March 28, 2023

Transitioning the Chemical Industry: Towards Sustainable Chemicals and Materials

A webinar offered by the Sustainable Chemistry Catalyst

UMASS Lowell

Welcome!

- **Webinar goal:** Share insights and learnings from initiatives working to transition the chemical sector towards the production of safer and sustainable chemicals, materials and products.

- **Logistics:**
  - **Please keep your lines muted and your videos off.**
  - Use "**speaker view**" in Zoom – it will offer the best viewing experience.
  - if you wish to ask a question or offer a comment, please use the **chat**.
  - This webinar is being **recorded** and will be **posted** on www.sustainablechemistrycatalyst.org

Speakers

Algreit Dume, Economist
DG Grow, EU Commission

Beverly Thorpe, Consulting Program Manager
Clean Production Action

Joel Tickner, Professor
University of MA Lowell

Respondents

John Shaw, CEO
Itaconix

Ken Geiser, Professor Emeritus
University of MA Lowell

The Transition Pathway for the Chemical Industry

Webinar "Transitioning the Chemical Industry: Towards Sustainable Chemicals and Materials"
28 March 2023, online

European Commission

Outline

1. Background

2. The outcome

3. Co-implementation

1. Background

European Commission

The 2021 updated Industrial Strategy

COM(2021) 350 final

- To co-create, in partnership with industry, public authorities, social partners and other stakeholders, **transition pathways** for ecosystems, where needed.
- Pathways offer a better bottom-up understanding of the **scale**, **cost, long-term benefits and conditions** of the required action to accompany the **twin transition** for the most relevant ecosystems, leading to an actionable plan in favour of sustainable competitiveness.
- **Priority to** tourism and energy-intensive industries (incl. **chemicals** and steel).

2. The outcome

European Commission

The transition pathway for the Chemical Industry

- Publication: 27 January 2023;
- It is an actionable plan co-developed by the European Commission with EU countries, industry, NGOs and other stakeholders
- Based on 8 building blocks developed by Industrial Forum

Sustainable competitiveness | Investment and funding | Research and Innovation | Regulation and Public Governance | Access to energy and feedstock | Infrastructure | Skills | Social dimension

- It identifies about 190 actions, grouped in 26 topics, needed for the twin transition and increased resilience of the chemical industry

European Commission

Example: Sustainable Competitiveness

- **Relevance for EU economy**:
  - ✓ EU chemical industry 4th largest industry in Europe (€499 bln sales in 2020);
  - ✓ However, its global market share is declining and forecasted to decline;
  - ✓ Therefore, need to ensure industry's continued competitiveness becoming more sustainable.

What should the industry do? (some examples)

Topic 1: International competitiveness

➢ Drive international competitiveness
- Analyse medium to long-term impacts of energy crisis on sustainable competitiveness
- KPIs and Sustainable Development indicators

➢ Promote the market for sustainable products
- SSbD framework
- 'market pull' and incentives: sustainable products with higher costs

Topic 5: New synergies

➢ Facilitate the exchange of information
- Euroclusters initiative

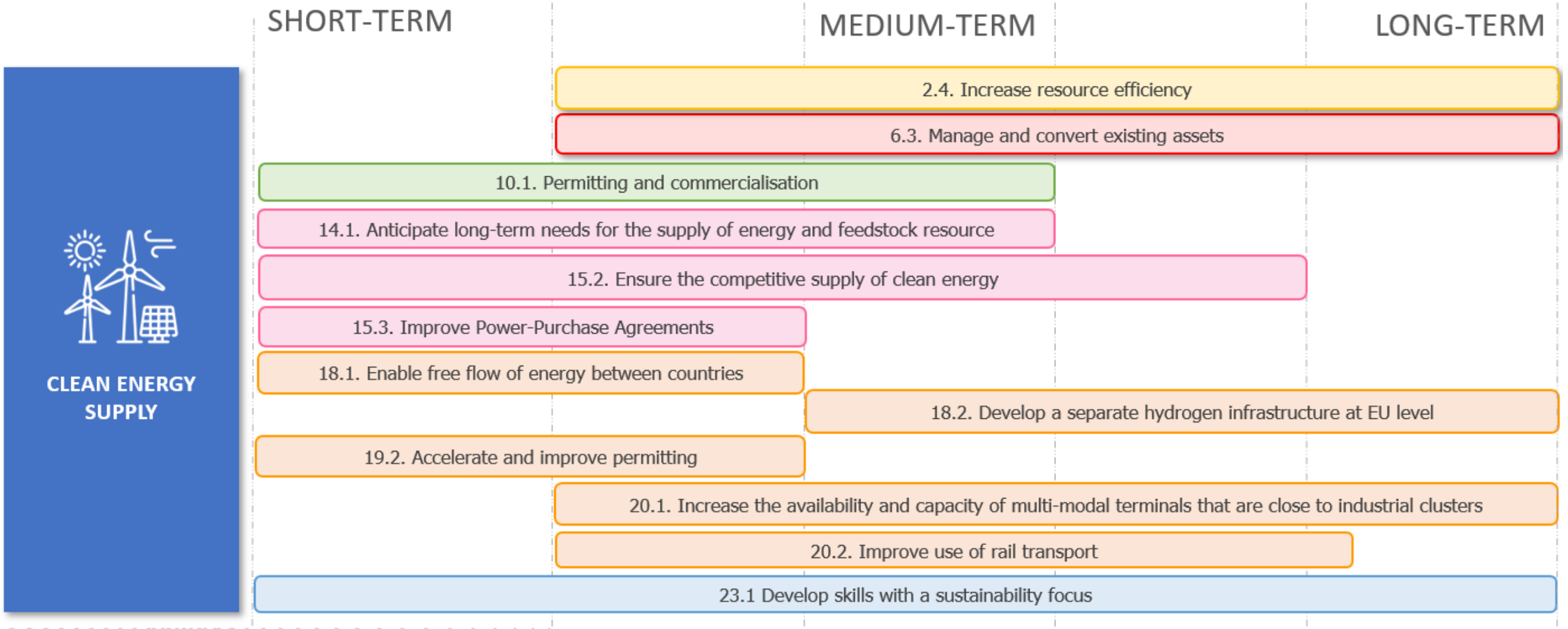
➢ Increase collaboration to de-risk investments
- cross-border projects on the generation and supply of energy and feedstock

➢ Partnerships for innovation
- Ensure shared access to the research and technology infrastructures as part of the European Research Area
- joint cross-sectoral projects that qualify IPCEIs

Topic 2: Reduction of unsustainable dependencies and supply-chain vulnerabilities

➢ Gather supply-chain information
- Undertake a strategic foresight exercise focusing on the EU open strategic autonomy (link with critical raw materials)
- Assess the need to build up and maintain strategic stocks of critical raw materials within the EU

Action-oriented roadmap – Clean energy supply



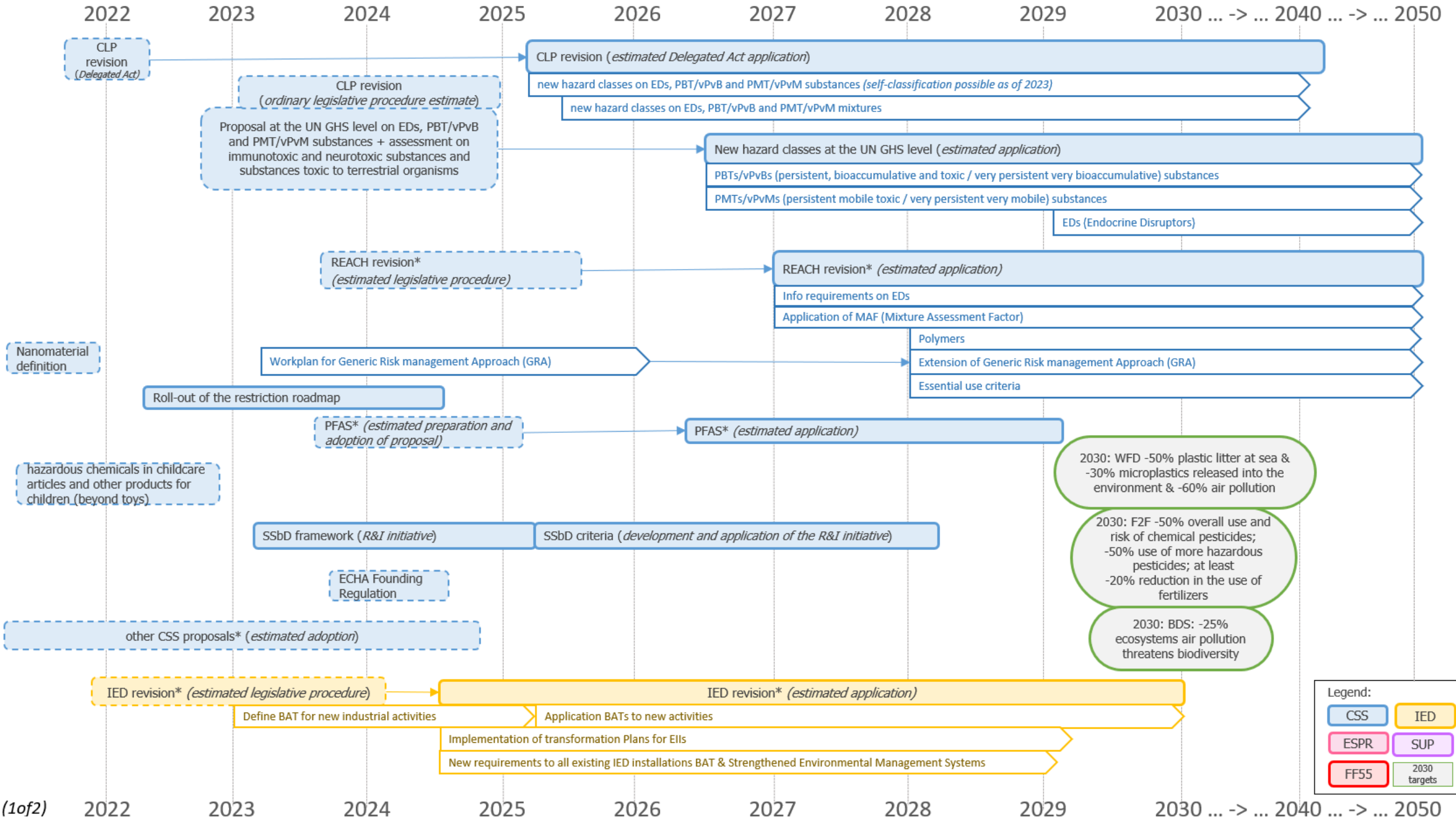
SUSTAINABLE COMPETITIVENESS
ACCESS TO ENERGY AND FEEDSTOCK
INVESTMENTS AND FUNDINGS
INFRASTRUCTURE
(SUPPORT TO) R&I, TECHNIQUES AND TECHNOLOGICAL SOLUTIONS
SKILLS
REGULATION AND PUBLIC GOVERNANCE (LEGISLATION)
SOCIAL DIMENSION

European Commission

Technology roadmap

EU Initiatives supporting Technological Transition *(SET Action Plan)*	Actions *(as presented in Building Blocks – Part II)*	EU Initiatives
A) ELECTRIFICATION	6.2. Develop hub structures 8.3. Development of an industrial technology roadmap 14. Anticipate l-t needs for the supply of energy and feedstock resource 15.1. Channel investments for clean energy 15.2. Ensure competitive supply of clean energy 15.3. Improve Power-Purchase Agreements 18.1 Enable the free flow of energy between countries 20.1. Increase availability and capacity of multi-modal terminals close to industrial clusters 20.2. Improve use of rail transport	• REPowerEU • EU Renewable Directive • TEN-E Regulation • Proposal for a directive on Energy Efficiency
B) HYDROGEN	6.2. Develop hub structures 6.3. Manage and convert existing assets 15.1. Channel investments for clean energy 15.2. Ensure the competitive supply of clean energy 18.2. Develop a separate hydrogen infrastructure at EU level	• European Clean Hydrogen Alliance • Hydrogen and decarbonised gas market package
C) BIOMASS	4.3. Strengthen initiatives with SMEs under the EIC 8.1. Promote safety and sustainability assessment approaches 9.1. Foster collaboration and partnerships 16.2. Biomass as an alternative feedstock 19.1. Develop recycling facilities and bio-refineries (and exploit synergies with the chemical industry)	• Revision of the Renewable Energy Directive • INCITE (Industrial Emissions Directive)
D) WASTE	3.2 Improve collaboration in value chains 3.3 Support product design and re-design 8.1. Promote safety and sustainability assessment approaches 11.1. Definitions and concepts 11.2. Methods 16.3. Waste as an alternative feedstock 22.1. Set a regulatory framework for the transport of waste 22.2. Improve the management of logistics for waste feedstock	• Hubs4Circularity • Waste Framework Directive • Landfill Directive
E) CCU & CCS	6.3. Manage and convert existing assets 9.2. Support for development 16.4. CO_2 as an alternative feedstock 22.2. Improve the management of logistics for waste feedstock	• Hubs4Circularity • Sustainable Carbon Cycle
F) PROCESS EFFICIENCY	3.2 Improve collaboration in value chains 3.3 Support product design and re-design 5.1. Facilitate exchange of information (new synergies) 5.3. Support the development of Partnerships for Innovation 6.3. Manage and convert existing assets 17. Process efficiency 19.1. Develop recycling facilities and bio-refineries (and exploit synergies with the chemical industry) 20.1. Increase the availability and capacity of multi-modal terminals that are close to industrial clusters 21.2. Deploy technologies to improve chemical manufacturing processes and data gathering 25.2. Safety and social security of workers	• REPowerEU • Industrial Symbiosis • Revision of the Industrial Emission Directive

European Commission


2022
2023
2024
2025
2026
2027
2028
2029
2030 ... -> ... 2040 ... -> ... 2050
CLP revision (Delegated Act)
CLP revision (estimated Delegated Act application)
new hazard classes on EDs, PBT/vPvB and PMT/vPvM substances (self-classification possible as of 2023)
new hazard classes on EDs, PBT/vPvB and PMT/vPvM mixtures
CLP revision (ordinary legislative procedure estimate)
Proposal at the UN GHS level on EDs, PBT/vPvB and PMT/vPvM substances + assessment on immunotoxic and neurotoxic substances and substances toxic to terrestrial organisms
New hazard classes at the UN GHS level (estimated application)
PBTs/vPvBs (persistent, bioaccumulative and toxic / very persistent very bioaccumulative) substances
PMTs/vPvMs (persistent mobile toxic / very persistent very mobile) substances
EDs (Endocrine Disruptors)
REACH revision* (estimated legislative procedure)
REACH revision* (estimated application)
Info requirements on EDs
Application of MAF (Mixture Assessment Factor)
Polymers
Nanomaterial definition
Workplan for Generic Risk management Approach (GRA)
Extension of Generic Risk management Approach (GRA)
Essential use criteria
Roll-out of the restriction roadmap
PFAS* (estimated preparation and adoption of proposal)
PFAS* (estimated application)
2030: WFD -50% plastic litter at sea & -30% microplastics released into the environment & -60% air pollution
hazardous chemicals in childcare articles and other products for children (beyond toys)
SSbD framework (R&I initiative)
SSbD criteria (development and application of the R&I initiative)
2030: F2F -50% overall use and risk of chemical pesticides; -50% use of more hazardous pesticides; at least -20% reduction in the use of fertilizers
ECHA Founding Regulation
2030: BDS: -25% ecosystems air pollution threatens biodiversity
other CSS proposals* (estimated adoption)
IED revision* (estimated legislative procedure)
IED revision* (estimated application)
Define BAT for new industrial activities
Application BATs to new activities
Implementation of transformation Plans for EIIs
New requirements to all existing IED installations BAT & Strengthened Environmental Management Systems
Legend:
CSS
IED
ESPR
SUP
FF55
2030 targets
(1of2)
2022
2023
2024
2025
2026
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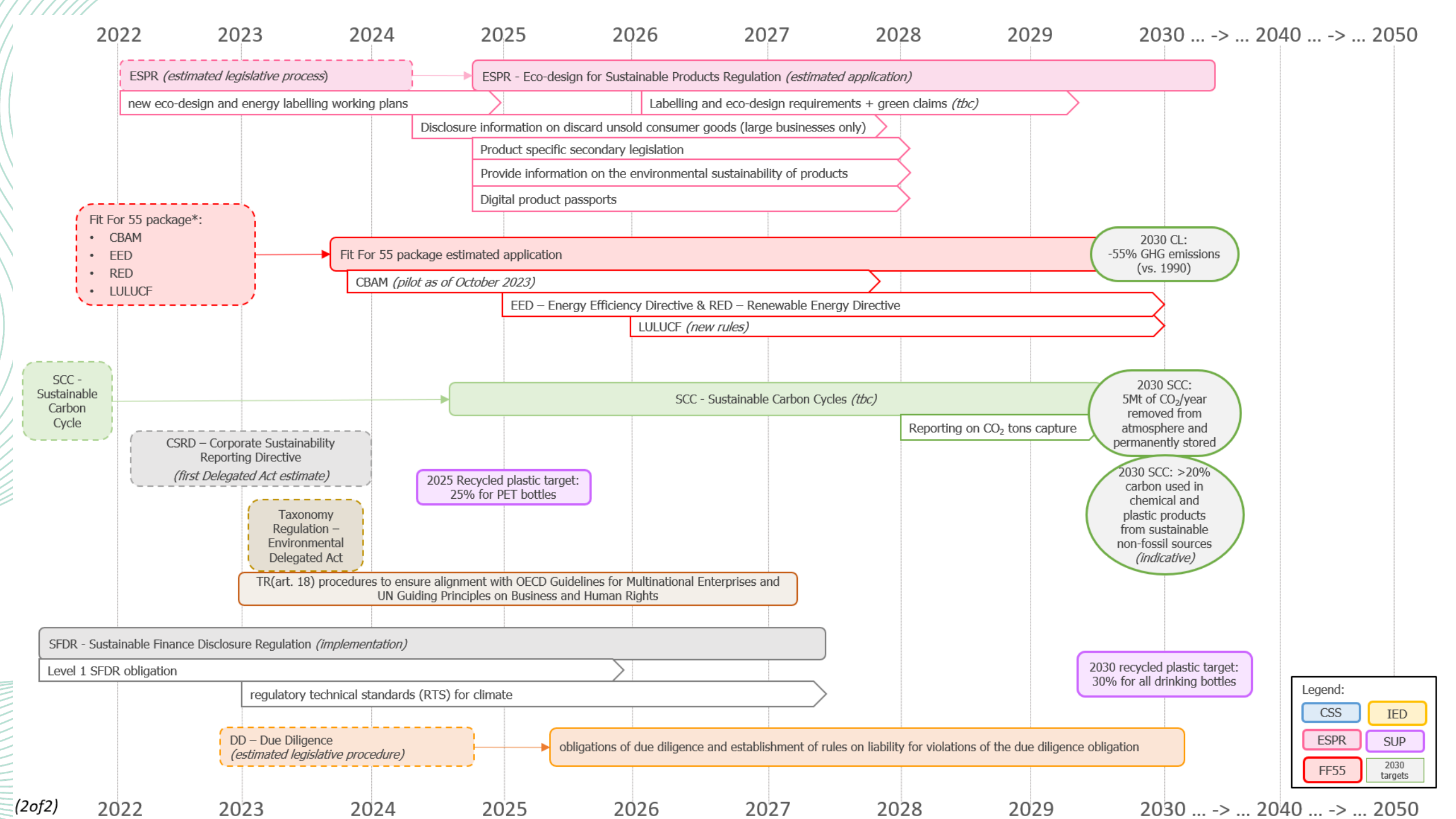
2029
2030 ... -> ... 2040 ... -> ... 2050


2022
2023
2024
2025
2026
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2028
2029
2030 ... -> ... 2040 ... -> ... 2050
ESPR (estimated legislative process)
ESPR - Eco-design for Sustainable Products Regulation (estimated application)
new eco-design and energy labelling working plans
Labelling and eco-design requirements + green claims (tbc)
Disclosure information on discard unsold consumer goods (large businesses only)
Product specific secondary legislation
Provide information on the environmental sustainability of products
Digital product passports
Fit For 55 package*:
CBAM
EED
RED
LULUCF
Fit For 55 package estimated application
2030 CL: -55% GHG emissions (vs. 1990)
CBAM (pilot as of October 2023)
EED – Energy Efficiency Directive & RED – Renewable Energy Directive
LULUCF (new rules)
SCC - Sustainable Carbon Cycle
SCC - Sustainable Carbon Cycles (tbc)
2030 SCC: 5Mt of CO2/year removed from atmosphere and permanently stored
Reporting on CO2 tons capture
CSRD – Corporate Sustainability Reporting Directive
(first Delegated Act estimate)
2025 Recycled plastic target: 25% for PET bottles
2030 SCC: >20% carbon used in chemical and plastic products from sustainable non-fossil sources (indicative)
Taxonomy Regulation – Environmental Delegated Act
TR(art. 18) procedures to ensure alignment with OECD Guidelines for Multinational Enterprises and UN Guiding Principles on Business and Human Rights
SFDR - Sustainable Finance Disclosure Regulation (implementation)
Level 1 SFDR obligation
regulatory technical standards (RTS) for climate
2030 recycled plastic target: 30% for all drinking bottles
DD – Due Diligence
(estimated legislative procedure)
obligations of due diligence and establishment of rules on liability for violations of the due diligence obligation
Legend:
CSS
IED
ESPR
SUP
FF55
2030 targets

(2of2)

3. Co-implementation

European Commission

Key elements of the Transition Pathway co-implementation process

Calls for pledges

Main objectives

- Encouraging stakeholders to take concrete initiatives to implement the actions of the Pathway
- Collect data to inform the monitoring and evaluation process

Interaction with stakeholders

Main objectives

- Establishing the governance of the process
- Setting priorities

Monitoring and Evaluation

Main objectives

- Develop KPIs to monitor and assess the actions for the twin transition

Publications: Annual progress report

Main objectives

- Assessing the status quo of the co-implementation
- Providing evidence on the actions taken and possible synergies among stakeholders

European Commission

First co-implementation meeting on 6th March

Main discussion points

Governance of the co-implementation process

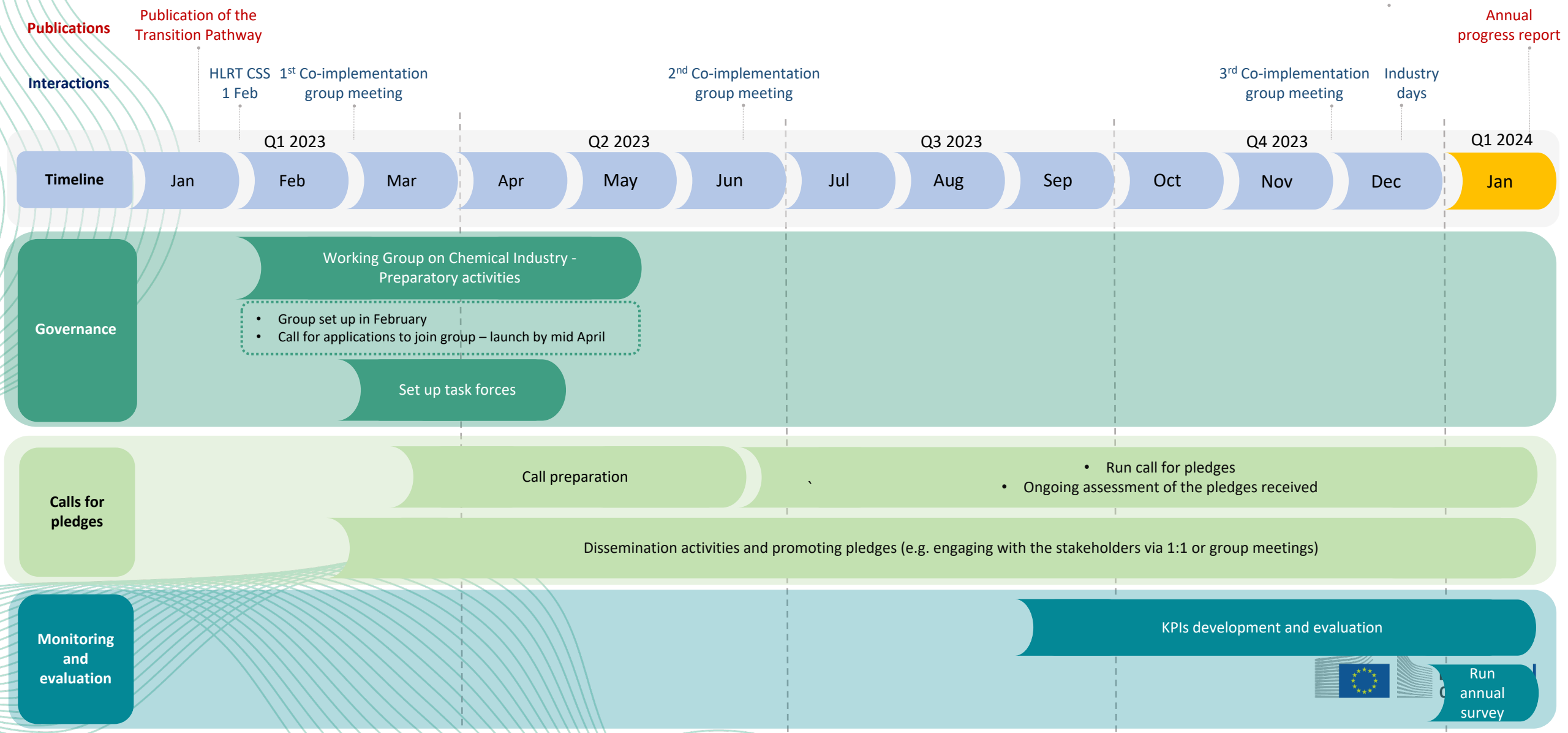
- An expert group – *"the Working Group on Chemical Industry"* – has been set up to discuss and facilitate cooperation among stakeholders.
- Stakeholders agreed to set up three task forces dealing with priority topics, specifically:
  - *International Competitiveness;*
  - *Anticipate long-term needs for the supply of energy and feedstock resources;*
  - *Circularity: recycling and re-use of infrastructure*.
- Each task force will focus on the following horizontal topics: the role of SMEs; regulatory predictability; skills for the twin transition and the development of KPIs.

Next steps

- Call for applications to join the "*Working Group on Chemical Industry":* launch by mid April
- First task forces' meetings: end of April 23
- Second co-implementation meeting on 22 June 23
- Third co-implementation meeting on 9 December 23

European Commission

Indicative timeline, Co-implementation in 2023



Thank you!

European Commission

‘Require Safer Substitutes and Solutions for a Non-Toxic Economy’

Bev Thorpe – Consultant Program Manager, Clean Production Action – March 28, 2023

The Louisville Charter is a roadmap to fundamentally transform the chemical industry

https://comingcleaninc.org/louisville-charter/endorse

- Endorsed by 125 organizations
- The charter was updated in 2021 to clarify the chemical industry transition roadmap, highlight this industry’s contribution to the climate crisis; advance environmental justice in impacted communities and prevent false solutions

The energy/chemicals/plastics link needs more scrutiny – consumption needs to be cut

Plastics consume 70% of petrochemicals; and 90% of all Chemicals of High Concern.

https://www.cleanproduction.org/resources/entry/plastics-scorecard-resource

Communities in the US are opposing proposed plastics expansion and promoting transition planning for workers

By 2050, 50 percent of the growth in oil demand will be related to plastics production, surpassing that for transport.

International scientists call for cap on production and release of chemicals

NEWS | 19 January 2022

Safe planetary boundary for pollutants has been exceeded, study finds

CHEMICAL SECTOR TRANSFORMATION WILL REQUIRE A HAZARD-FIRST APPROACH IN ALL DECISION MAKING

- redesigning chemical products and systems to reduce both carbon and chemical footprints
  - Decarbonize **and** Detoxify

- altering production processes and substituting with intentionally safer, low hazard alternatives throughout the lifecycle – beginning with feedstock chemicals

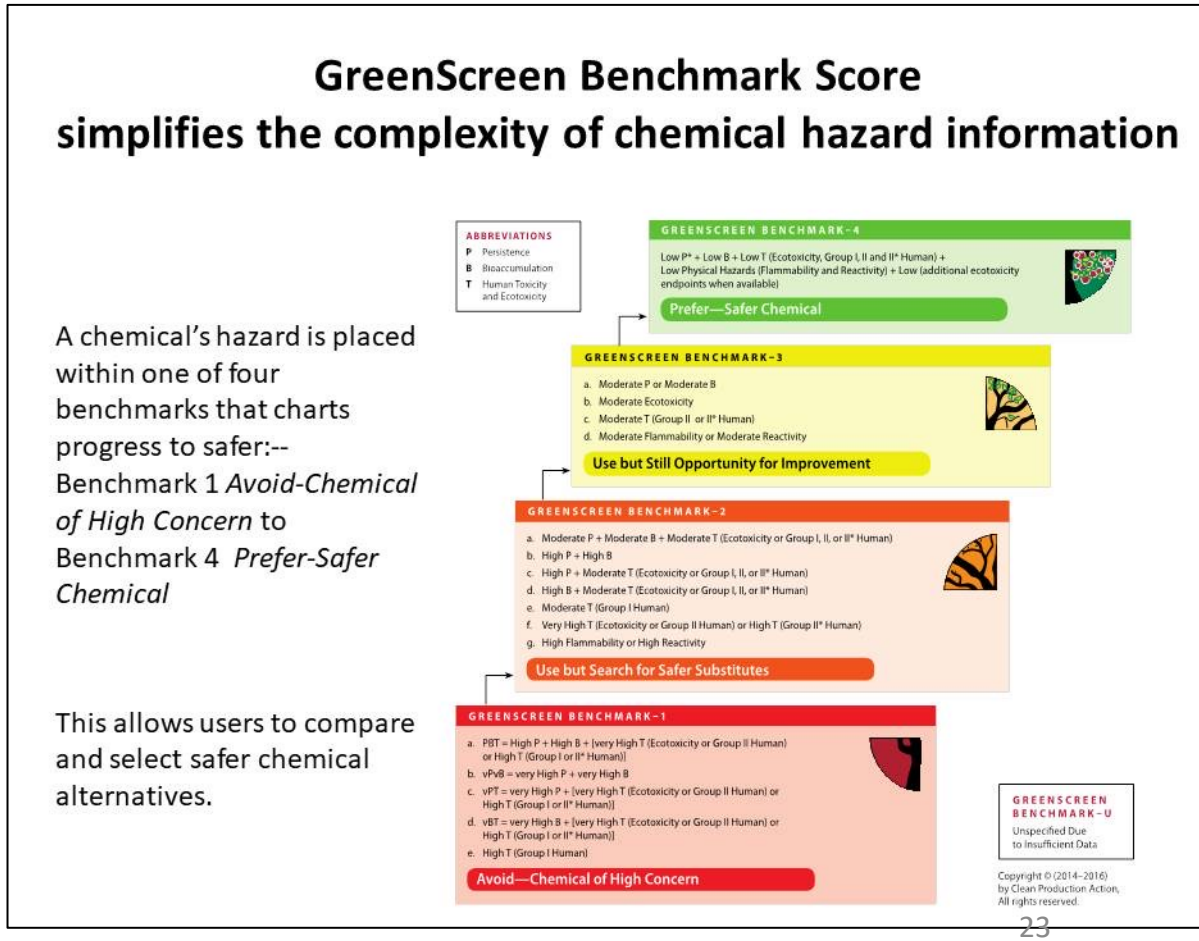
Safer alternatives needed for majority of current petrochemical building block chemicals

Currently seven building block chemicals are the basis for 90 percent of organic petrochemical production.

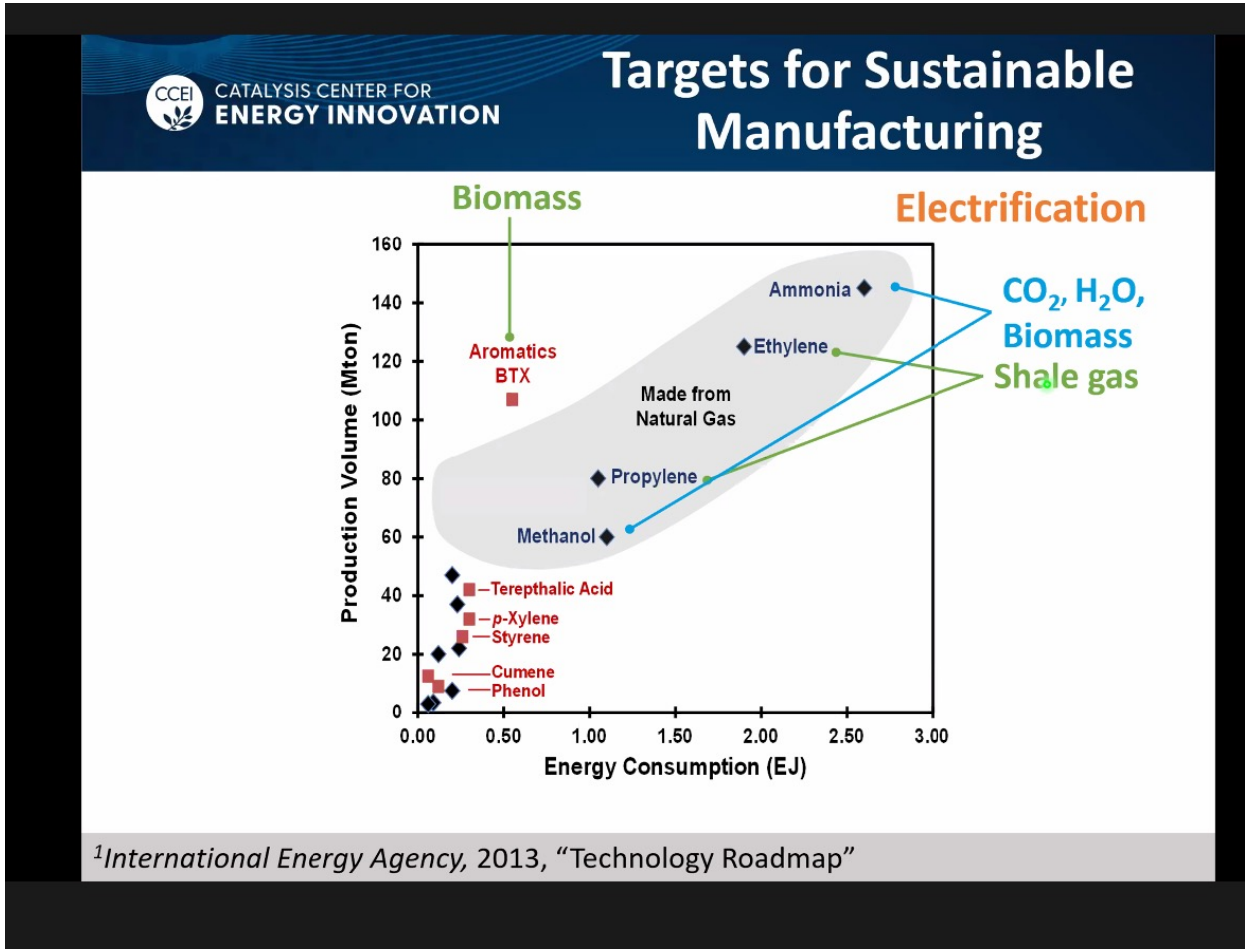
GreenScreen hazard assessments reveal five are Benchmark-1 chemicals 'chemicals of high concern' -- and two are Benchmark-2 'use but search for safer substitutes.'

The 7 platform chemicals are:

- **methanol**;
- olefins—**ethylene, propylene**, and **butadiene**;
- aromatics— **benzene, toluene, and xylene.**



Using Biobased carbon to make hazardous feedstock chemicals is not sustainable



[1]*International Energy Agency,* 2013, "Technology Roadmap"

R&D being directed into fossil-free carbon for manufacturing chemicals

- These include non arable biomass, lignocellulose, algae, chitin, biocrude from sewage and food waste, and carbon from CO2 capture

But there is no 'joined-up' focus on detoxifying --resulting in same hazardous chemicals production and use

Funding and R&D needs a Hazard-First focus to avoid false solutions:

- “We introduce a … framework that determines the most profitable processes to produce benzene, toluene, and/or xylenes from biomass via methanol.”
- https://pubs.acs.org/doi/10.1021/acs.energyfuels.6b00619

- **benzene, toluene, and xylene are all chemicals of high concern**
- There is no ‘green benzene’

Ensure roadmaps to a circular economy prioritize chemical hazard reduction and full material disclosure to avoid false solutions.

Biobased Polyvinyl Chloride (PVC) – is certified by the Roundtable on Sustainable Biomaterials – but lacks consideration of chemical hazard

Advancing the transition to a bio-based and circular economy

The Roundtable on Sustainable Biomaterials (RSB) provides collaborative partnerships, innovative solutions and trusted certification for a just and sustainable transition to a net positive world.

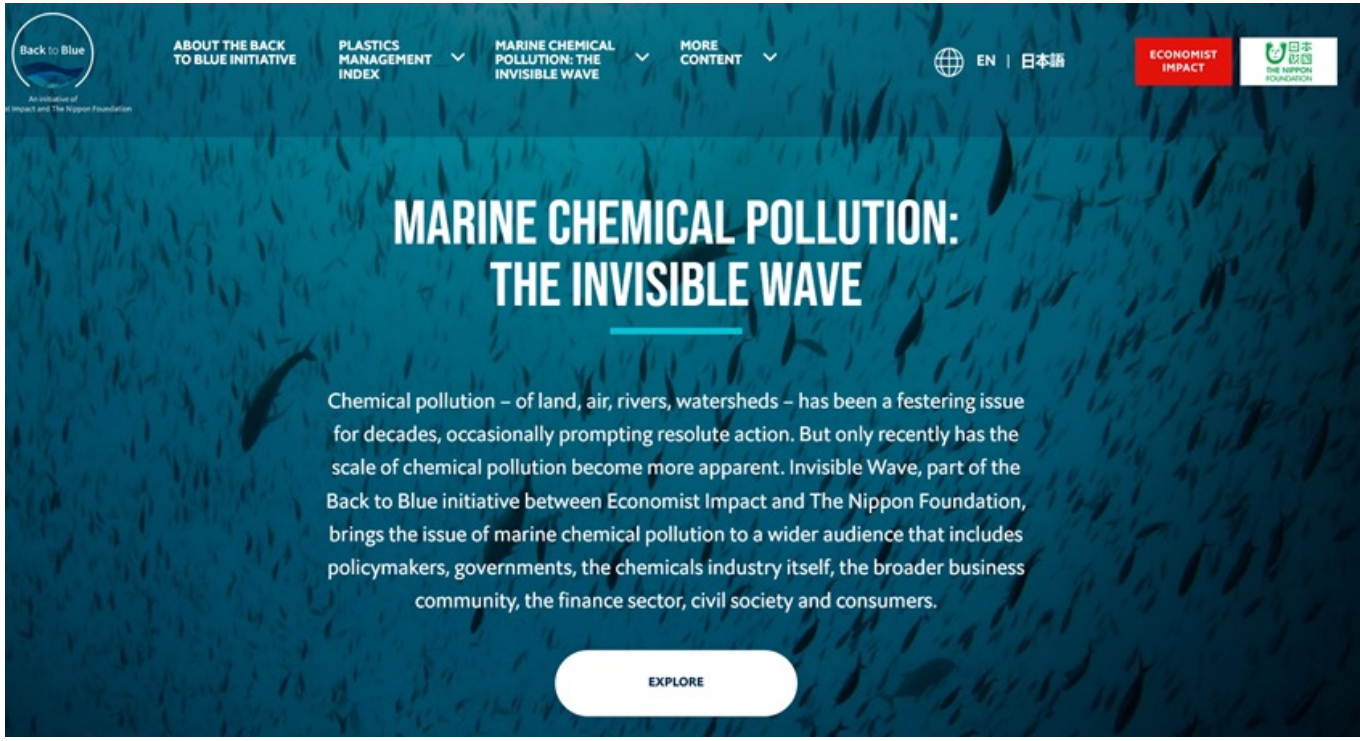
‘Bio-naphtha’ is still a high hazard chemical;

vinyl chloride monomer and additives used in PVC lifecycle are chemicals of high concern

Reward and incentivize innovation in safer chemicals production through financial incentives

Investors, financial bodies and regulators keen to support protection of biodiversity and environmental justice could:

- remove $20 billion/year subsidies on fossil fuel developments and reallocate to safer chemical design
- tax the use of hazardous chemicals;
- integrate chemical footprint reduction goals and investment in safer chemicals into all ESG reporting
- Outline a just transition plan for impacted workers and communities during the transition



Ocean Business Action Platform has developed a set of Sustainable Ocean Principles. Major investment funds are working with the UN Global Compact to support companies using the principles as a reporting mechanism.

Scale benefits to local communities through smaller-scale, decentralized, and modular chemical and material manufacturing facilities

Principles of Green Engineering

- "Actively engage communities and stakeholders in development of engineering solutions"

Local communities need to be at the table from the beginning of any proposal for new chemical production facilities.

"Producing the same cancer-causing chemical with wood pulp instead of fossil fuels won't help fenceline communities. Those facilities are still going to be in our backyard. The real solution is to stop producing chemicals that cause cancer, and move all production away from where human beings live." – Louisville resident

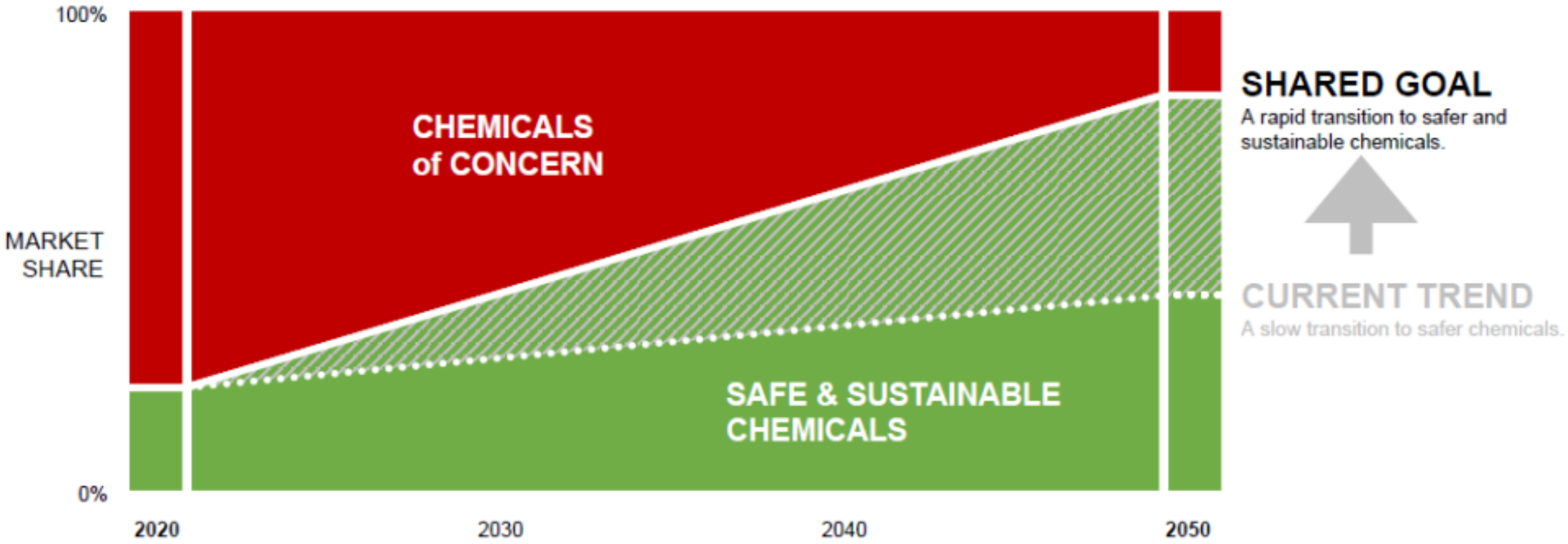
Needs and Opportunities: Transitioning the Chemical Sector

Joel Tickner
Sustainable Chemistry Catalyst
Lowell Center for Sustainable Production, University of Massachusetts Lowell

March 28, 2023

The Big Goal

To accelerate the transition to safe and sustainable chemicals.



Rethinking chemistry requires engaging the entire value chain

https://www.tandfonline.com/doi/full/10.1080/00139157.2022.2021793?scroll=top&needAccess=true

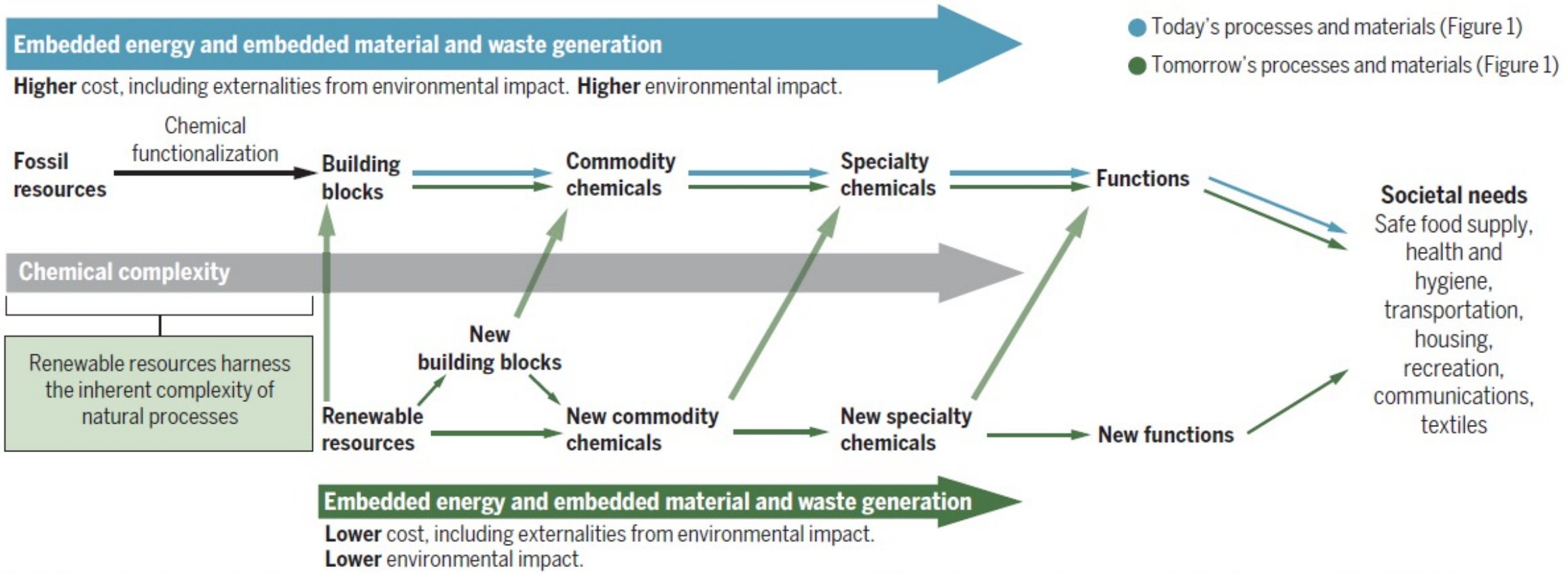
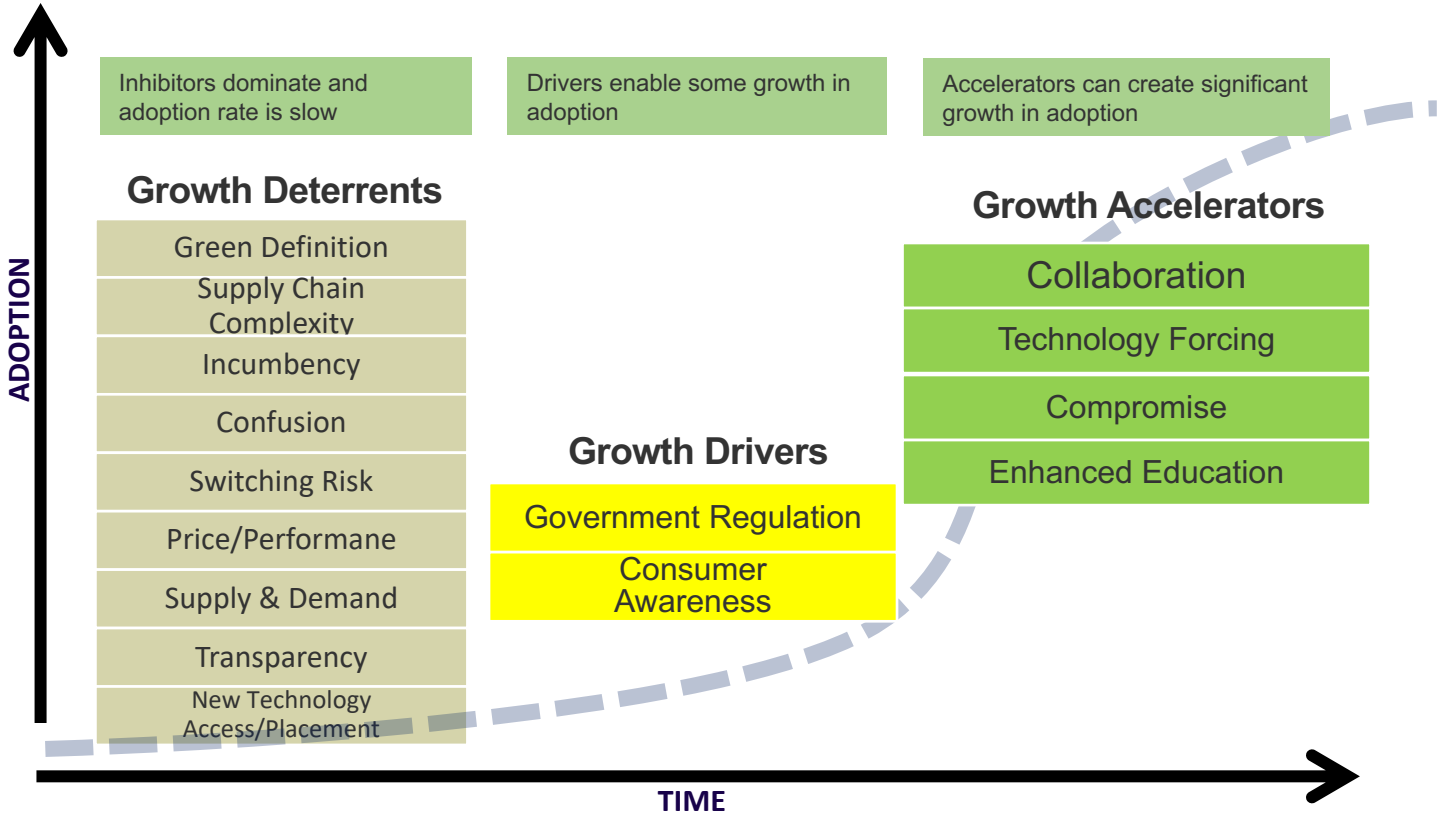


Fig. 3. Benefits of moving from fossil to renewable resources using greener transformation schemes and process chains in terms of embedded energy; embedded materials, including water; waste generation; and environmental and economic costs.

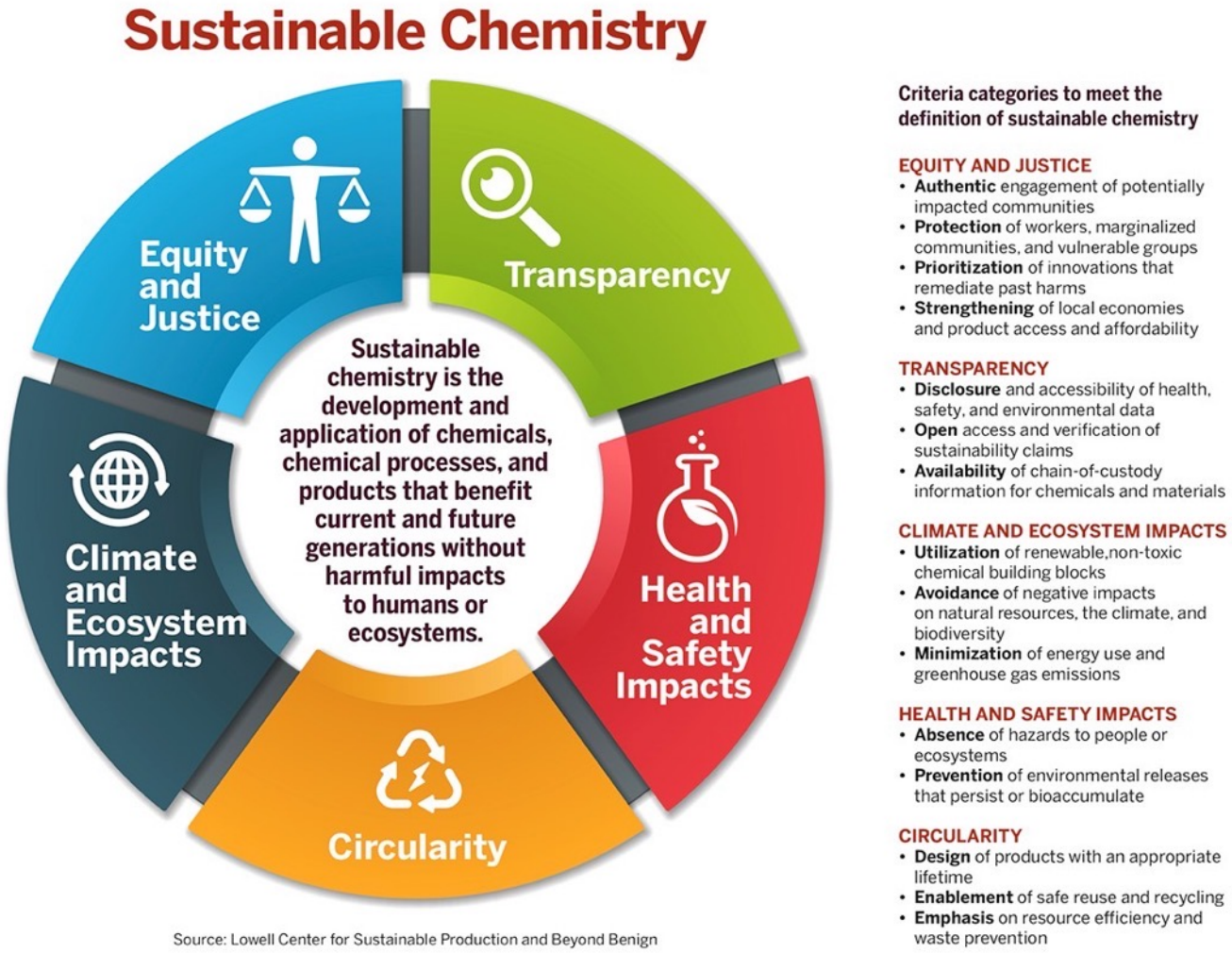
Zimmerman et al. Designing for a green chemistry future, Science Jan 2020

Inhibitors and accelerators of green and sustainable chemistry



https://greenchemistryandcommerce.org/resources/gc3-publications

Defining the direction – sustainable chemistry

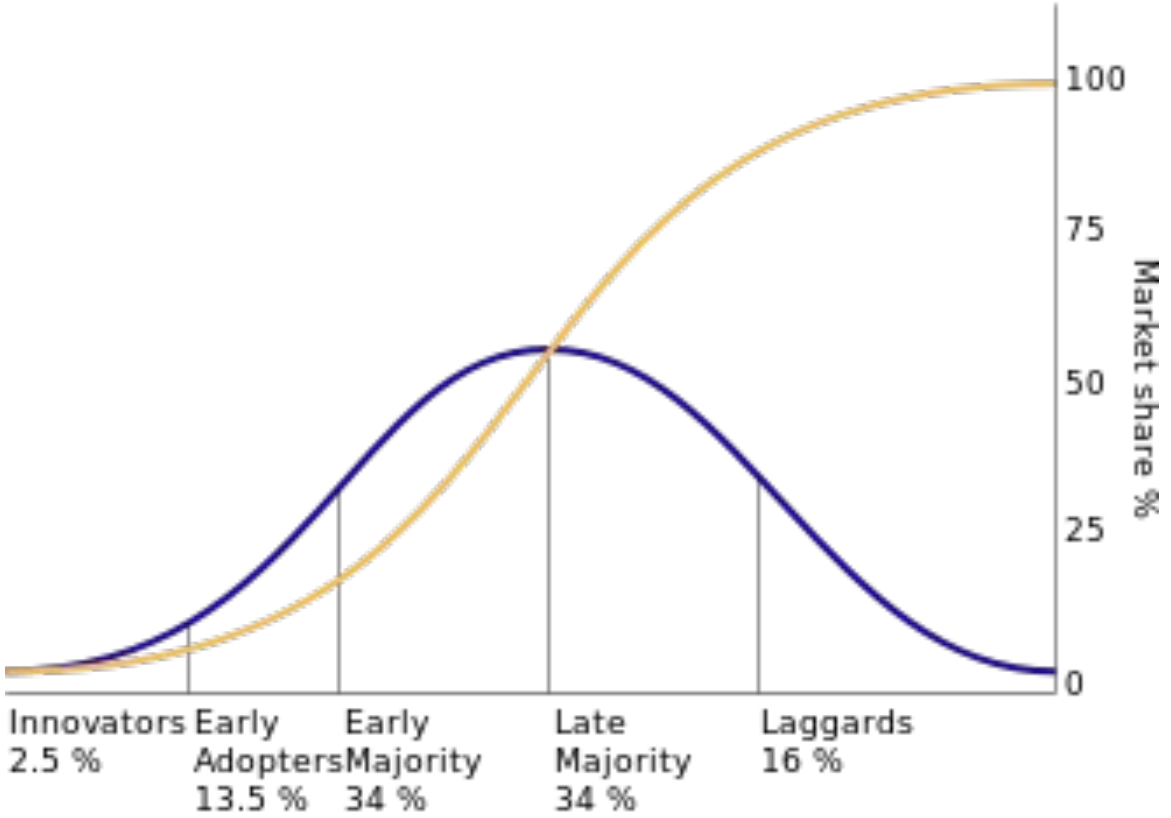


https://www.sustainablechemistrycatalyst.org/s/Defining-Sustainable-Chemistry-Report-Feb-2023.pdf

What will it take…

- A clear transition roadmap with roles, responsibilities and accountability and short and longer term benchmarks
- The same government intervention and public-private investments that rapidly grew markets for the current generation of chemicals, including:
  - Public-private, long-term, sustained investment and support for research and innovation, infrastructure, and technology transfer for safer, fossil carbon-free production and products
  - Regulatory and financial incentives and disincentives to reduce production of and demand for fossil carbon-based, toxic, and non-circular chemicals and materials
  - Public-private sector partnerships and supply chain collaborations that align demand signals and grow markets for more sustainable chemicals and materials.

The goal is to “tip the scales” towards a transition to safe and sustainable chemistries



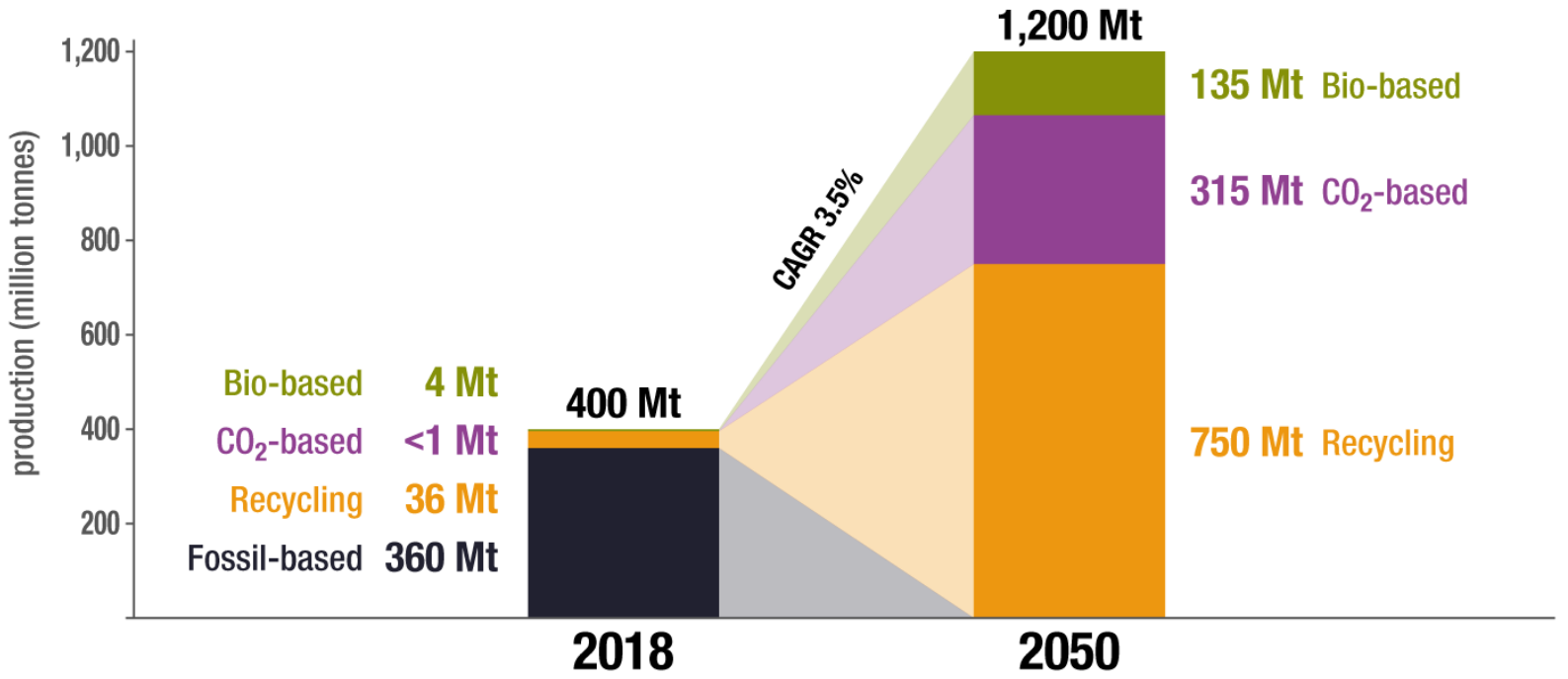
From Rogers: Diffusion of Innovations (1962)

A 30 year transition where timing matters

- Not too fast or too slow…
- Pacing
  - What can be accomplished - 10, 20, 30 years out
  - In line with capital and R&D cycles
  - What are acceptable transitional technologies and strategies without getting "locked-in"
- Where do we start?
  - Key priorities. What chemistries? What foundational technologies?
- How do we accelerate the timeframes?
  - Examples? Rubber Reserve Program? Montreal Protocol? …

World Plastic Production and Carbon Feedstock

in 2018 and Scenario for 2050 (in million tonnes)



The virgin plastic production of 364 Million t in 2018 will increase to 450 Million t in 2050, completely based on renewable carbon. The total demand for plastics of 1,200 Million t in 2050 will be mainly covered by recycling.

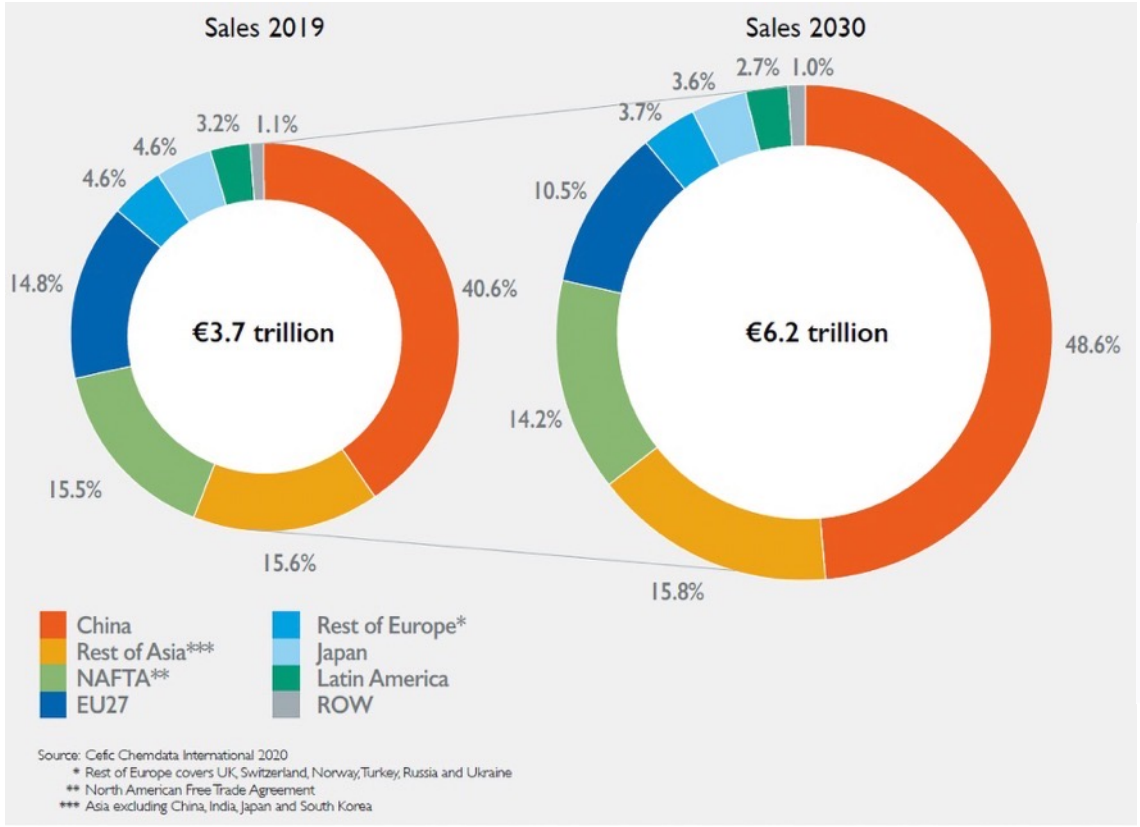
available at www.renewable-carbon.eu/graphics

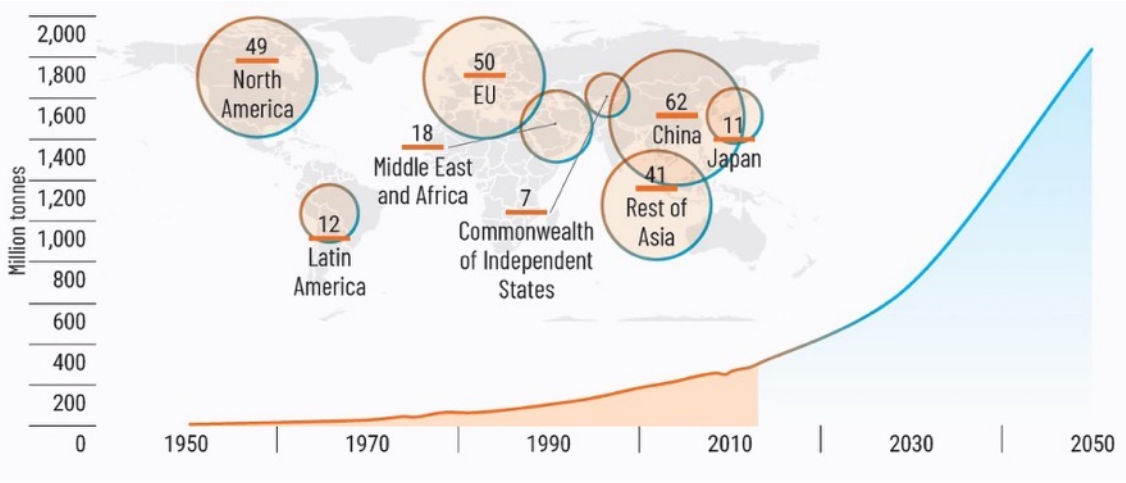
Renewable Carbon: Key to a Sustainable and Future-Oriented Chemical and Plastic Industry," Sept 2020

Additional investments needed

- An interdisciplinary, diverse, and highly-trained workforce
- Transition support for workers and communities, including clean –up and restoration
- Support for a similar transition in industrializing countries.

Petrochemical growth – a challenge for the future in industrializing countries





https://www.unep.org/explore-topics/chemicals-waste/what-we-do/policy-and-governance/global-chemicals-outlook

The opportunities…are now.

- Increased attention to the climate/toxics/plastics crises with increased and successful advocacy – risk and opportunity are becoming clearer as a business case
- New government policies
- Massive government investment
- Clear commitments from the investment community
  - Cop26 Investor commitments to address the “Code Red for Humanity”

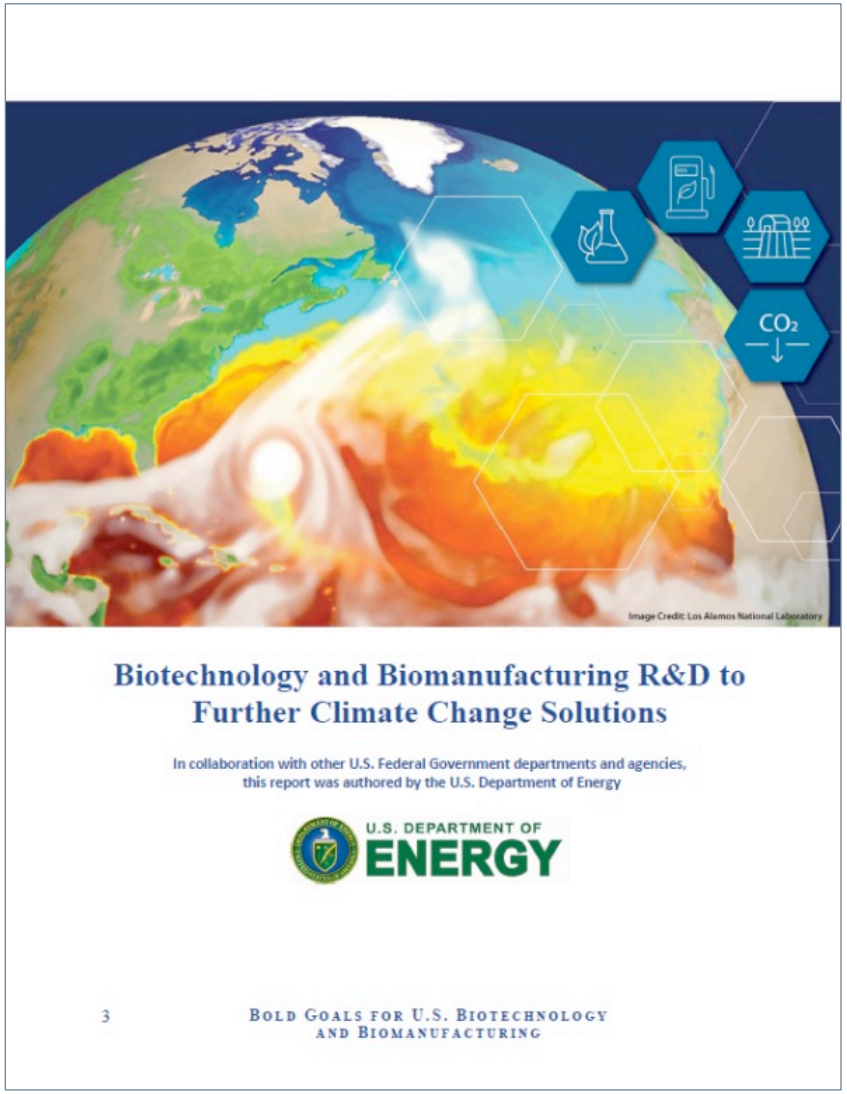
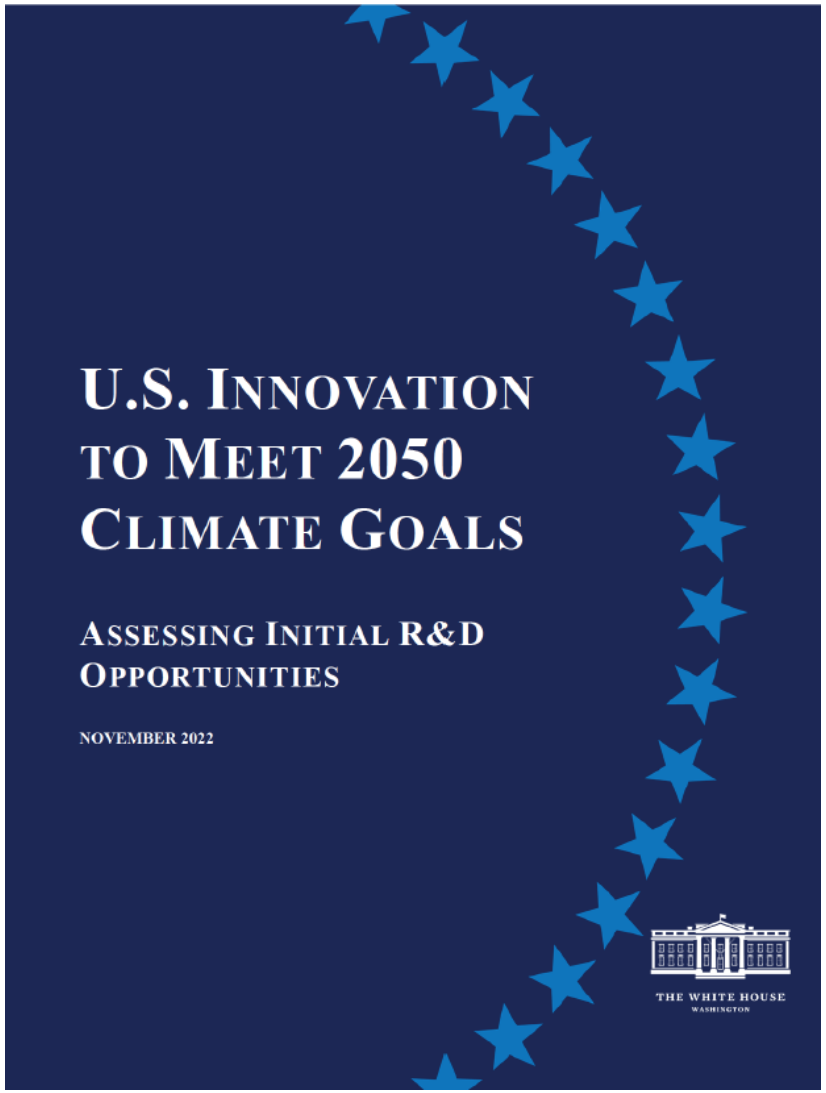


Image Credit: Los Alamos National Laboratory
Biotechnology and Biomanufacturing R&D to Further Climate Change Solutions
In collaboration with other U.S. Federal Government departments and agencies, this report was authored by the U.S. Department of Energy
U.S. DEPARTMENT OF ENERGY
3
BOLD GOALS FOR U.S. BIOTECHNOLOGY AND BIOMANUFACTURING


U.S. INNOVATION TO MEET 2050 CLIMATE GOALS
ASSESSING INITIAL R&D OPPORTUNITIES
NOVEMBER 2022
THE WHITE HOUSE
WASHINGTON

Prioritizing sustainable chemistry investment in decarbonization actions

- Bipartisan Infrastructure Law
- Inflation Reduction Act
  - 48C Tax Credit
  - EERE/IEDO Funding
  - Office of Clean Energy Demonstrations (OCED) - Advanced Industrial Facilities Deployment Program
  - DOE Loan Office
  - Greenhouse gas reduction fund/Green Bank
  - Climate Pollution Prevention grants
- CHIPS and Science
- Bioeconomy Executive Order
- Leveraging Community Benefits Plan requirement to address toxicity

An opportunity – U.S. Sustainable Chemistry R&D Act

The bill creates a national coordinating entity housed in the National Science and Technology Council to better align federal programs and activities in support of sustainable chemistry. **The entity will:**

- **Develop** descriptive attributes of sustainable chemistry.
- **Establish** a baseline of current sustainable chemistry activities across the US economy to provide a tool for comparing the progress and effectiveness of the entity's coordinating activities.
- **Coordinate** and support Federal R&D, technology transfer, commercialization, education, and training efforts in sustainable chemistry, including budget coordination and support for public-private partnerships.
- **Identify** methods by which Federal agencies can facilitate the development of incentives for the use of sustainable chemistry processes and products.
- **Consult** with the private sector, academia, state and tribal governments, and NGOs in carrying out its duties.
- **Report** to Congress on existing activities and recommendations for future activities no later than 3 years after enactment.

H. R. 6395

One Hundred Sixteenth Congress
of the
United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Friday, the third day of January, two thousand and twenty

An Act

To authorize appropriations for fiscal year 2021 for military activities of the Department of Defense, for military construction, and for defense activities of the Department of Energy, to prescribe military personnel strengths for such fiscal year, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021".

SEC. 2. ORGANIZATION OF ACT INTO DIVISIONS; TABLE OF CONTENTS.

Subtitle E—Sustainable Chemistry

SEC. 261. NATIONAL COORDINATING ENTITY FOR SUSTAINABLE CHEMISTRY.

(a) ESTABLISHMENT.—Not later than 180 days after the date of enactment of this title, the Director of the Office of Science and Technology Policy shall convene an interagency entity (referred to in this subtitle as the "Entity") under the National Science and Technology Council with the responsibility to coordinate Federal programs and activities in support of sustainable chemistry, including those described in sections 263 and 264.

(b) COORDINATION WITH EXISTING GROUPS.—In convening the Entity, the Director of the Office of Science and Technology Policy shall consider overlap and possible coordination with existing committees, subcommittees, or other groups of the National Science and Technology Council, such as—

(1) the Committee on Environment;
(2) the Committee on Technology;
(3) the Committee on Science; or
(4) related groups or subcommittees.

(c) CO-CHAIRS.—The Entity shall be co-chaired by the Director of the Office of Science and Technology Policy and a representative from the Environmental Protection Agency, the National Institute of Standards and Technology, the National Science Foundation, or the Department of Energy, as selected by the Director of the Office of Science and Technology Policy.

It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use.

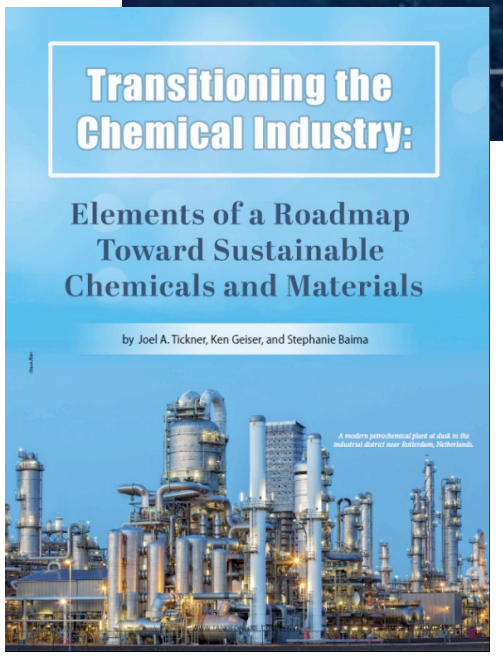
It also aims to protect, conserve and enhance the EU's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts. At the same time, this transition must be just and inclusive.

Figure 1: The European Green Deal

A chemical industry transition is NOT out of reach

It is necessary to address the “last chance decade” for climate action and action to address irreversible chemical pollution

But: It will take unprecedented political will, business leadership, continued public pressure, and an ambitious vision focusing not only on changing the industry but also on changing the production and consumption systems that have supported it.



Tickner, Geiser, and Baima - https://www.tandfonline.com/doi/full/10.1080/00139157.2022.2021793?scroll=top&needAccess=true

For more information

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www.greenchemistryandcommerce.org

www.saferalternatives.org

Reflections – A business perspective

Questions? Comments?

Closing Remarks

Upcoming Events

Registration opening April 12!

2023 GC3 European Forum: A Journey to Change Chemistry

June 13-15, 2023 | Hosted by Covestro in Leverkusen, Germany

Save the dates!

2023 A4 International Symposium on Alternatives Assessment: Enhancing Safety, Health and Equity

October 25-26, 2023 | Hosted by WA Dept. of Ecology in Tacoma, WA US

2023 GC3 US Roundtable

November 14-16, 2023 | Hosted by MilliporeSigma in St. Louis, MO US