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The Bioeconomy, Climate Change, and Sustainable Development

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Plenary Session I

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Outline

- Bioeconomy – a transition to a “sustainable” future
- Climate Relevance
- Sustainable Development Relevance
- Integrated Systems for a Sustainable Bioeconomy
  - Technologies and Innovation
  - Sustainability Dimensions along the value chains
- Conclusions

GLOBAL BIOECONOMY SUMMIT 2015

Bioeconomy Policies around the World

German Bioeconomy Council, http://gbs2015.com/documentation

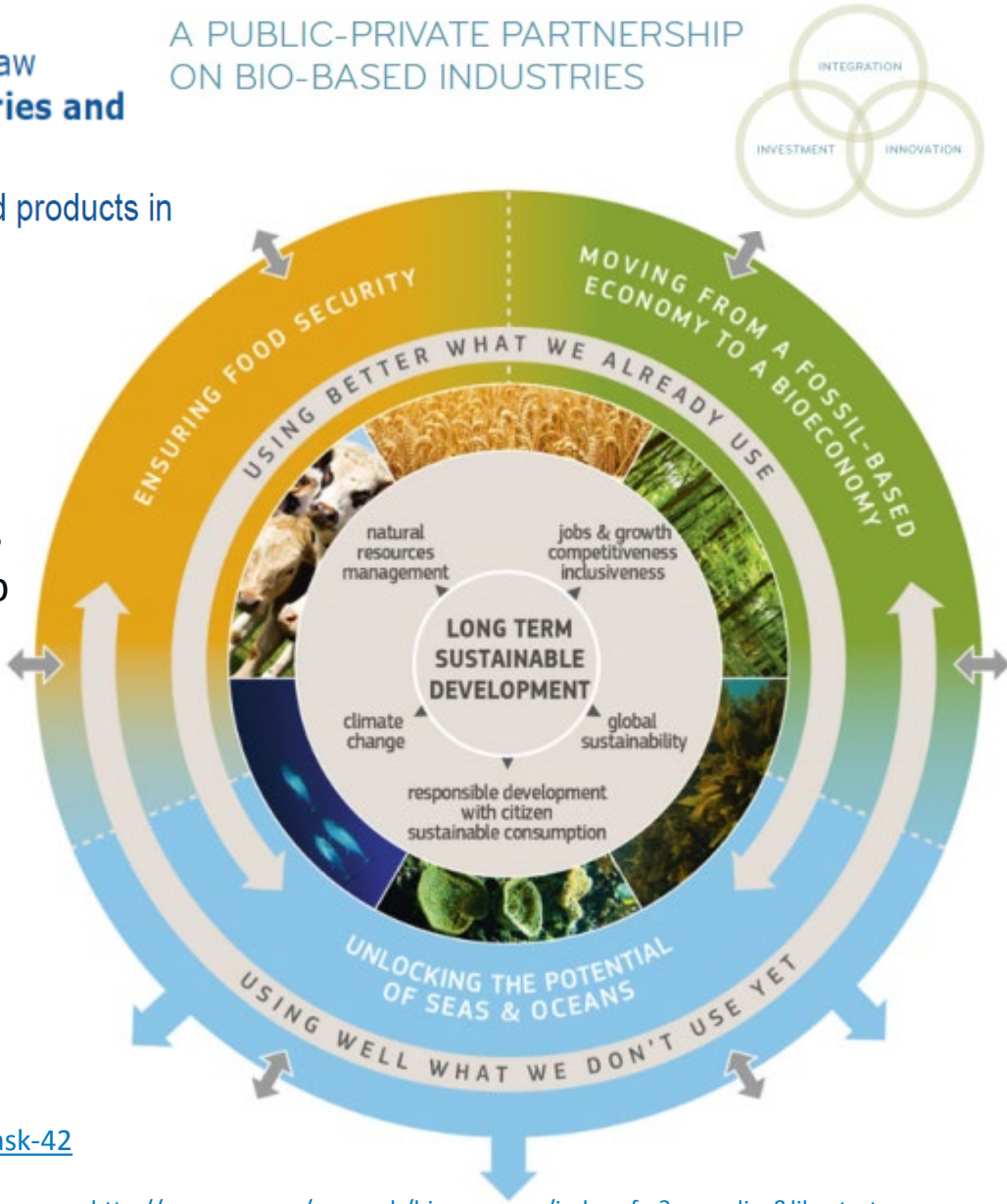
European Union

The Bioeconomy

Using research and innovation to produce renewable raw materials sustainably in **agriculture, forestry, fisheries and aquaculture**...

...and to process renewable raw materials into value added products in the **food, bio-based and energy industries**.

A PUBLIC-PRIVATE PARTNERSHIP ON BIO-BASED INDUSTRIES



Bioeconomy is the production of biomass and the conversion of biomass into value added products, such as food, feed, bio-based products and bioenergy. It includes the sectors of agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. Reference: EU Bioeconomy Communication COM(2012)60

EU Bioeconomy		
	10^{12} $	**10^{6} jobs**
2009 (a)	24.9	21.5
2012 (b)	32.7	21.9

(a) http://www.ieabioenergy.com/wp-content/uploads/2013/10/Task-42-Biobased-Chemicals-value-added-products-from-biorefineries.pdf

b) EnvironmentalDevelopment15(2015)3–34

http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy

Bioeconomy Vision evolved from 2002 to present

Executive Office of the President

Putting the Bioeconomy Blueprint to Work

April 26, 2012

- **Expanding biobased products purchasing program**
- **Building support for biofuel production facilities**
- **Growing the economy and rural jobs by supporting biomass production**

U.S. Agency Activities – Sustainable Bioeconomy

"The global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security benefits."

Agency	Feedstock Supply	Biomass Conversion	Bioenergy Distribution	Bioenergy End Use
DOE - Energy	● ● ● ●	● ● ● ● ●	● ● ●	● ● ● ● ●
USDA - Agriculture	● ● ● ● ●	● ● ● ●	● ● ● ● ●	● ● ● ●
DOT - Transportation	● ● ● ●	● ● ●	● ● ● ● ●	● ● ● ● ●
EPA- Environmental Protection	● ● ● ● ●	● ● ● ● ●	● ● ● ● ●	● ● ● ●
DOI- Interior	● ●	●		
NSF-National Science Foundation	● ● ●	● ● ● ●	●	
DOD-Defense		● ●	● ● ● ●	● ● ● ●

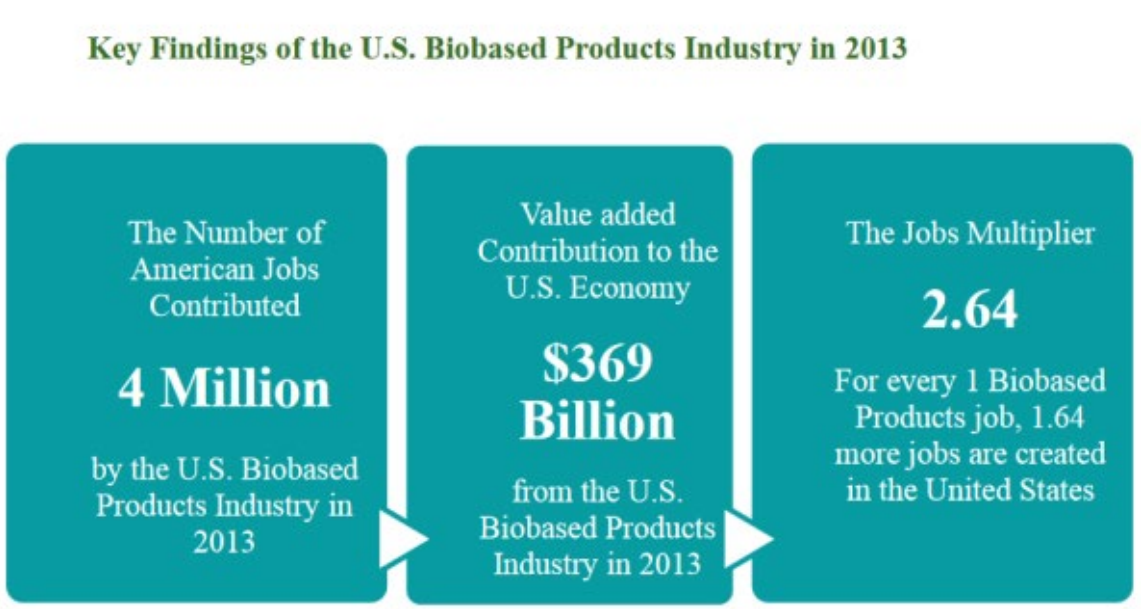
● Use an integrated systems approach
● Provide the science and the technology
● Public and private collaboration to overcome barriers and accelerate deployment
● Develop a workforce for the future bioeconomy
● Understand and inform policy

http://biomassboard.gov/pdfs/farb_2_18_16.pdf

Biobased Products

- Agriculture and Forestry
- Biorefining
- Biobased Chemicals
- Enzymes
- Bioplastic Bottles
  And Packaging
- Forest Products
- Textiles

Excludes energy, livestock, food, feed, pharmaceuticals



U.S. program adds value and jobs across all states

The term 'biobased product' as defined by Farm Security and Rural Investment Act (FSRIA), means a product determined by the U.S. Secretary of Agriculture to be a commercial or industrial product (other than food or feed), that is composed in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials.

BioPreferred®

The USDA BioPreferred® Program

Golden, J.S., Handfield, R.B., Daystar, J. and, T.E. McConnell (2015). An Economic Impact Analysis of the U.S. Biobased Products Industry: A Report to the Congress of the United States of America. A Joint Publication of the Duke Center for Sustainability & Commerce and the Supply Chain Resource Cooperative at North Carolina State University.

Voluntary Consumer Label

http://www.biopreferred.gov/BPResources/files/EconomicReport_6_12_2015.pdf
http://biomassboard.gov/pdfs/tac_2015_q3_handfield.pdf

Estimated current and 2030 potential U.S. bioeconomy

Bioeconomy Parameter	2014 Current	~2030 Potential
Biomass Utilization	406 million dry tons*	1130 million dry tons**
Total requirement (including supply chain losses)	439 million dry tons	1228 million dry tons
Biofuels Production	16 billion gallons (128 million dry tons)	52 billion gallons (701 million dry tons)
Biopower Production (EIA)	53 billion kWh 1363 TBtu (257 million dry tons)	78 billion kWh 1376 TBtu (292 million dry tons)
Livestock Anaerobic Digestion	3 billion kWh 11 TBtu (10 million dry tons)	27 billion kWh 90 TBtu (88 million dry tons)
Biochemicals Production	1.1 billion pounds (3 million dry tons)	13.1 billion pounds (34 million dry tons)
Wood Pellet Production	15 billion pounds (8 million dry tons)	31 billion pounds (15 million dry tons)

* Current biomass utilization is derived from uses in 2014 using various sources: EIA, EPA RFS, USDA
** 2030 potential utilization is derived from projections using various sources: EIA, EPA RFS, USDA

http://energy.gov/sites/prod/files/2016/01/f28/QTR2015-7A-Bioenergy-Conversion_0.pdf

BETO: Supporting Innovation across the Supply Chain

Research, Development, Demonstration, & Market Transformation

Feedstock Supply & Logistics R&D

- Terrestrial
- Algae
- Preprocessing
- Logistics

Conversion R&D

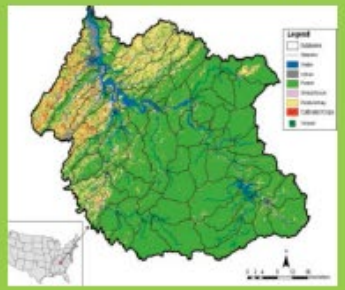
- Biochemical
- Thermochemical
- Deconstruction
- Upgrading

Demonstration & Market Transformation

- Integrated Biorefineries
- Biofuels Distribution Infrastructure

Cross Cutting

Sustainability



Strategic Analysis

Strategic Communications

BIO ENERGY
U.S. DEPARTMENT OF ENERGY
2016

[Bioenergy 2016: Mobilizing the Bioeconomy through Innovation](#)
Washington, DC, July 12–14, 2016

Interagency Cooperation

Defense Production Act (DPA) Initiative

US DOD, DOE, and collaborators

Company	Location	Feedstock	Capacity	Off-Take Agreements
EMERALD BIOFUELS	Gulf Coast	Fats and Greases	82 MM g/y	TBD
Fulcrum BIOENERGY	McCarran, NV	MSW	10 MM g/y	UNITED, CATHAY PACIFIC
RED ROCK BIOFUELS	Lakeview, OR	Woody Biomass	12 MM g/y	SOUTHWEST AIRLINES

Aviation **Biofuels w/ USDA**

ARPA-E

Agro-Energy Goal: Sustainable, Economical, Crop Production

FOOD – FUEL – FEED - FIBER

Context:

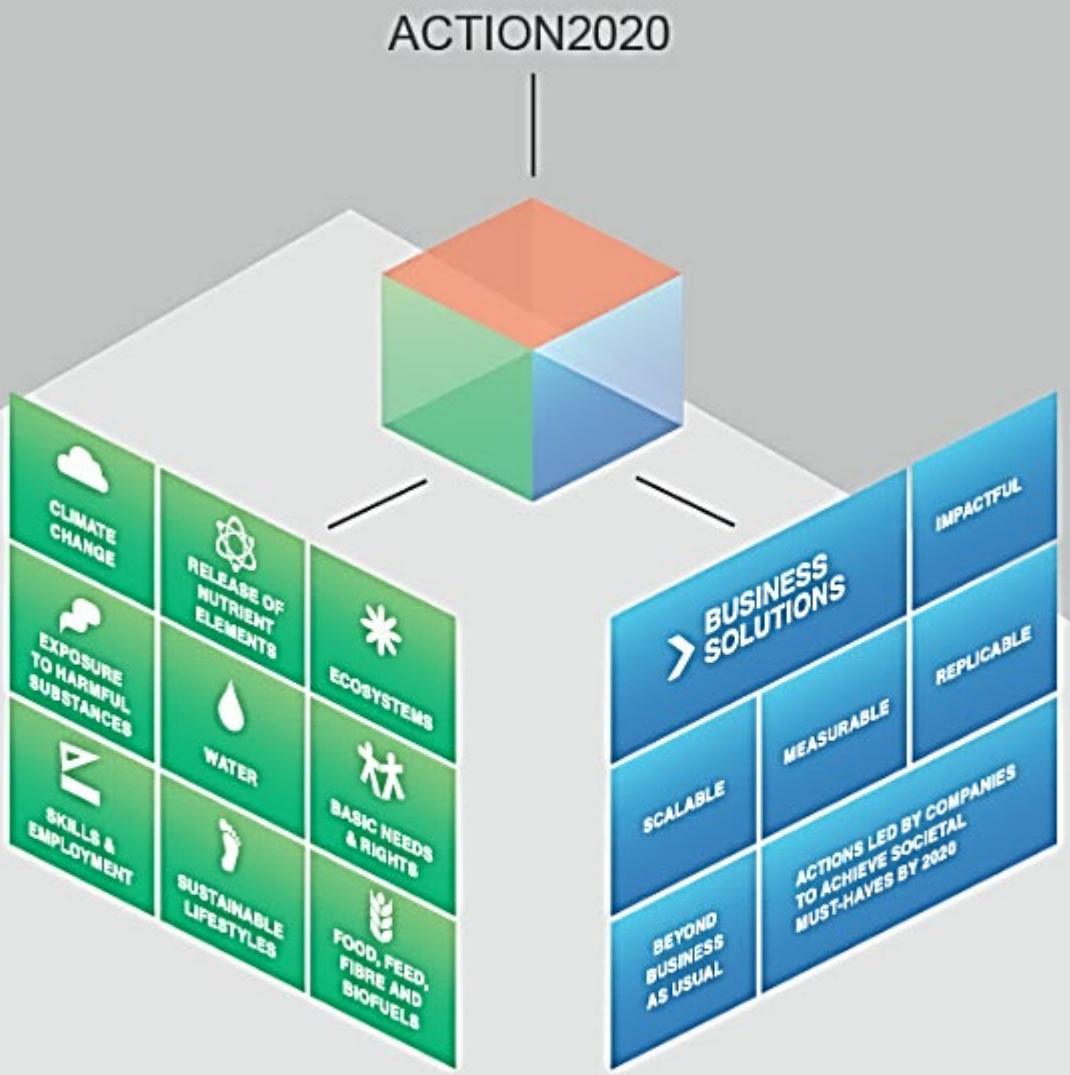
Economic		Environment		Natural Resources	
Food	Energy	Climate	Greenhouse Gas	Fresh Water	Soil Carbon
Demand Doubles		2°C	9.9 GtC	70% H_2O	120 GtC

National Science Foundation
WHERE DISCOVERIES BEGIN

Innovations at the Nexus of Food, Energy and Water Systems

Action2020 is a platform for business to take action on sustainable development to 2020 and beyond.

Through collaboration toward common goals, business can address some of the critical environmental and social problems the world faces while strengthening their own resilience to global challenges.



PRIORITY AREAS
Action2020 focuses on Nine Priority Areas, each with their own challenges and objectives – the Societal Must-Haves.

BUSINESS SOLUTIONS
Business Solutions are impactful, measurable, scalable, replicable and beyond business-as-usual. Leveraging the power of business to solve problems – to create Business Solutions.

LCTPi
Led by wbcsd Low Carbon Technology Partnerships initiative

If fully implemented, the proposed solutions could mitigate approximately 6 Gt of CO_2 emission per annum. This is equivalent to 15% of annual global emissions.

Leadership Statement

OUR STATEMENT OF AMBITION IS TO:

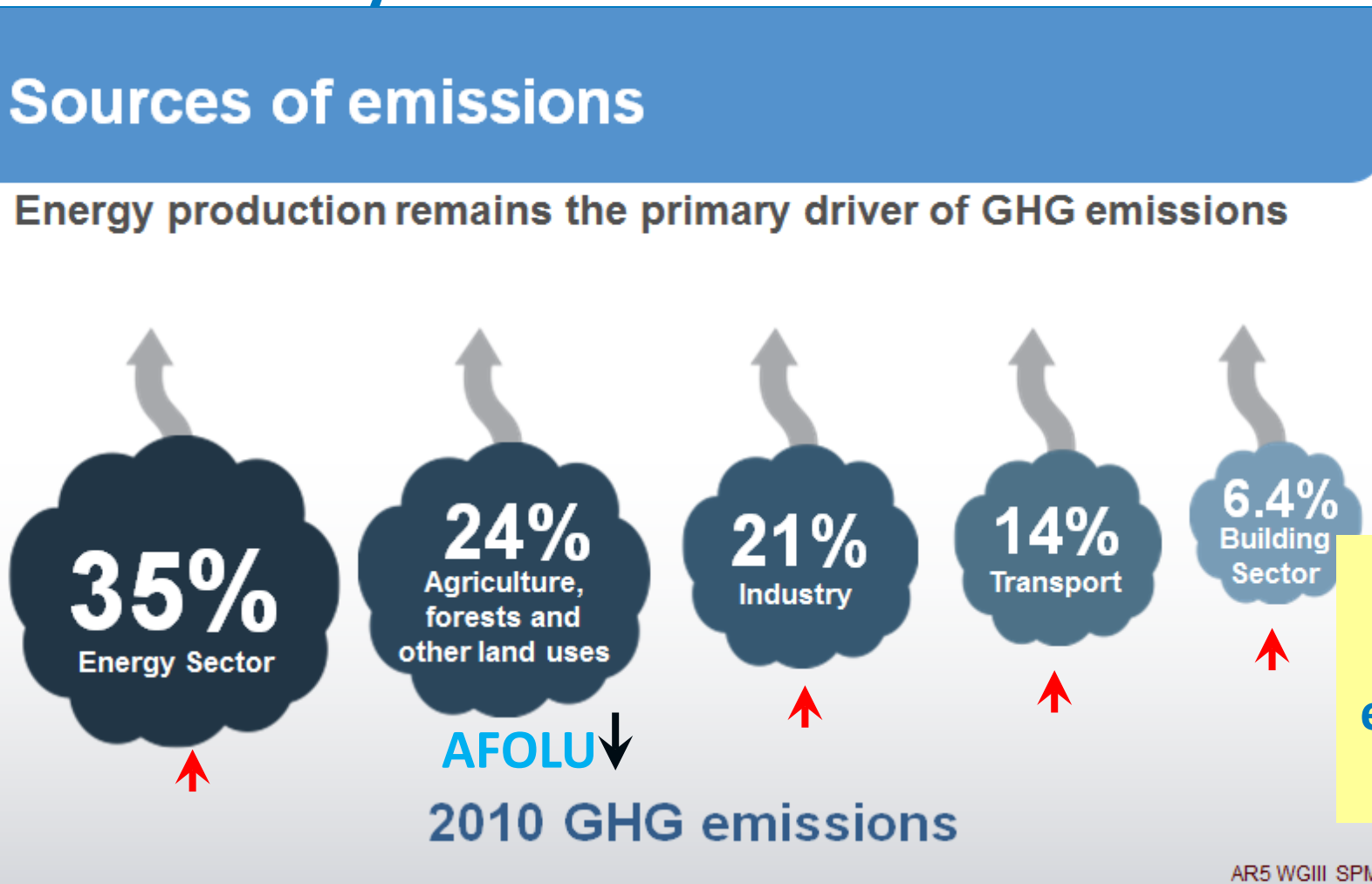
- **Bring the world's forests under sustainable management to:**
  - **stabilize forest cover by 2030; and**
  - **restore forest cover to 1990 levels by 2050**
- **Meet the tripling global demand for forest products from sustainably managed forests by 2050**
- **Fast-track development of the bio-economy through cross-sector and value chain collaboration**

The solutions for sustainable production and consumption that we proposed reflect the need to increase yields and forest carbon stocks over the long-term. The solutions are grouped into three priority action areas:

1. Sustainable forest management (SFM)
2. Forest products and the bio-economy
3. Resource efficiency and breakthrough technologies

http://lctpi.wbcsd.org/portfolio-item/forests/
also Climate Smart Agriculture in this Initiative within the Clean Energy Ministerial

Bioeconomy Relevance to Climate



IPCC Sectors emissions trend

Global Anthropogenic Emissions

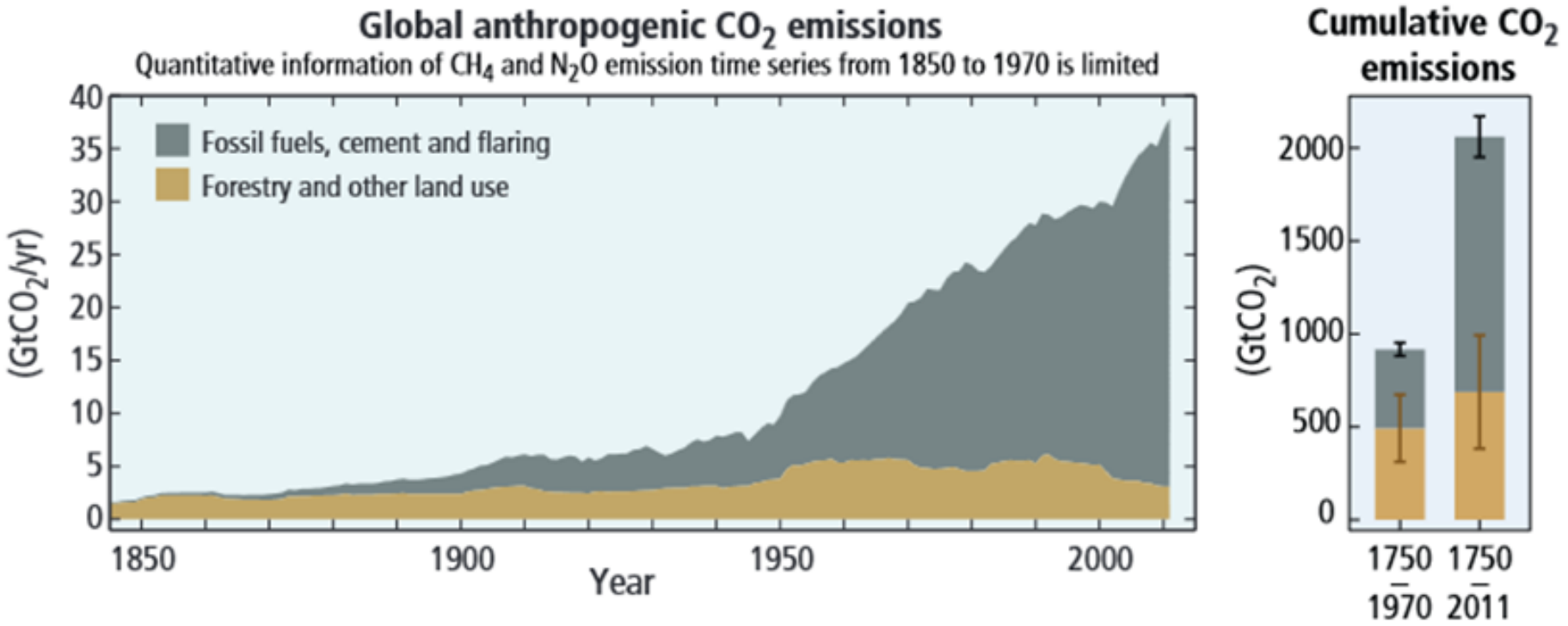
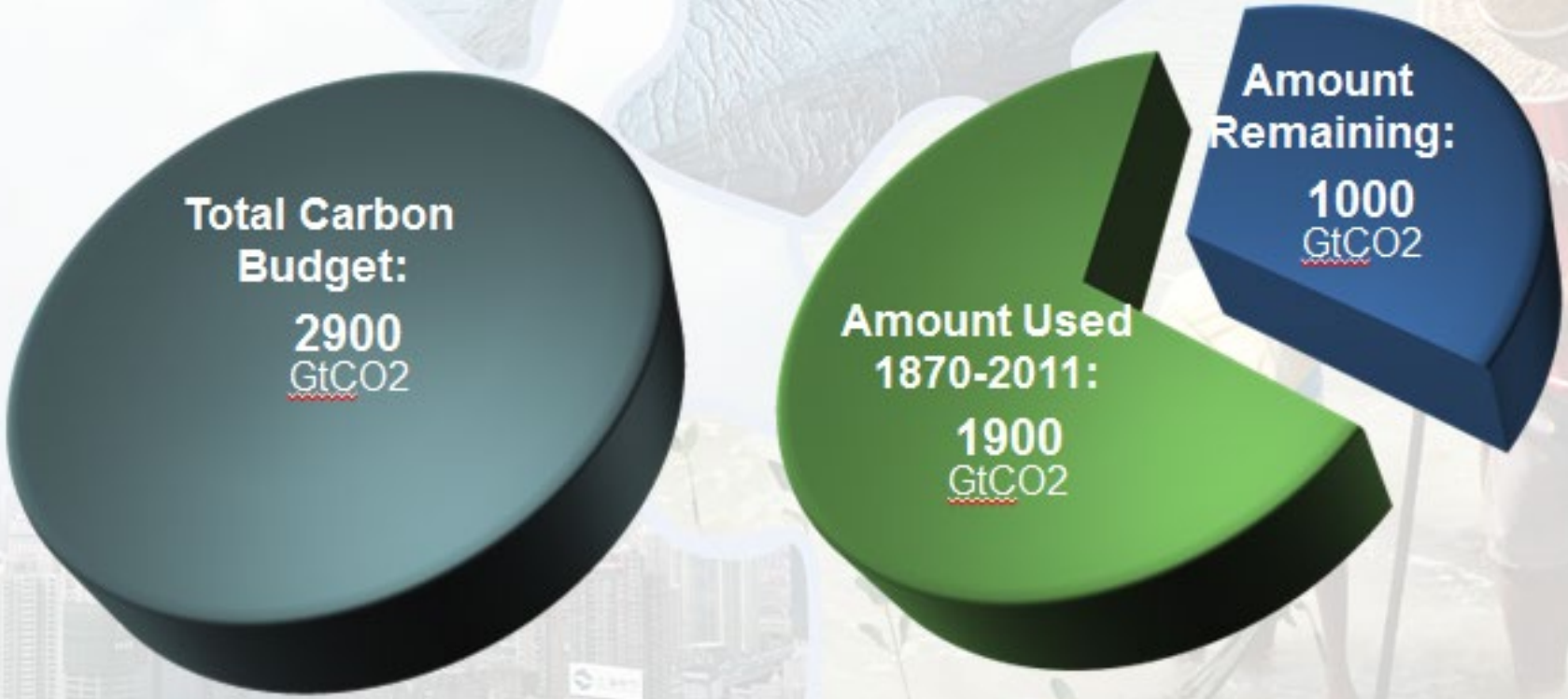


Figure SPM 1. of Synthesis Report

http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf

The window for action is rapidly closing

65% of our carbon budget compatible with a 2° C goal already used

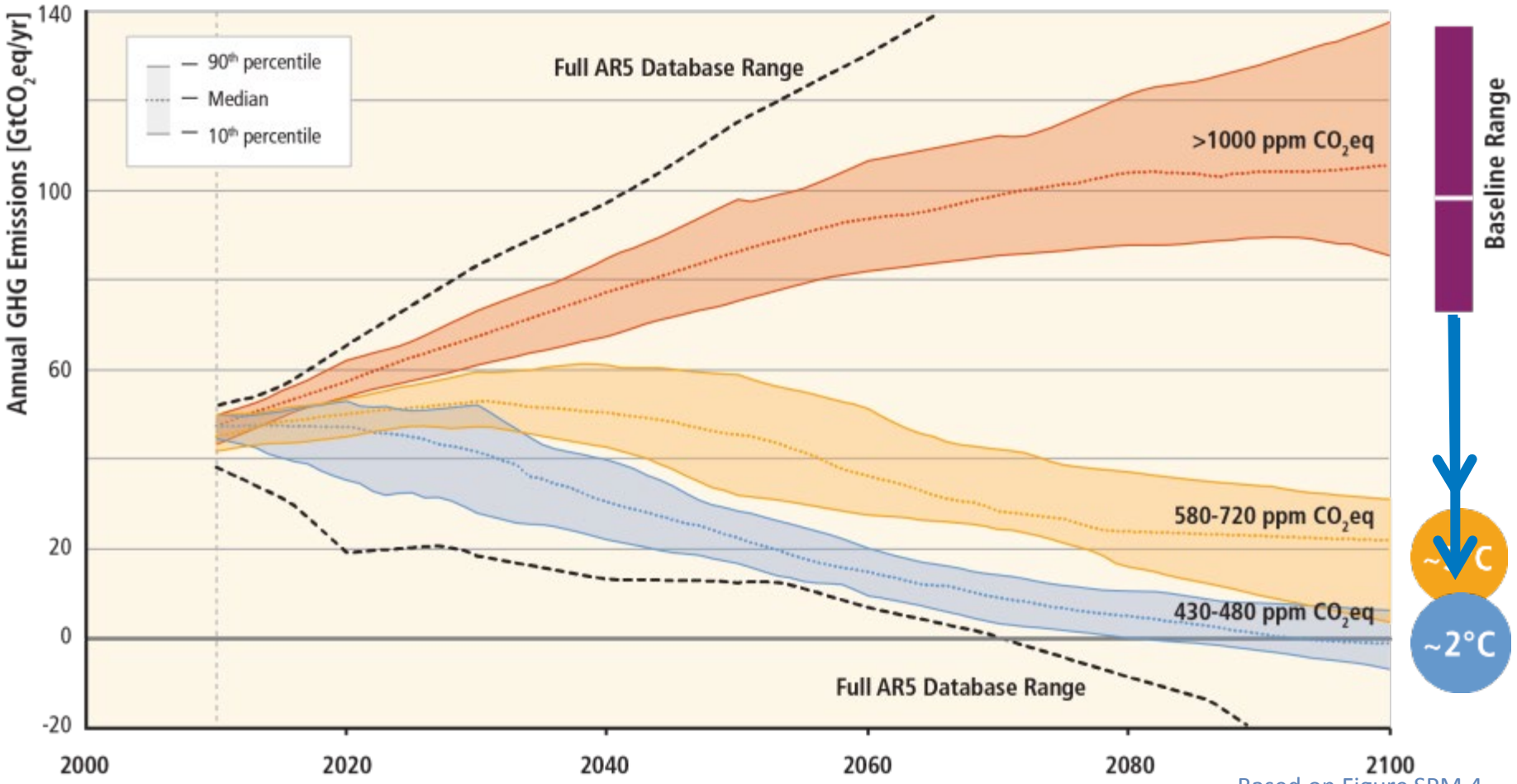


AR5 WGI SPM

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Lower ambition mitigation goals require similar reductions of GHG emissions.



Based on Figure SPM.4

Mitigation Measures

More efficient use of energy

Greater use of low-carbon and no-carbon energy

- Many of these technologies exist today

Improved carbon sinks

- Reduced deforestation and improved forest management and planting of new forests
- Bio-energy with carbon capture and storage

Negative Emissions

Lifestyle and behavioral changes

AR5 WGIII SPM

Global Sustainable Bioeconomy

UN Agenda 2030

- Enabler of Several Global Sustainable Development Goals
  - Multiple Interlinked Dimensions
  - Nexus of Land, Water, Agriculture, Forestry, Energy, Chemicals, other Industries, Rural and Urban residue management
- High Efficiency Resource use is key – which resource?
  - Sustainable production and consumption patterns, e.g. for bioeconomy along multiple products/applications

Green ⇨ Sustainable Technologies

IMPORTANT

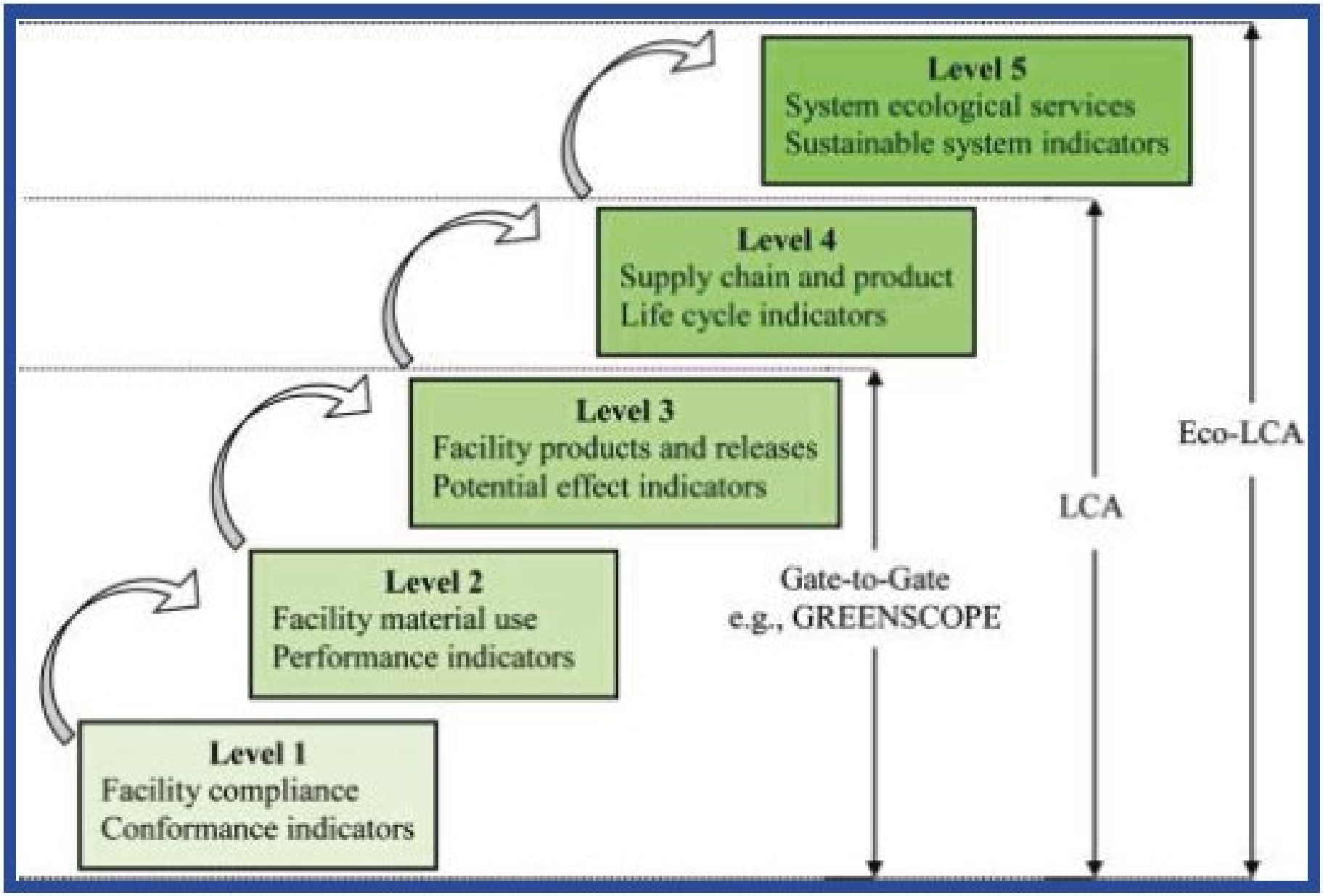
Green Chemistry Principles

1. Waste prevention instead of remediation
2. Atom efficiency
3. Less hazardous/toxic chemicals
4. Safer products by design
5. Innocuous solvents and auxiliaries
6. Energy efficient by design
7. Preferably renewable raw materials
8. Shorter syntheses (avoid derivatization)
9. Catalytic rather than stoichiometric reagents
10. Design products for degradation
11. Analytical methodologies for pollution prevention
12. Inherently safer processes

Green Engineering Principles

P – Prevent wastes
R – Renewable materials
O – Omit derivatization steps
D – Degradable chemical products
U – Use of safe synthetic methods
C – Catalytic reagents
T – Temperature, Pressure ambient
I – In-Process monitoring
V – Very few auxiliary substrates
E – E-factor, maximize feed in product
L – Low toxicity of chemical products
Y – Yes, it is safe

Sheldon, R. A., Fundamentals of green chemistry: efficiency in reaction design. Chemical Society Reviews 2012, 41, (4), 1437-1451

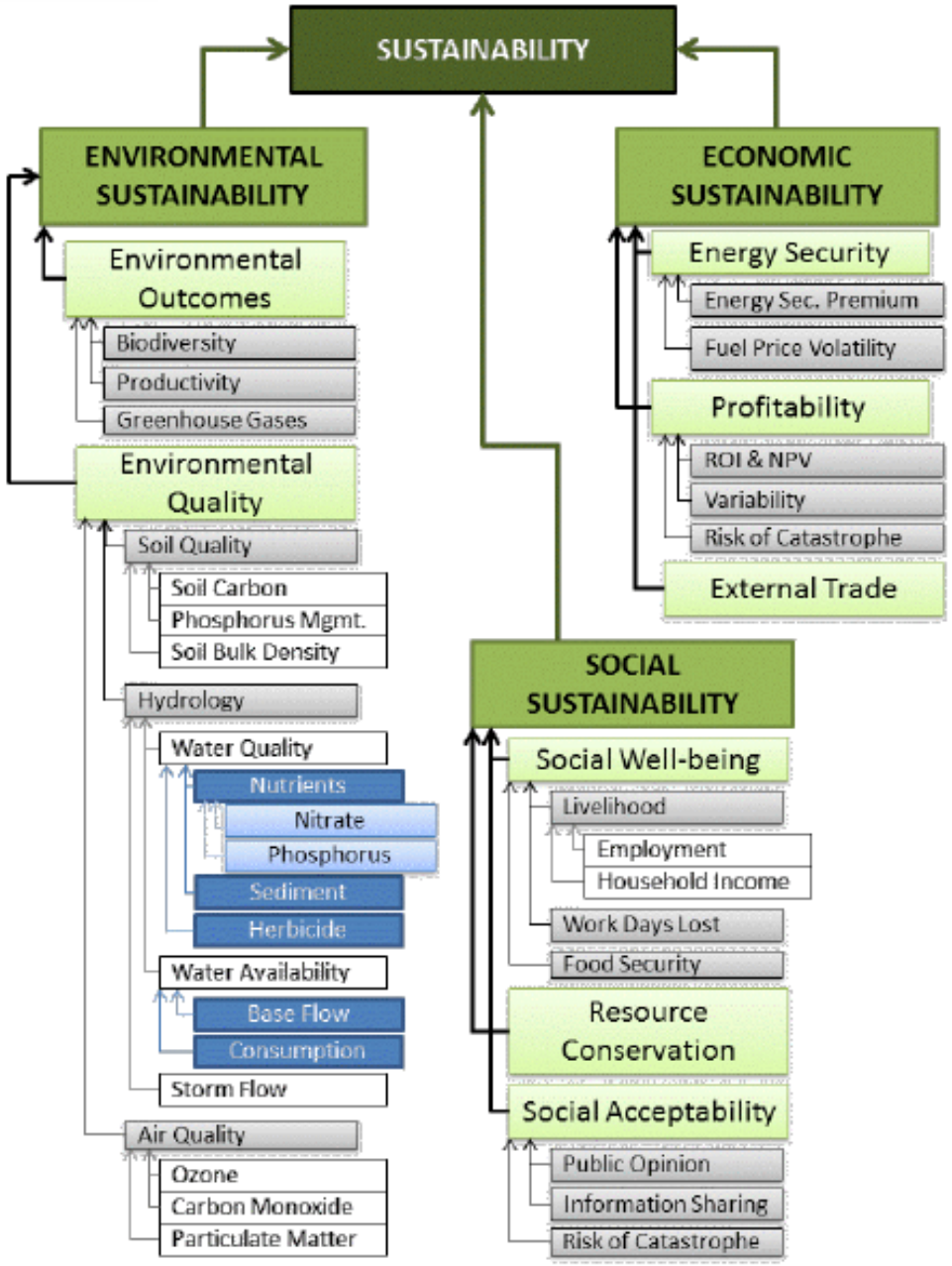

Level 5
System ecological services
Sustainable system indicators
Level 4
Supply chain and product
Life cycle indicators
Level 3
Facility products and releases
Potential effect indicators
Level 2
Facility material use
Performance indicators
Level 1
Facility compliance
Conformance indicators
Gate-to-Gate
e.g., GREENSCOPE
LCA
Eco-LCA

https://www.basf.com/us/en/company/sustainability/management-and-instruments/quantifying-sustainability/seebalance.html

BASF

SITE and CONTEXT SPECIFIC ESSENTIAL for large and small scales

Ester Parish, Virginia Dale,
Oak Ridge National Laboratory
http://www.ornl.gov/sci/ees/cbes/



GLOBAL IMPACT

The Corbay Commission (Netherlands)

"The content of the concept of sustainability will change and be refined in the course of time, and policy and sustainability criteria will have to be modified to follow suit.

Sustainability is not a static achievement but a dynamic learning process.

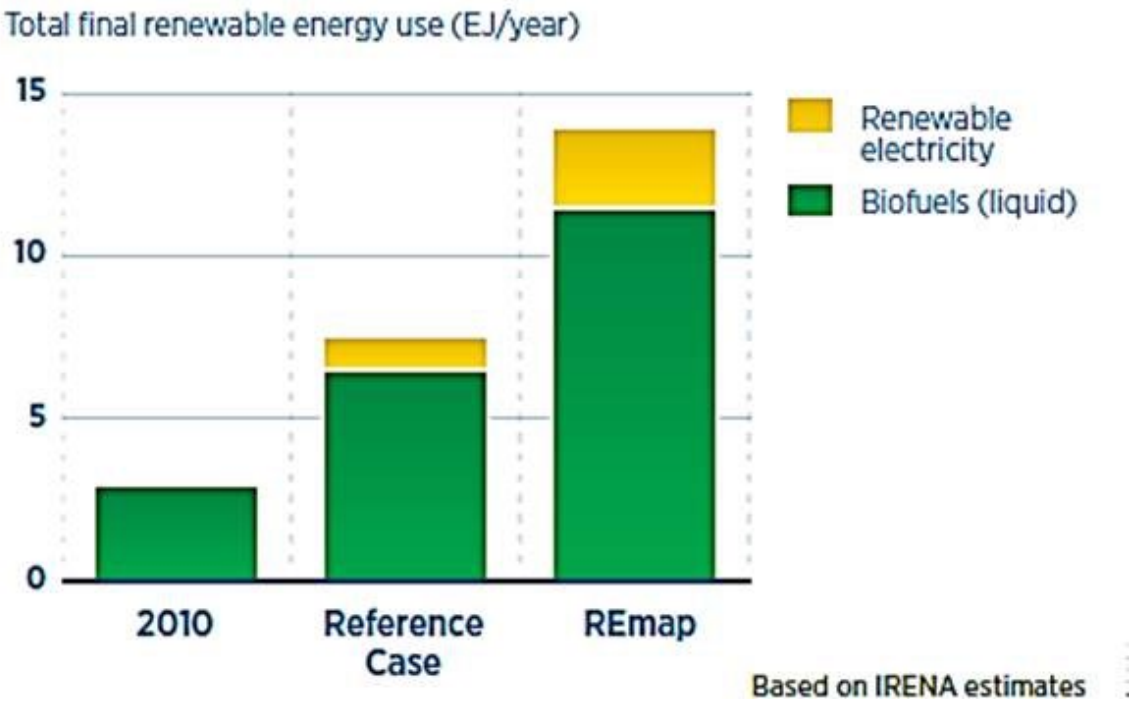
New topics and new questions will arise all the time."

Conclusions for unleashing global bioeconomy

- Systems' thinking needed
- Sustainable biomass production underpins all applications – it is context dependent
  - Integrated assessment of social, environmental, economic aspects of biomass production on landscape, watershed, local economy and associated supply systems
- Many dimensions to measure sustainability. Process of selecting meaningful dimensions and parameters and indicators continues
- Technology developers and users awareness and engagement in these assessments is important for product acceptability, market development, and contribution to sustainable development.
- High efficiency of resource use is a requirement
- Sustainable Energy for All UN goals are ambitious for all countries

Sustainable Energy for All

Liquid biofuels account for 85% of the renewable energy use in transport, which represents a fourfold increase in their use by 2030 from 2014.



Renewable energy share must at least double over today's level of 18%. Half of renewable energy today is traditional uses of bioenergy, with the other half coming from modern renewable technologies. By 2030 the share of modern renewables could reach 36% which is a doubling over today's level. However because traditional uses of bioenergy are phased out during the period, the modern renewable energy share would quadruple.

http://www.irena.org/remap/

Acknowledgments
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http://www.nrel.gov/research_fellows/chum.html

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UN Agenda 2030