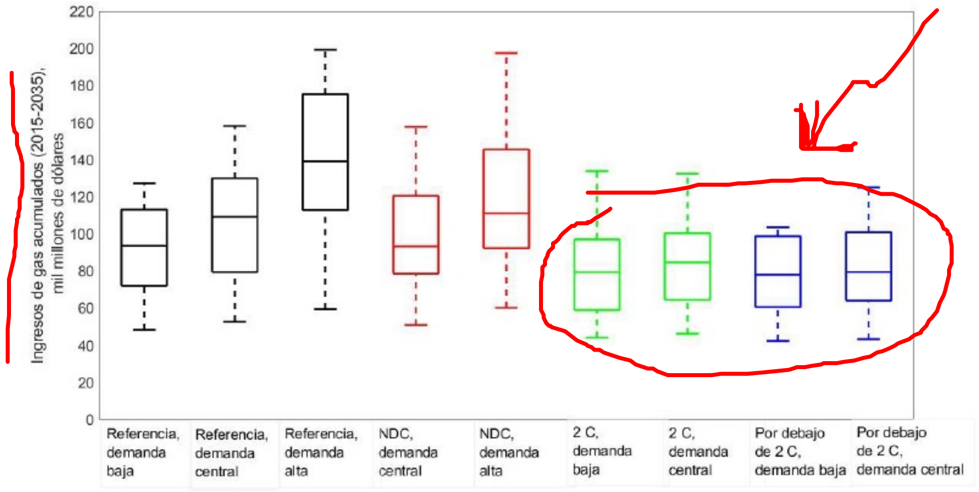


Gráfico 11: Rango de recaudación acumulada en América Latina y el Caribe en cada escenario individual

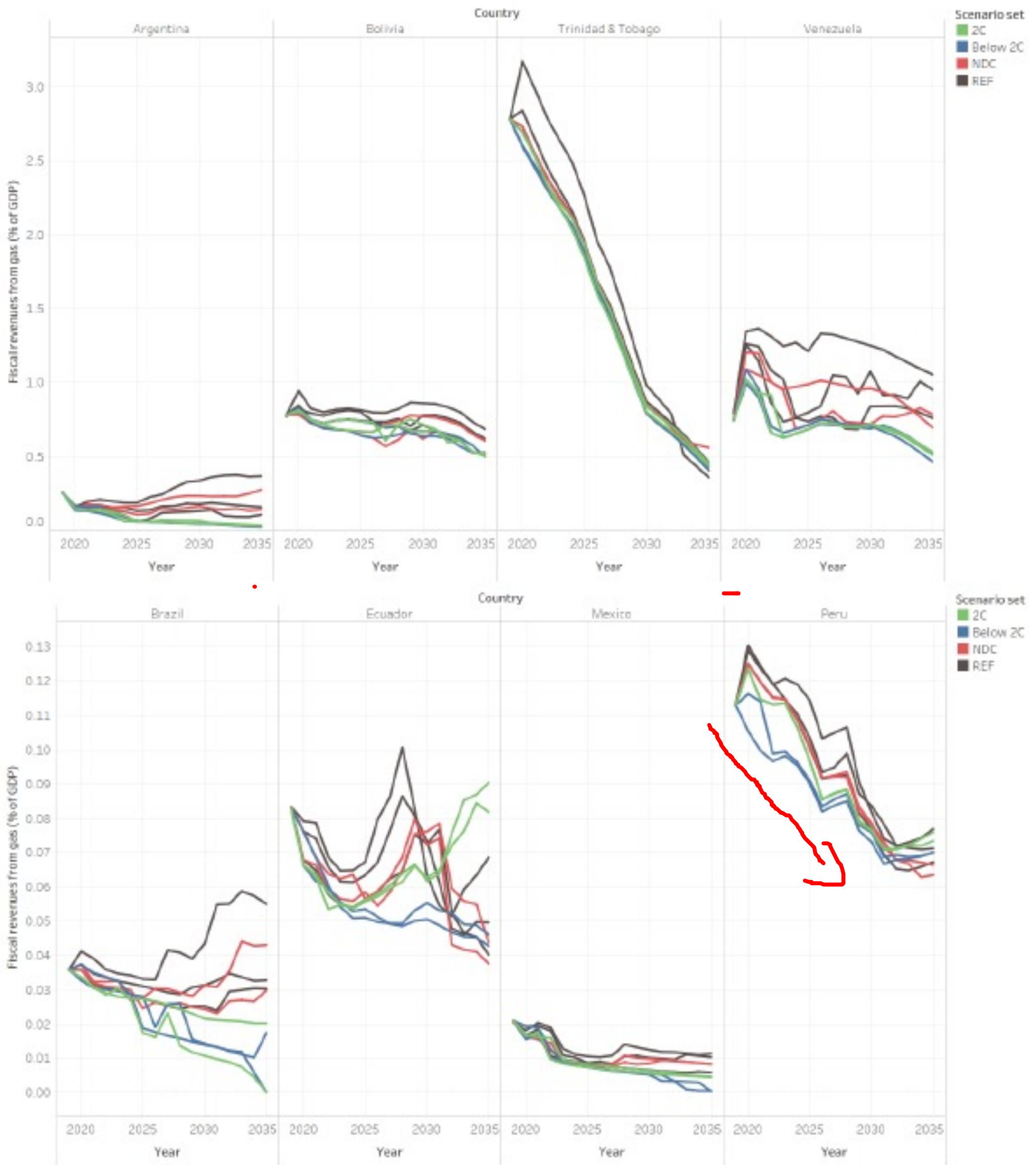
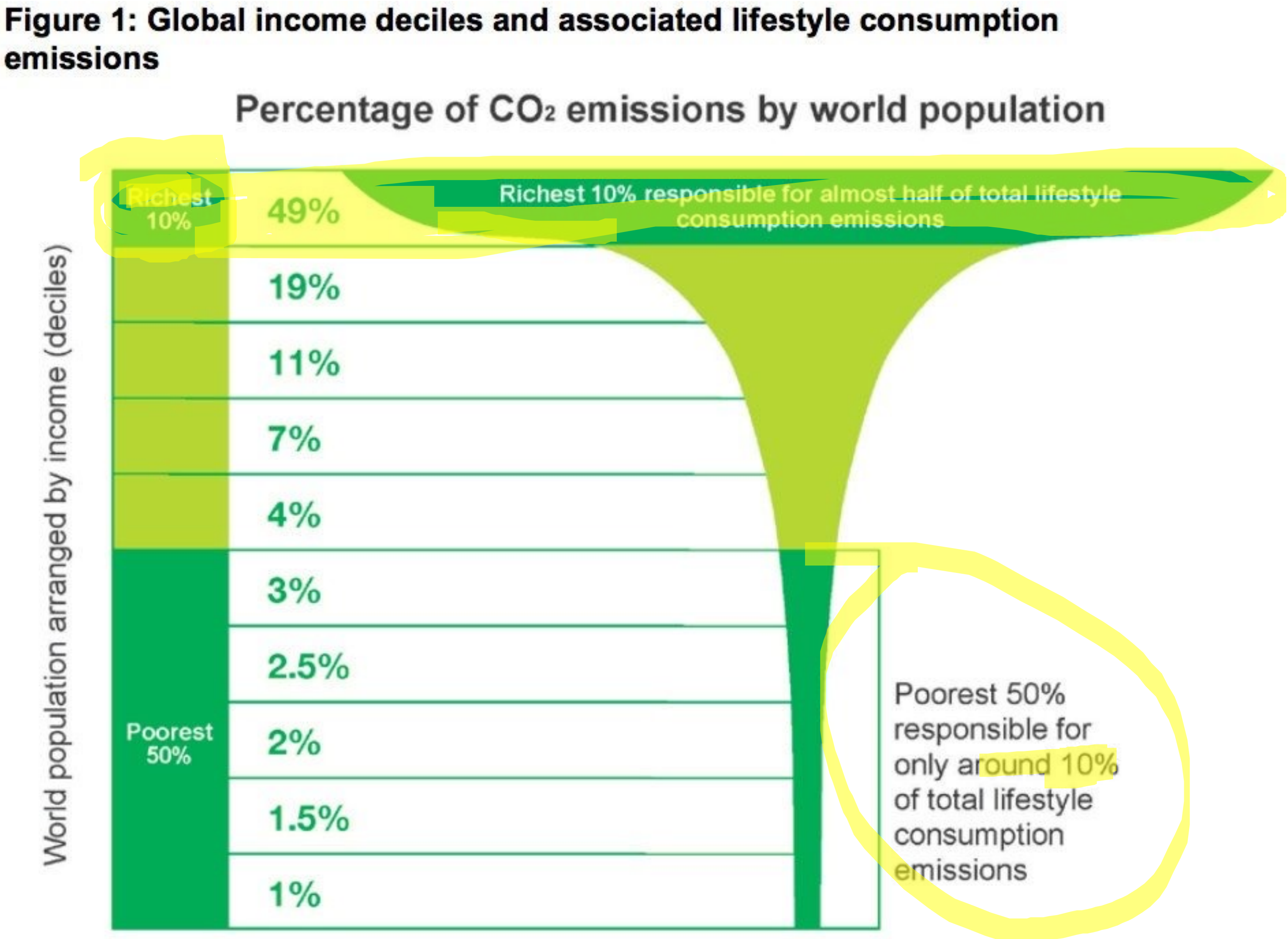


Gráfico 15. Contribución de los ingresos fiscales derivados del gas (% del PIB) por escenario climático. Cada línea representa uno de los escenarios en el cuadro 2. El color de las líneas se refiere al escenario de la demanda mundial bajo diferentes objetivos de temperatura. El panel superior muestra los países con mayores contribuciones al PIB (Argentina, Bolivia, Trinidad y Tobago y Venezuela), mientras que el panel inferior muestra una selección de países con pequeñas contribuciones al PIB (Brasil, Ecuador, México y Perú).

Hallazgos

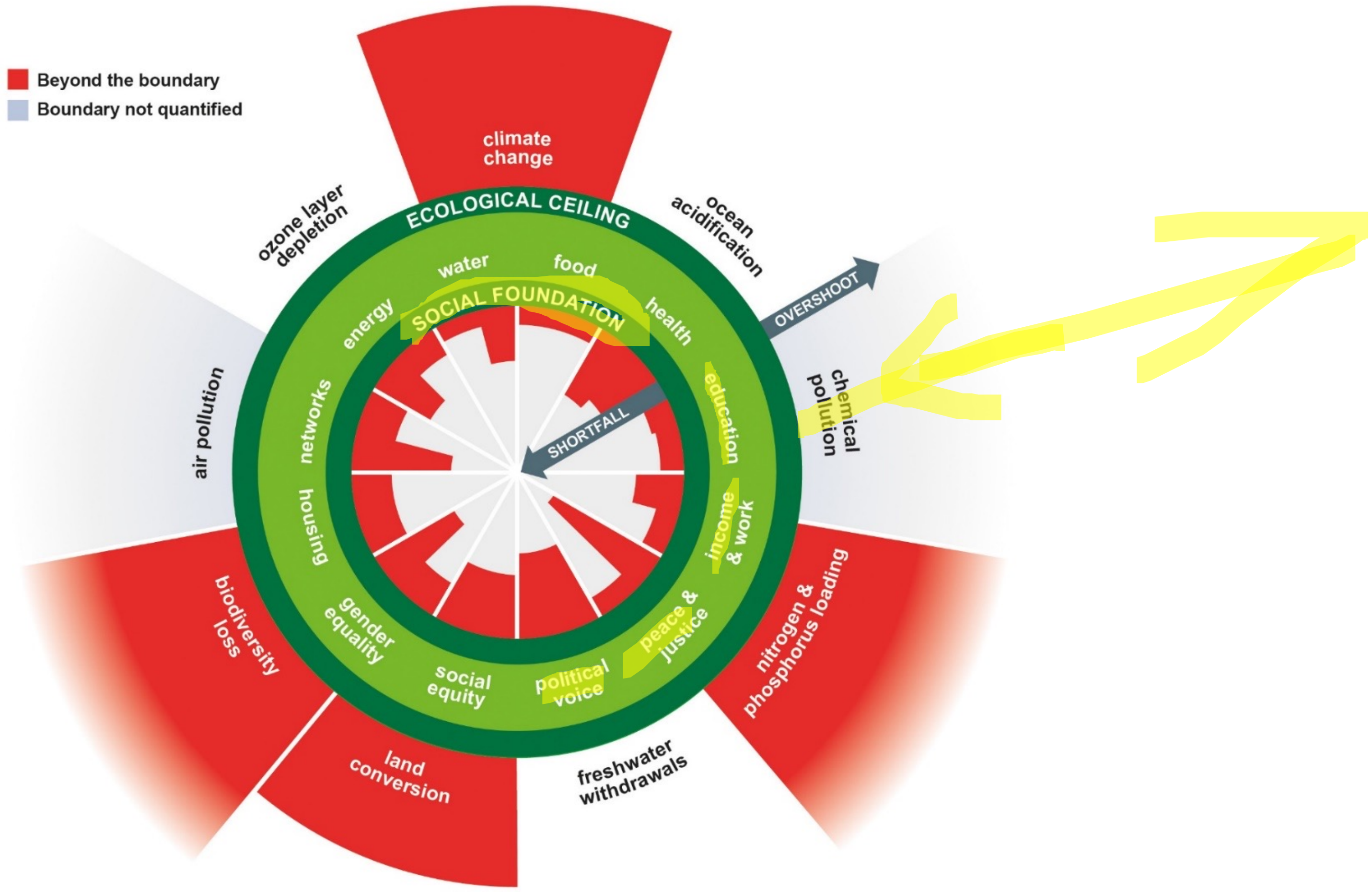
- Entre 39-50% de las reservas (o entre 65-71% si se incluye a Venezuela) permanecen en el subsuelo en escenarios coherentes con la consecución de los objetivos de temperatura del Acuerdo de París (es decir, un calentamiento de 2 °C o inferior).
- Los ingresos públicos procedentes de las operaciones de gas natural son mucho más sensibles a los cambios en la demanda mundial y al rigor de la futura descarbonización que a cualquier esfuerzo del gobierno por maximizar los ingresos mediante cambios en las tasas impositivas.
- Teniendo en cuenta el nivel de descarbonización requerido para alcanzar los objetivos de Por debajo de 2 ºC, el consumo en América Latina y el Caribe debe disminuir entre 32-45% por debajo de los niveles de 2018. En dicho escenario estimamos que la mediana de los ingresos es de USD 80.000 millones, en comparación con la mediana de USD 111.000 millones en los escenarios que ignoran todo el objetivo climático
- Dado que los escenarios coherentes con el Acuerdo de París proyectan una disminución del consumo y la producción mundial de gas, los gobiernos de América Latina y el Caribe deberían centrar sus esfuerzos de generación de ingresos en otros sectores.
- También observamos que el gas natural se elimina progresivamente de los sectores de generación de energía y residencial en América Latina y el Caribe, lo que significa que la inversión generalizada en redes de distribución de gas natural a menor escala quedaría bloqueada en nuestros escenarios coherentes con el calentamiento de 2 °C y Por debajo de 2 °C.

Sobrepoblación?



Oxfam, Extreme Carbon Inequality, Media Briefing, 2015.

Doughnut economy



Doughnut economy, Kate Raworth, 2017.

Decrecimiento – Degrowth

- Economías de corto plazo a largo plazo
- Contracción con coordinación / planificación / diseño
- Desfinanciarización
- ¿High-tech society?
- Lo público
- Reducción de jornada de trabajo

Global Warming Potential

United States Environmental Protection Agency

Índice que refleja cuánto tiempo permanece en la atmósfera, en promedio, y con qué fuerza absorbe la energía

- "El **CO2**, por definición, tiene un **GWP de 1** independientemente del período de tiempo utilizado, ya que es el gas que se usa como referencia. El CO2 permanece en el sistema climático durante mucho tiempo: las emisiones de CO2 causan aumentos en las concentraciones atmosféricas de CO2 que durarán miles de años."
- "Se estima que el metano (**CH4**) tiene un **GWP de 28–36 en 100años**"
- "El óxido nitroso (**N2O**) tiene un **GWP 265 – 298 veces más que el CO2** en una escala de tiempo de 100 años."

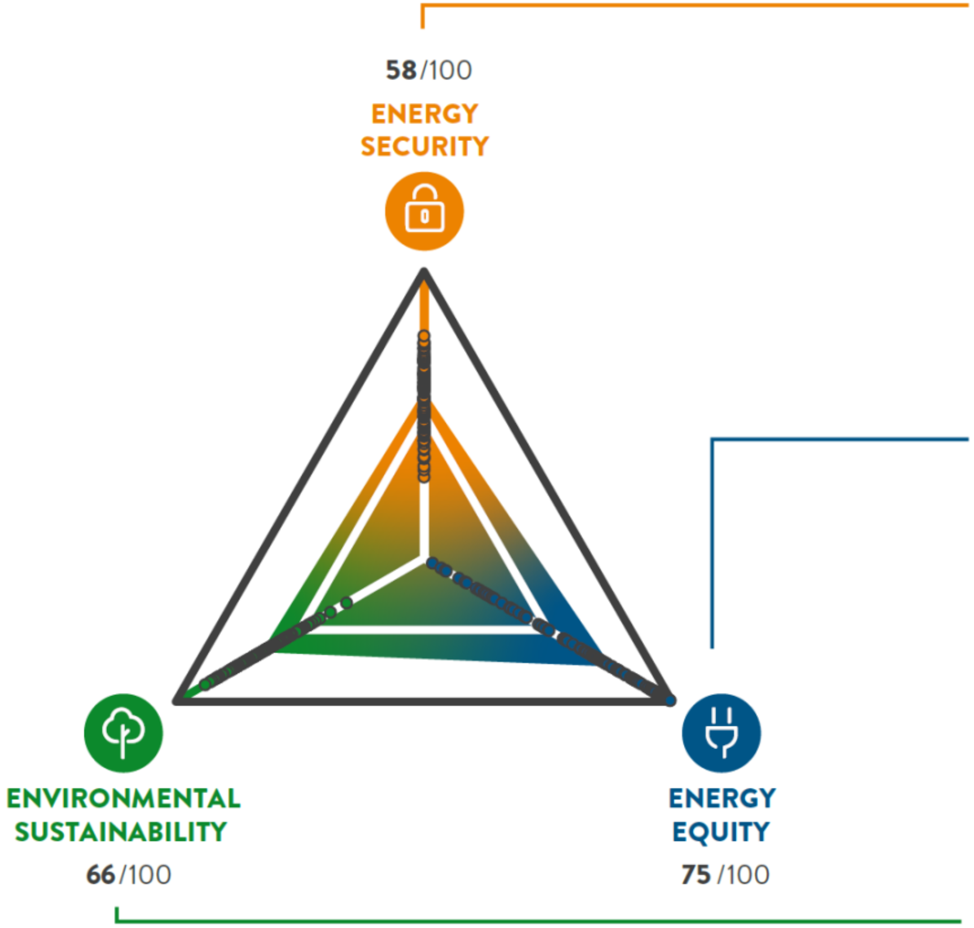
Common Name	Chemical Formula	GWP_{100}*
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298

GHG—greenhouse gas, GWP—global warming potential, GWP_{100}—the number of years over which the global warming potential was calculated

*Huxley et al, 2009

https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

2021 TRILEMMA RESULTS



World Energy Trilemma Index

Reflects a nation's capacity to meet current and future energy demand reliably, withstand and bounce back swiftly from system shocks with minimal disruption to supplies.

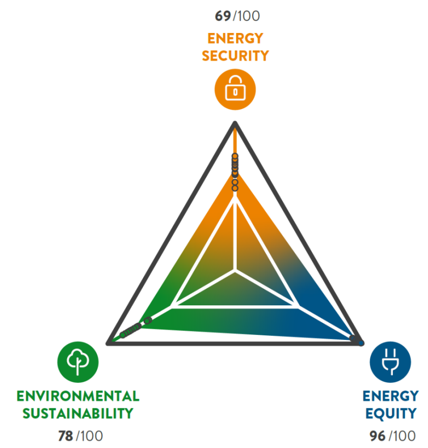
Assesses a country's ability to provide universal access to affordable, fairly priced and abundant energy for domestic and commercial use.

Represents the transition of a country's energy system towards mitigating and avoiding potential environmental harm and climate change impacts.

Source: World Energy Council

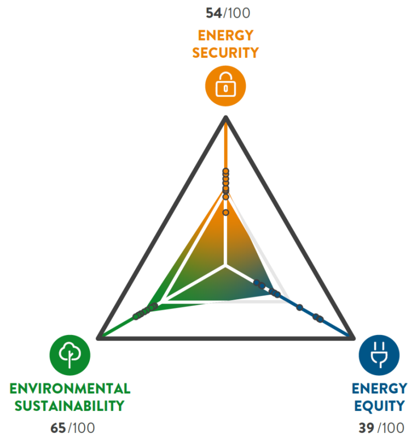
2021 TOP PERFORMERS AND IMPROVERS

TOP 10 RANK OVERALL PERFORMERS



Rank		Grade	Score
1	Sweden	AAAa	84.2
2	Switzerland	AAAa	83.8
3	Denmark	AAAa	83.0
4	Finland	AAAa	81.7
4	United Kingdom	AAAa	81.7
5	France	AAAa	81.1
5	Austria	AAAa	81.0
6	Canada	AABa	80.6
7	Germany	AAAa	80.4
8	Norway	BAAa	79.6
9	New Zealand	AAAa	79.1
9	United States	AABa	79.0
10	Spain	ABAa	76.9
10	Luxembourg	CAAa	76.9

TOP 10 COUNTRIES OVERALL IMPROVERS



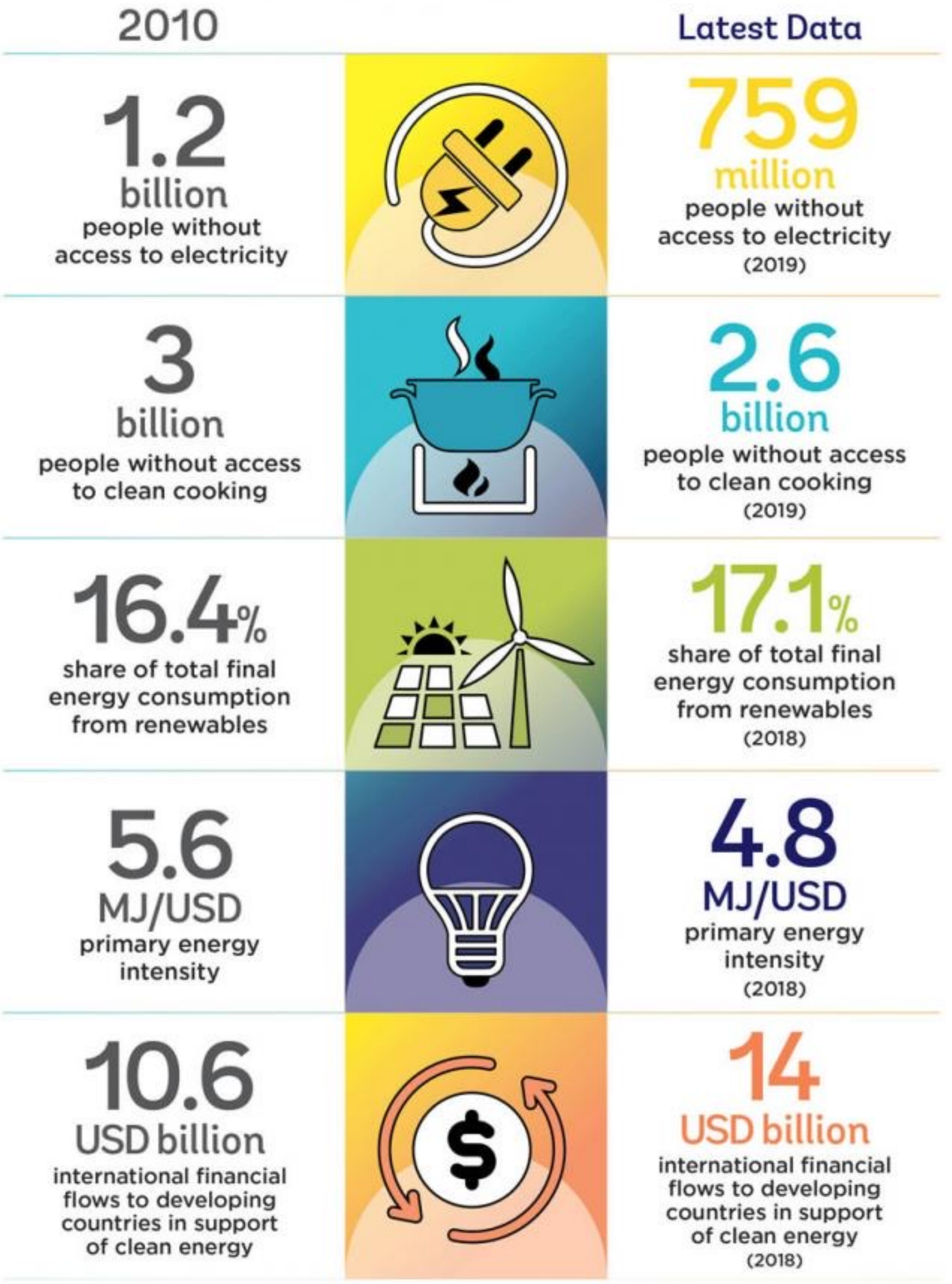
Rank		Grade	Score	Improvement since 2000
82	Cambodia	CDDd	47.5	57%
83	Myanmar	BDCd	47.4	34%
59	Dominican Rep.	DCBc	60.7	33%
80	Kenya	BDBc	50.7	33%
88	Ethiopia	DDCd	42.1	31%
76	Honduras	CDBd	52.5	28%
53	Thailand	CCCb	62.7	26%
78	Nicaragua	CDBd	51.7	26%
60	Sri Lanka	CCBc	60.1	25%
51	China	BBDb	64.0	25%

Source: World Energy Council

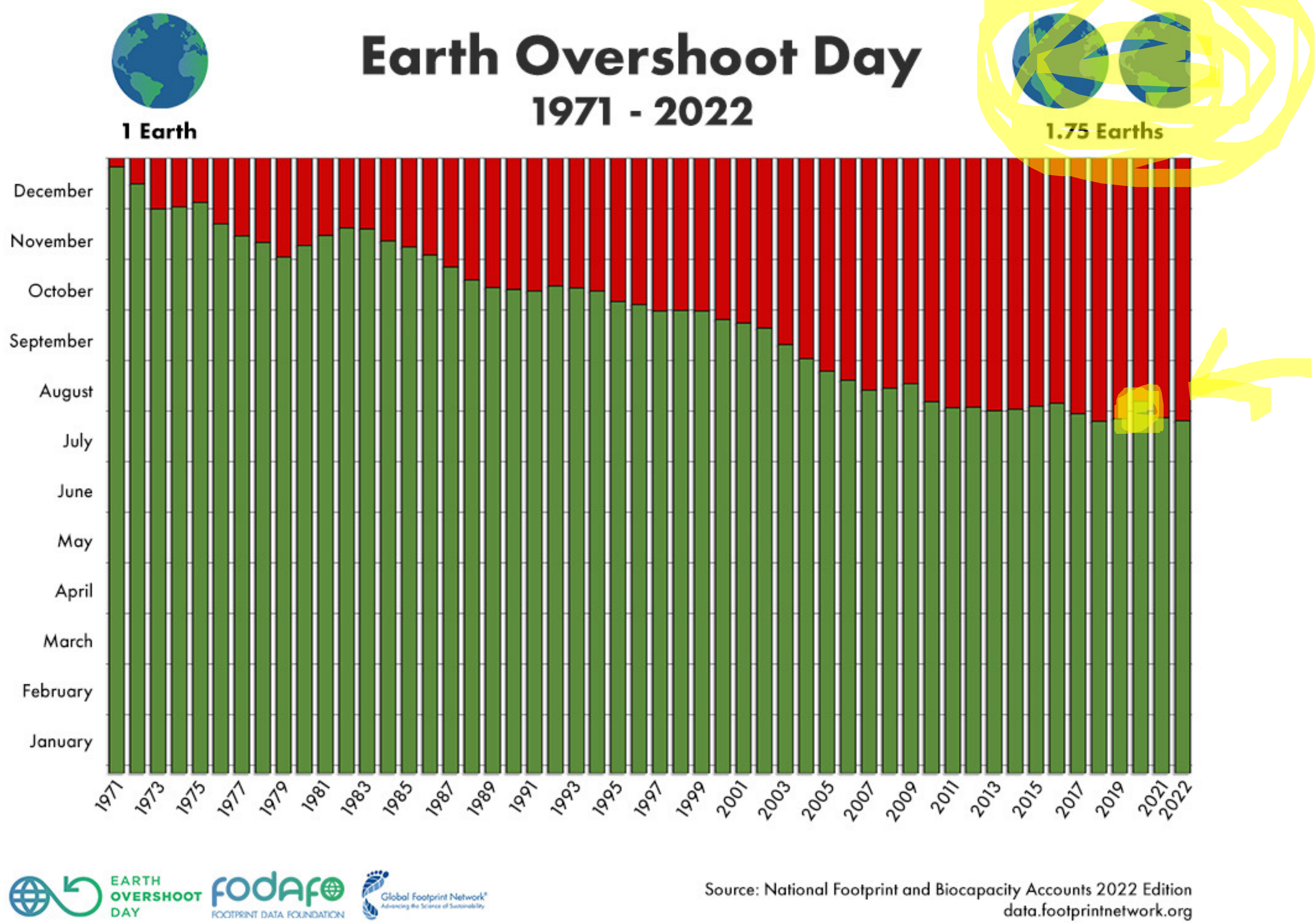
Score is rounded to one decimal point. Countries share a rank if difference in their score is less than 0.1.

https://trilemma.worldenergy.org/

Pobreza energética



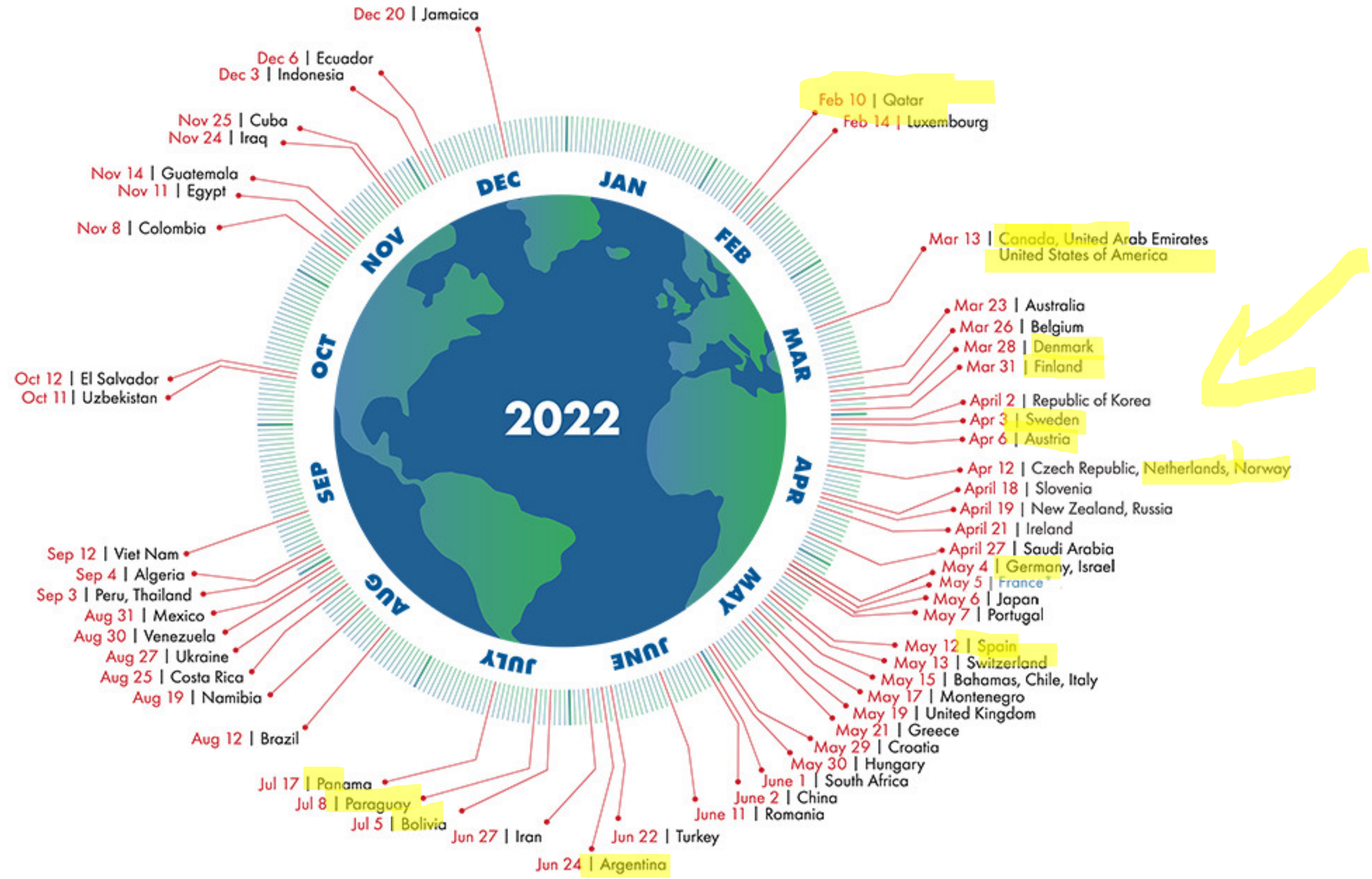
Latest data on primary indicators of global progress toward SDG7 targets. Source: IEA, IRENA, UNSD, World Bank, WHO



Earth Overshoot Day
1971 - 2022
1 Earth
1.75 Earths
December
November
October
September
August
July
June
May
April
March
February
January
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2022
EARTH OVERSHOOT DAY
fodafo
FOOTPRINT DATA FOUNDATION
Global Footprint Network
Source: National Footprint and Biocapacity Accounts 2022 Edition
data.footprintnetwork.org

Country Overshoot Days 2022

When would Earth Overshoot Day land if the world's population lived like...



For a full list of countries, visit overshootday.org/country-overshoot-days.

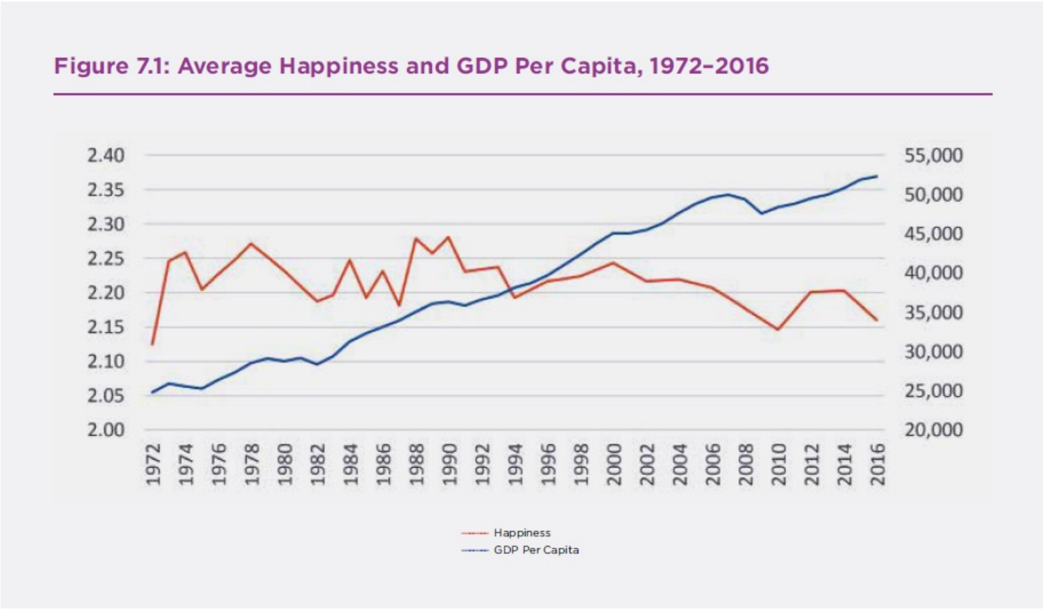
*France Overshoot Day updated April 20, 2022 based on nowcasted data. See overshootday.org/france.

EARTH OVERSHOOT DAY

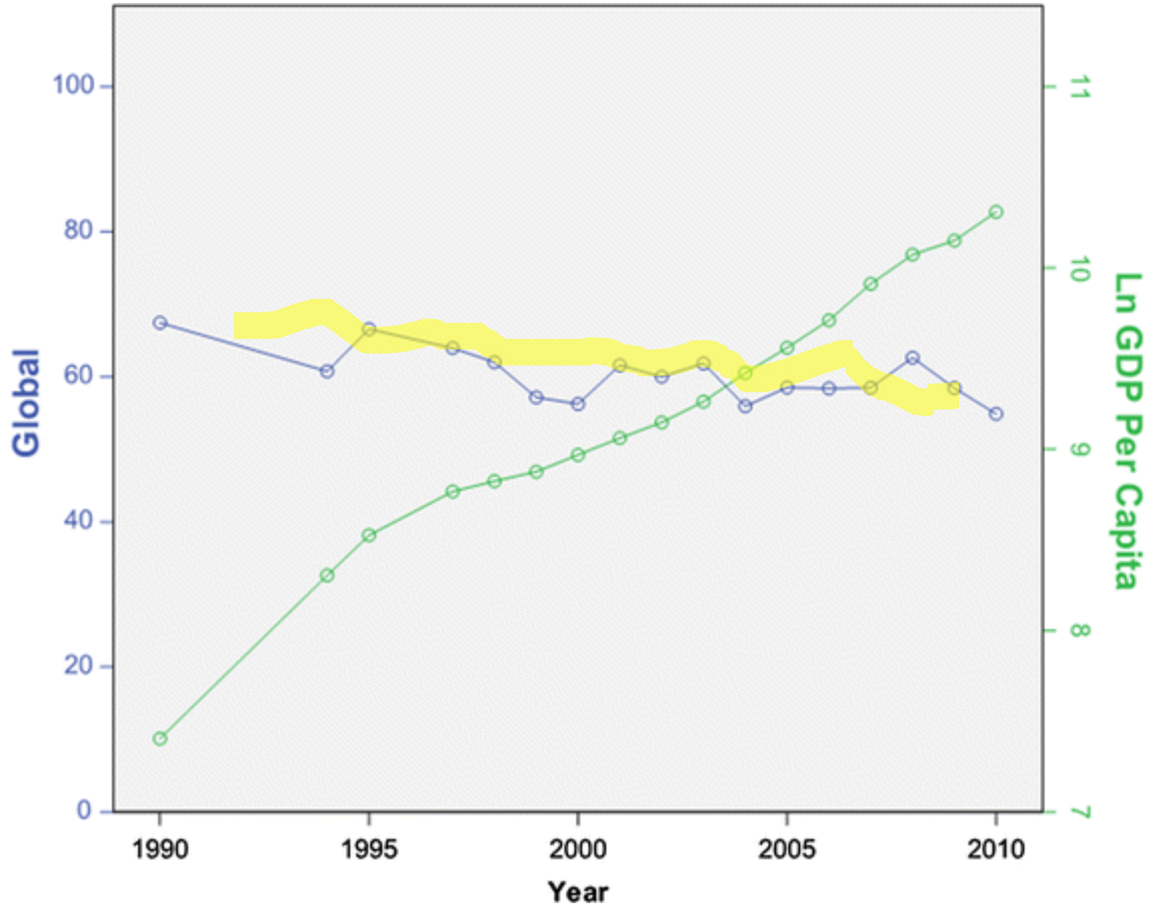
Source: National Footprint and Biocapacity Accounts, 2022 Edition
data.footprintnetwork.org

Global Footprint Network
Advancing the Science of Sustainability

Easterlin Paradox



The Easterlin paradox is an empirical relationship observed between measures of overall subjective well-being (such as life satisfaction or happiness) and income first noted by Richard Easterlin (1974). In Easterlin's original article, he observed that, although higher incomes are associated with higher levels of happiness within a country, average levels of happiness for a country do not appear to increase over time in line with increases in average income. In other words, the rich are happier than the poor, but there is no evidence that countries increase in average happiness as they get richer



The trends in Ln GDP per capita and global happiness in China (1990–2011). *Source*: Why Economic Growth did not Translate into Increased Happiness: Preliminary Results of a Multilevel Modeling of Happiness in China Jiayuan Li Social Indicators Research volume 128, pages241–263 (2016)