The Future of Systems Engineering: Systems Engineering Application Extensions

A Systems Community Initiative

EMEA WSEC workshop: SE and Climate Change, 26 April 2023

Tom Strandberg
Systems Engineering Application Extensions Stream Lead

FuSE Workshop: Extending SE to address climate change

- **FuSE Application Extensions**
- Introduction to the Topic: Gerhard Krinner
- Workshop
- Next steps

Systems Engineering Vision 2035

Executive Summary

- The Global Context for Systems Engineering
- The Current State of Systems Engineering
- The Future State of Systems Engineering
- Realizing the Vision

5 Categories:

https://www.incose.org/about-systems-engineering/se-vision-2035

The world is coming to a conclusion that we need to take a systems approach to solve our challenges.

A better world through a systems approach

However, the world's recognition of Systems Engineering and INCOSE is still very limited.

Industry adoption of SE

https://violin-strawberry-9kms.squarespace.com/industry-adoption

INCOSE | Vision35

Introduction | Chapter One | Chapter Two | Chapter Three | Chapter Four | Summary | More | Contact

ELECTRONICS

HEALTHCARE

AUTOMOTIVE

FACILITIES AND INFRASTRUCTURE

INFORMATION TECHNOLOGY

POWER AND ENERGY

AEROSPACE

TRANSPORTATION

DEFENSE

LOGISTICS

Applications

1. Systems engineering contributes innovative solutions to major societal challenges.

2. Systems engineering demonstrates value for projects and enterprises of all scales, and applies across an increasing number of domains.

Practices

3. Systems engineering anticipates and effectively responds to an increasingly dynamic and uncertain environment.

4. Model-based systems engineering, integrated with simulation, multi-disciplinary analysis, and immersive visualization environments is standard practice.

5. Systems engineering provides the analytic framework to define, realize, and sustain increasingly complex systems.

6. Systems engineering has widely adopted reuse practices such as product-line engineering, patterns, and composable design practices.

Tools and Environment

7. Systems engineering tools and environments enable seamless, trusted collaboration and interactions as part of the digital ecosystem.

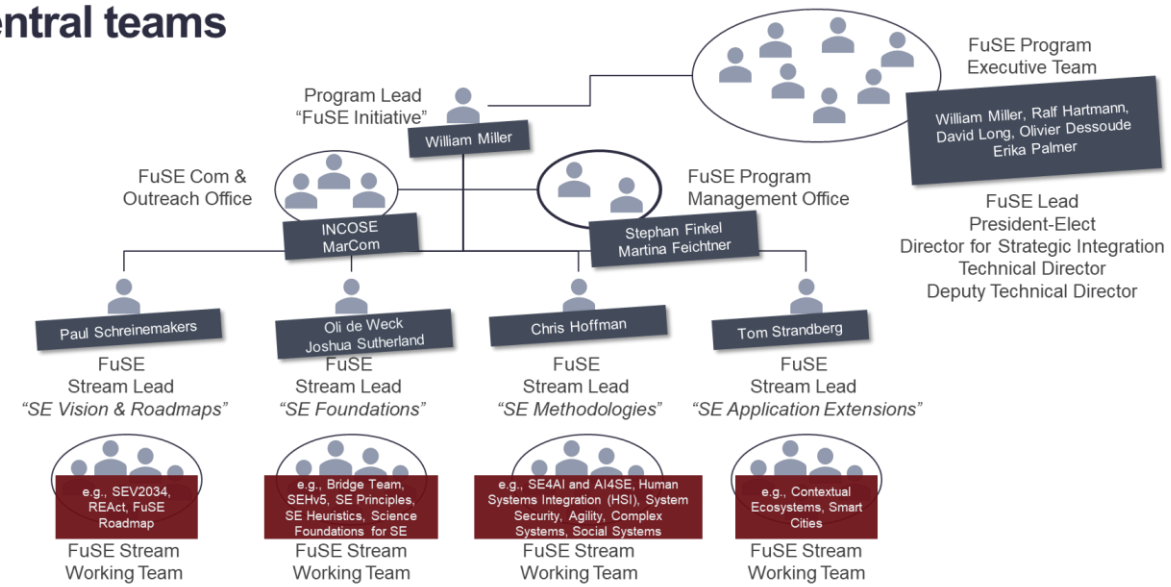
Research

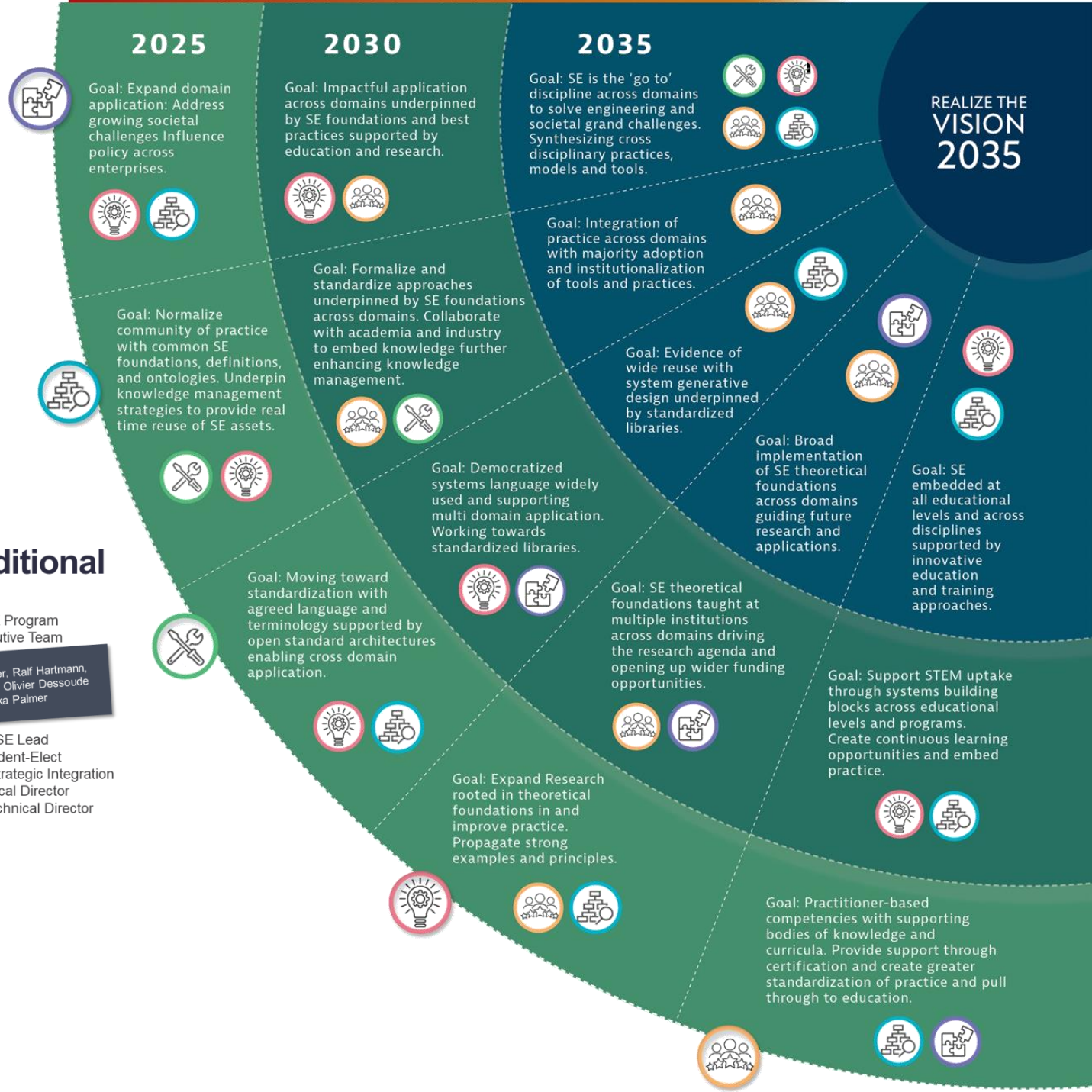
8. Systems engineering practices are based on accepted theoretical foundations and taught as part of the systems engineering curriculum.

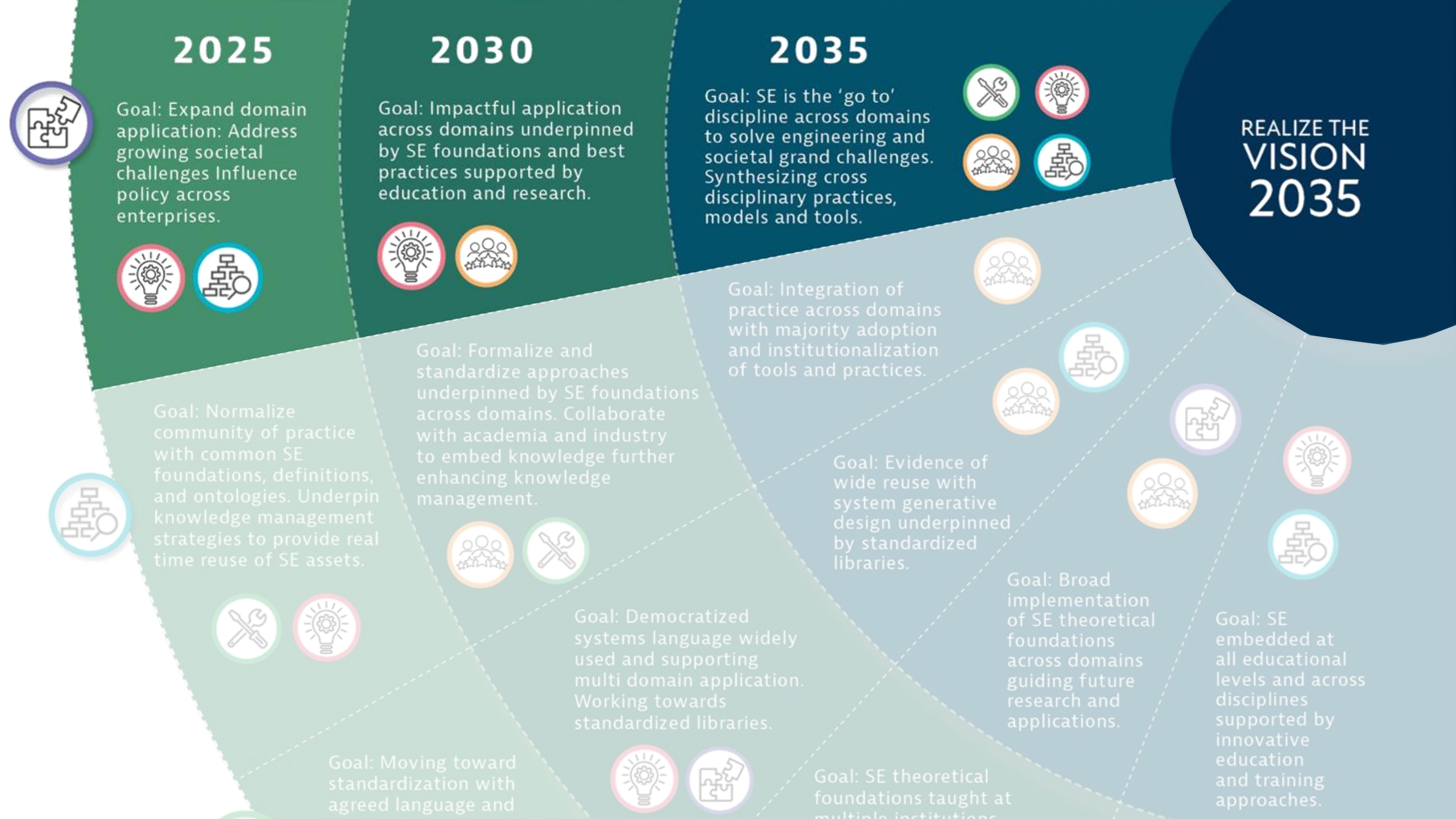
Competencies

9. Systems engineering education is part of the standard engineering curriculum, and is supported by a continuous learning environment.

The FuSE program is organized in 4 streams with additional central teams






2025
Goal: Expand domain application: Address growing societal challenges Influence policy across enterprises.
2030
Goal: Impactful application across domains underpinned by SE foundations and best practices supported by education and research.
2035
Goal: SE is the 'go to' discipline across domains to solve engineering and societal grand challenges. Synthesizing cross disciplinary practices, models and tools.
REALIZE THE VISION 2035
Goal: Integration of practice across domains with majority adoption and institutionalization of tools and practices.
Goal: Formalize and standardize approaches underpinned by SE foundations across domains. Collaborate with academia and industry to embed knowledge further enhancing knowledge management.
Goal: Normalize community of practice with common SE foundations, definitions, and ontologies. Underpin knowledge management strategies to provide real time reuse of SE assets.
Goal: Evidence of wide reuse with system generative design underpinned by standardized libraries.
Goal: Democratized systems language widely used and supporting multi domain application. Working towards standardized libraries.
Goal: Broad implementation of SE theoretical foundations across domains guiding future research and applications.
Goal: SE embedded at all educational levels and across disciplines supported by innovative education and training approaches.
Goal: Moving toward standardization with agreed language and
Goal: SE theoretical foundations taught at

FuSE Application Extensions Stream Output

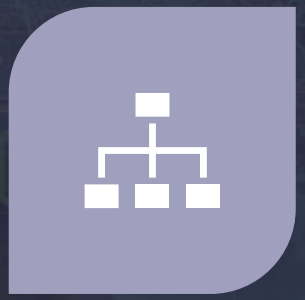
- Identify topics that can mobilize initiatives that can contribute to the realization of the SE Vision 2035 Roadmap.
  - Existing, e.g. Smart Cities Initiative
  - Potential new ones, e.g. Sustainability
- Stimula and support to initiatives
  - Typically, cross-WG, cross-organization
- Coordination and collaboration
  - products, papers, workshops, lobbying

How?

DEFINE TOPICS THAT CAN SUPPORT EXTENDING THE APPLICATION OF SE

DEFINE TARGET GROUPS AND THE MESSAGE REQUIRED

DEFINE HOW TO APPROACH THE TARGET GROUP



IDENTIFY THE RESOURCES REQUIRED, INTERNAL AND EXTERNAL TO INCOSE

STIMULATE AND SUPPORT JOINT INITIATIVES

Initial Selection of Topics.

Smart Cities

Innovation

Asset Management

Grand Challenges

FuSE Workshop: Extending SE to address climate change

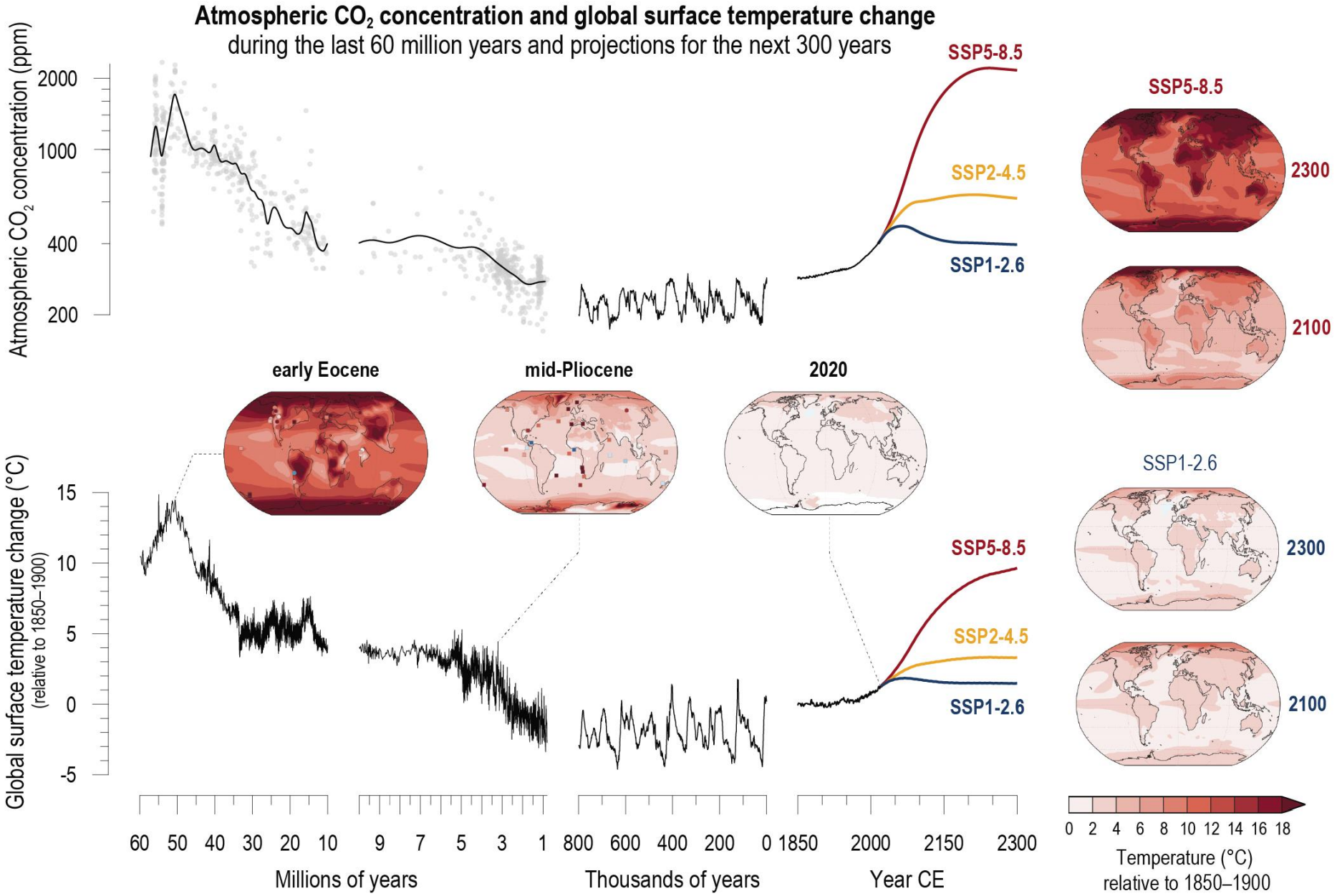
- FuSE Application Extensions
- **Introduction to the Topic: Gerhard Krinner**
- Workshop
- Next steps

A look at systems transitions in the IPCC AR6

Gerhard Krinner, IGE Grenoble
gerhard.krinner@cnrs.fr

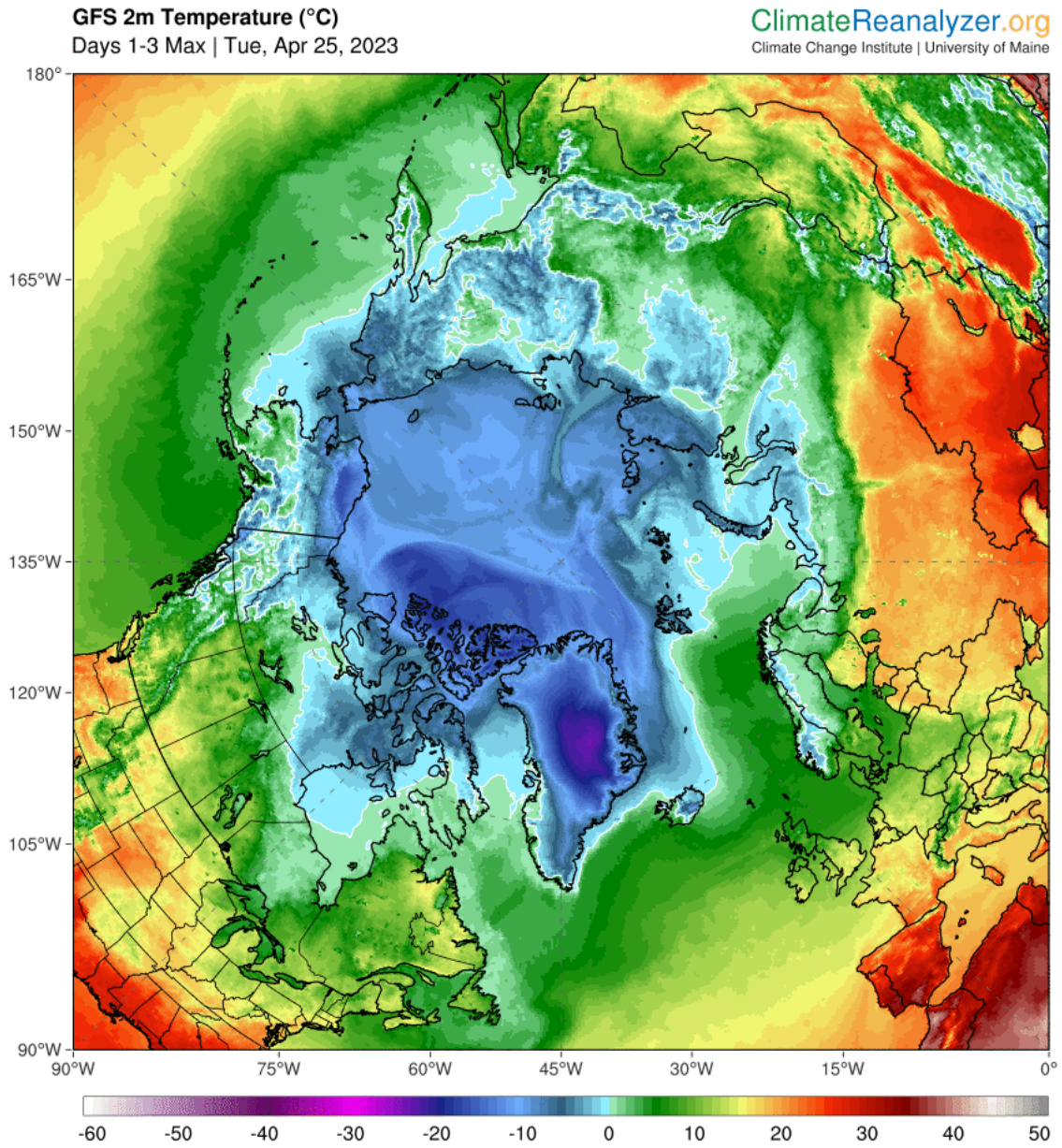
A look at the very long term

Strong correlation between CO_2 concentration and global temperature



The current Andalusian heatwave

Record hot temperatures (for April) will likely be exceeded on Thursday

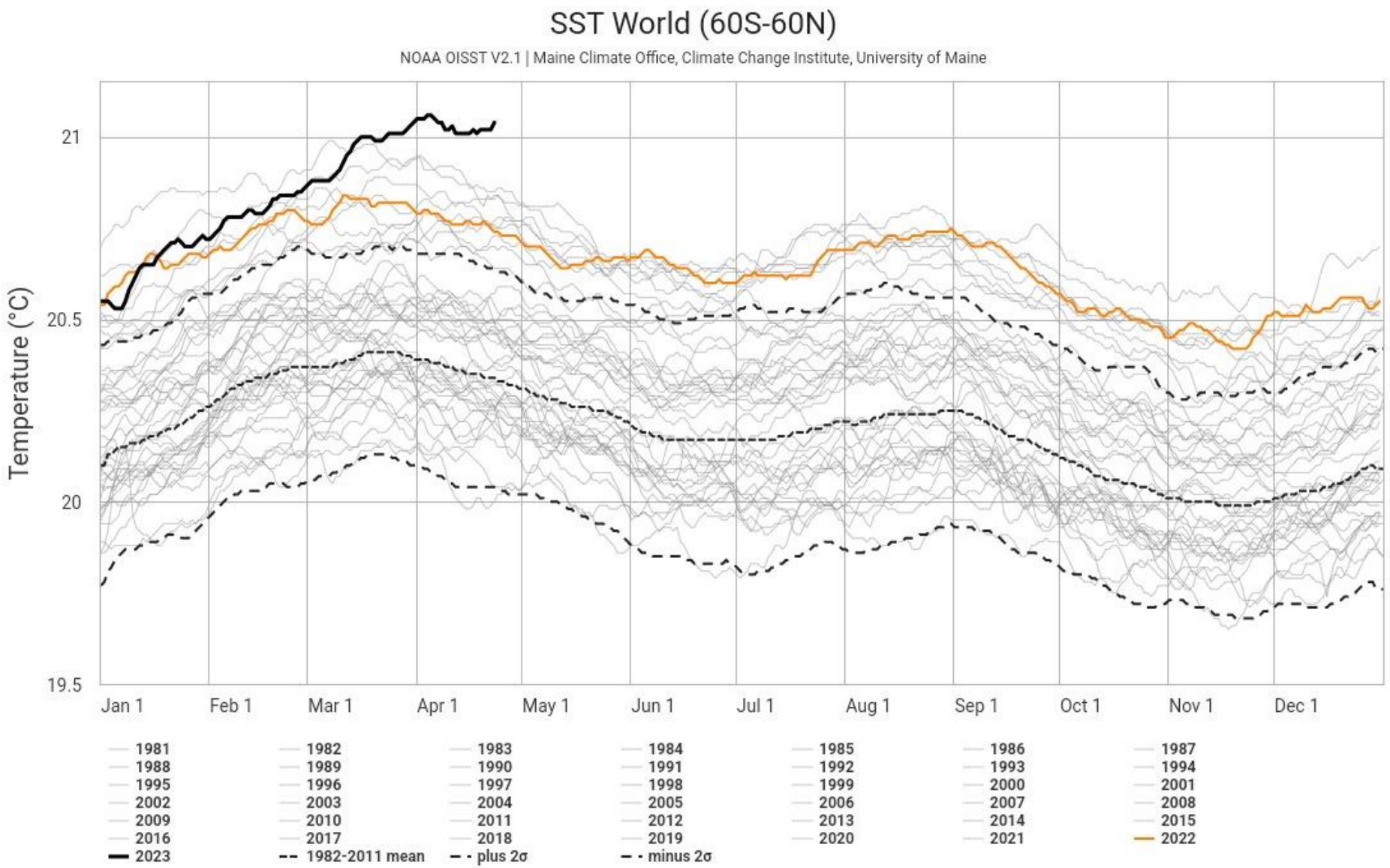


The global ocean

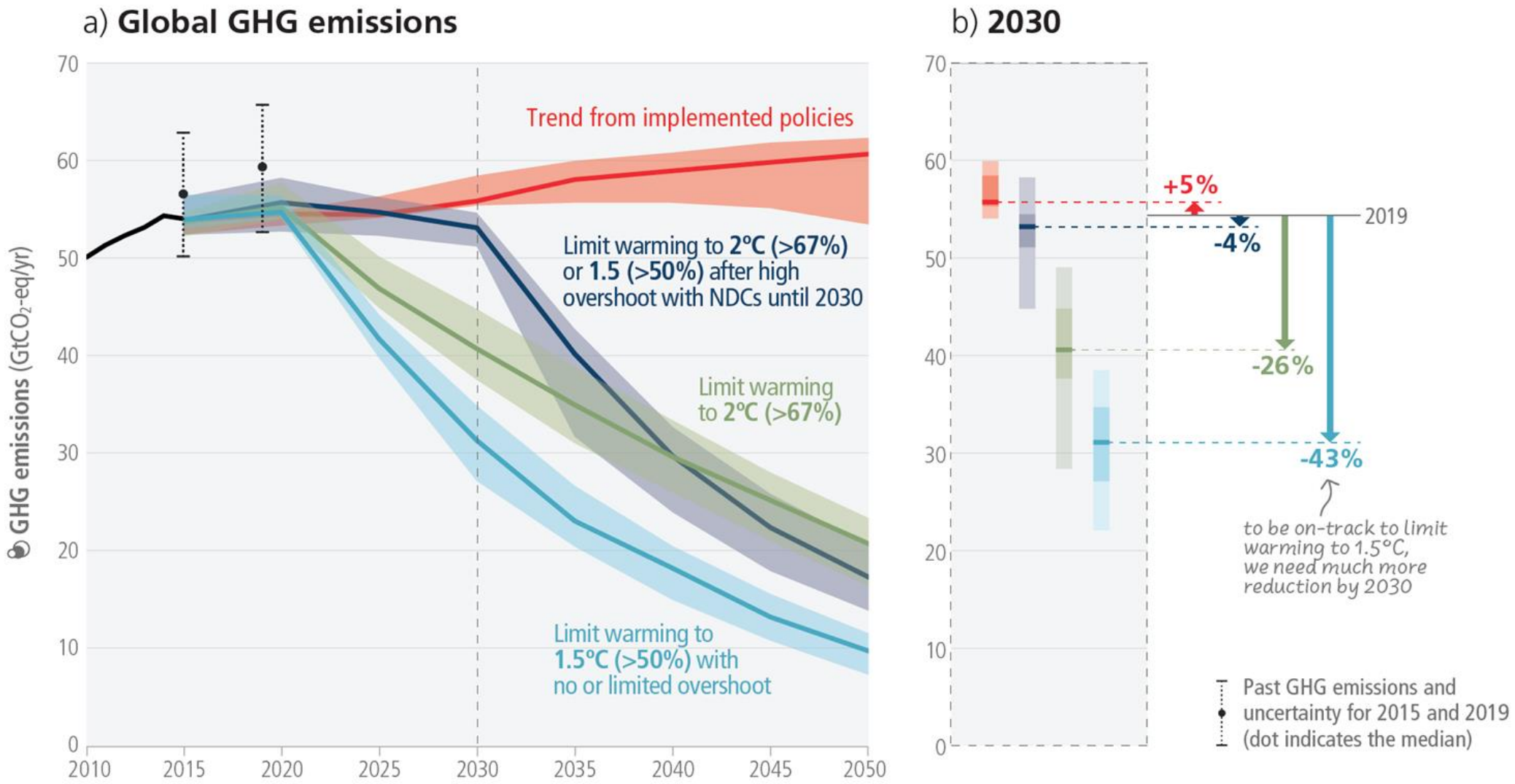
60°S-60°N average temperature above 21°C for the first time

>4σ above the 1982-2011 mean

Ocean is currently transitioning from La Niña to El Niño state – 2024 will likely be a new record year



Humanity is not on a trajectory towards 1.5 or 2°C warming by 2100



Mitigation and adaptation options depend on the sector

Reductions in GHG emissions in industry, transport, buildings, and urban areas:
Combination of energy efficiency and conservation and a transition to low-GHG technologies and energy carriers

End-use sectors:
- Socio-cultural options and behavioural change
- Most of the potential in developed countries (if combined with improved infrastructure design and access)

Energy:
- Transitioning from fossil fuels without carbon capture and storage (CCS) to very low- or zero-carbon energy sources
- Demand-side measures and improving efficiency
- CDR

Mitigation and adaptation options depend on the sector (cont'd)

Urban sector:

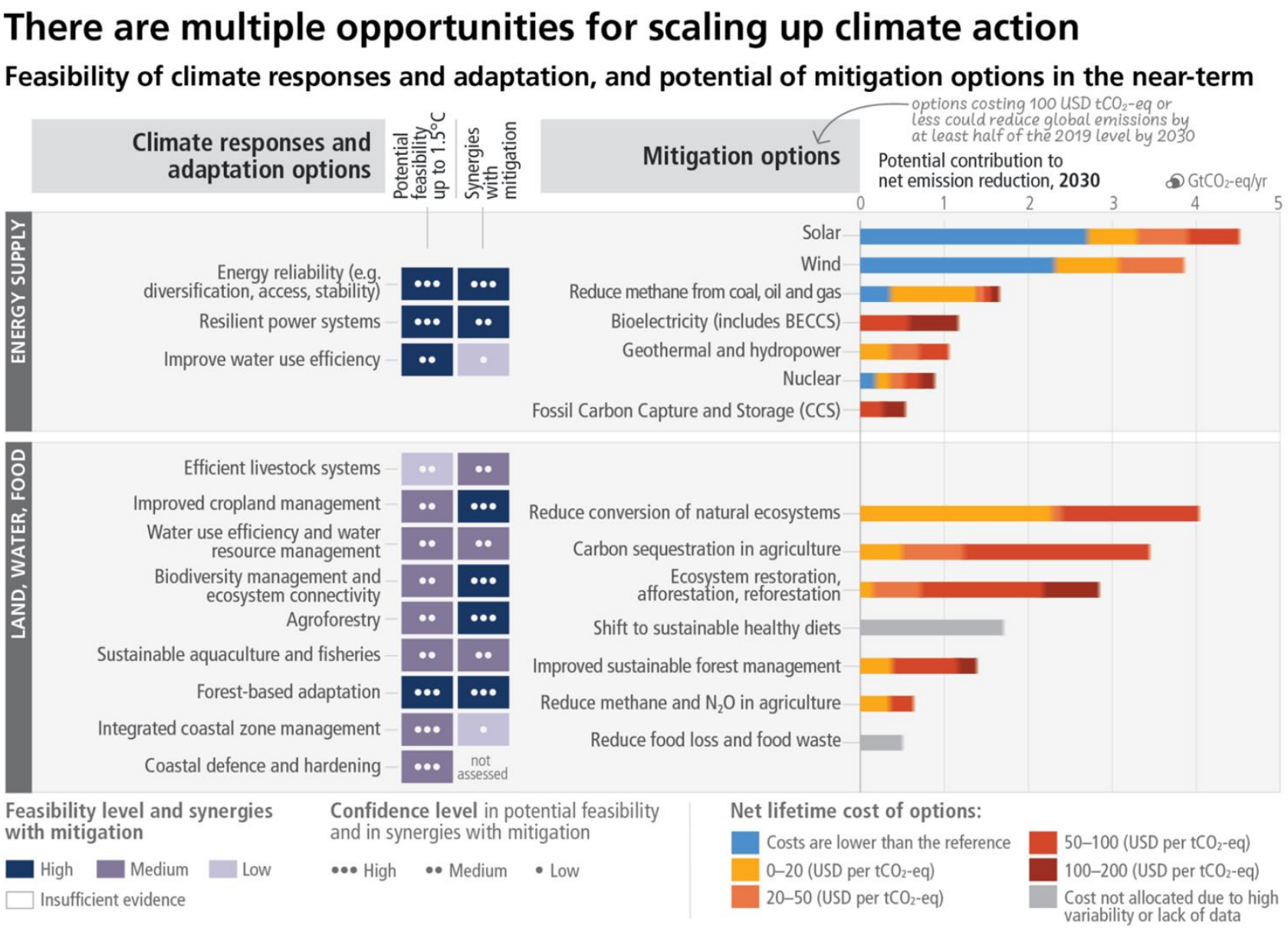
Deep emissions reductions and integrated adaptation actions are advanced by:

- integrated, inclusive land use planning and decision-making
- compact urban form by co-locating jobs and housing
- reducing or changing urban energy and material consumption
- electrification in combination with low emissions sources
- improved water and waste management infrastructure
- enhancing carbon uptake and storage in the urban environment

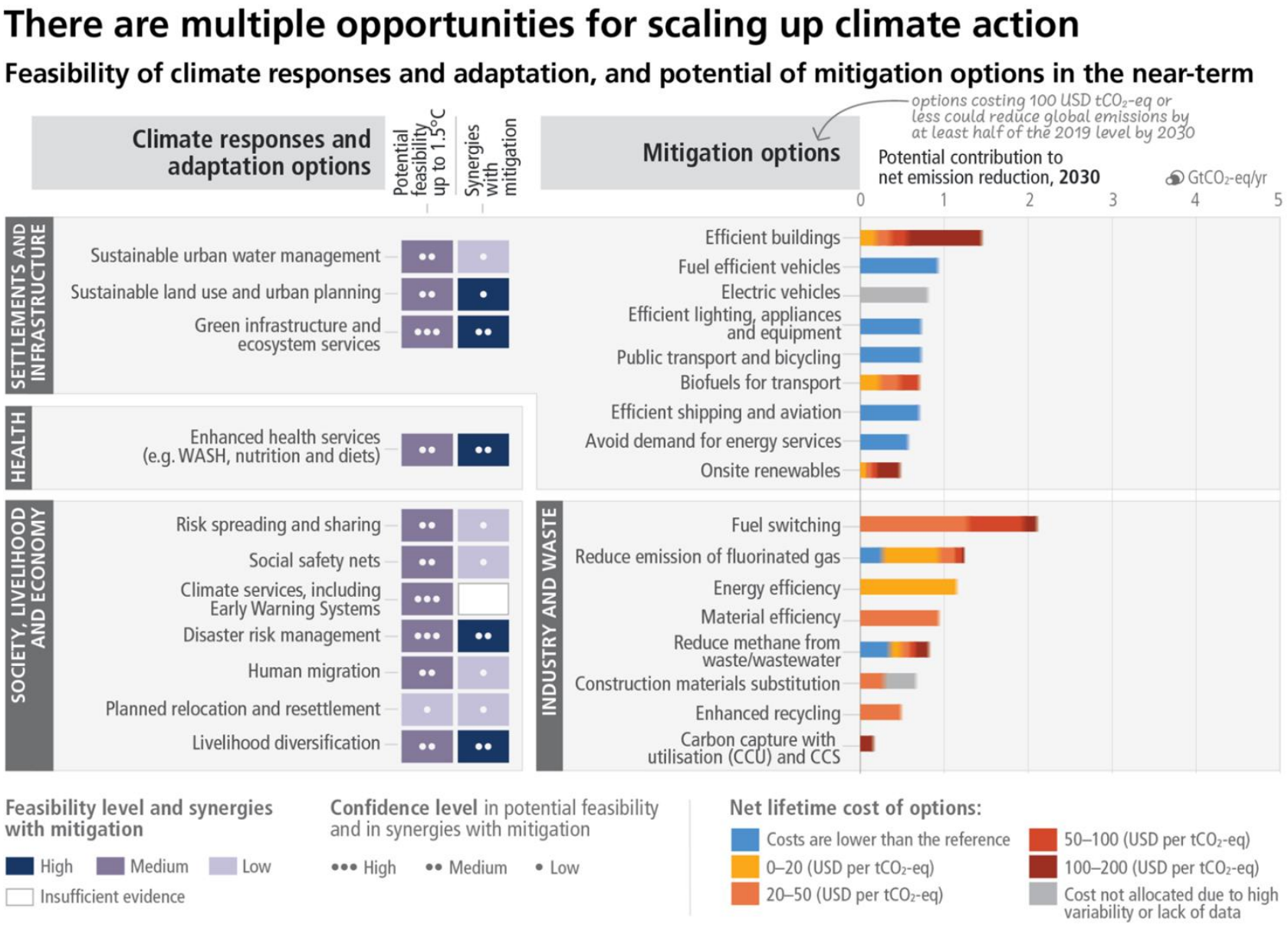
AFOLU mitigation options:

- Can deliver large-scale GHG emission reductions and enhanced CO_2 removal if sustainably implemented
- Reduced deforestation in tropical regions: highest total mitigation potential
- Many barriers to implementation and trade-offs: impacts of climate change, competing demands on land, conflicts with food security and livelihoods, complexity of land ownership and management systems, cultural aspects

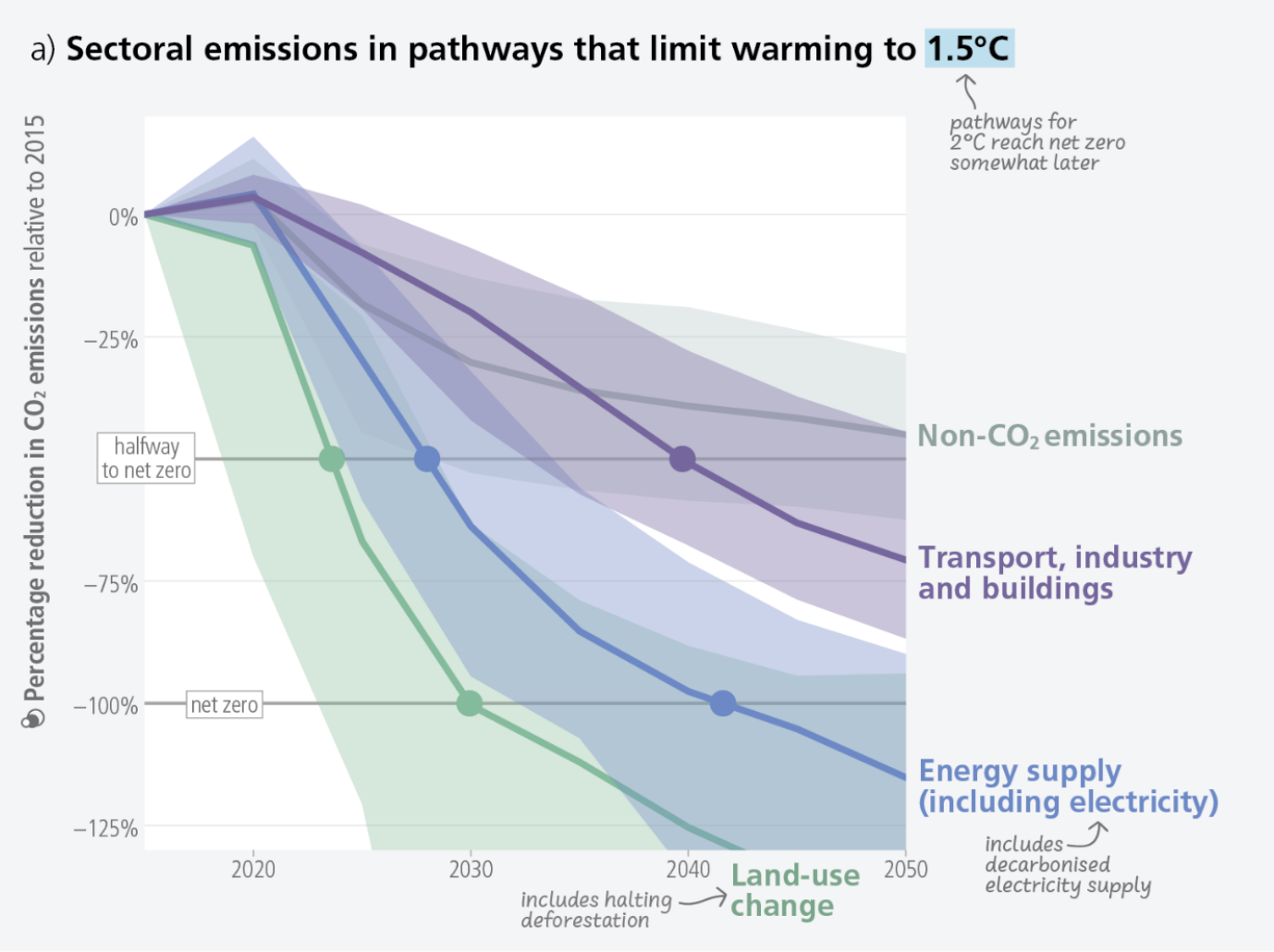
Many options exist for scaling up climate action

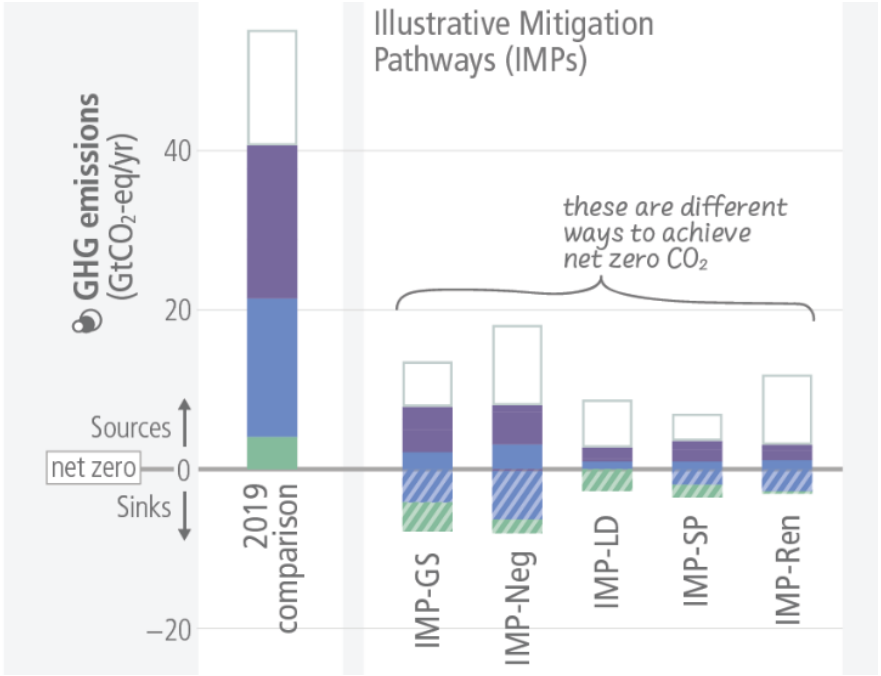


Many options exist for scaling up climate action



The pace of the transition to net zero CO_2 depends on the sector

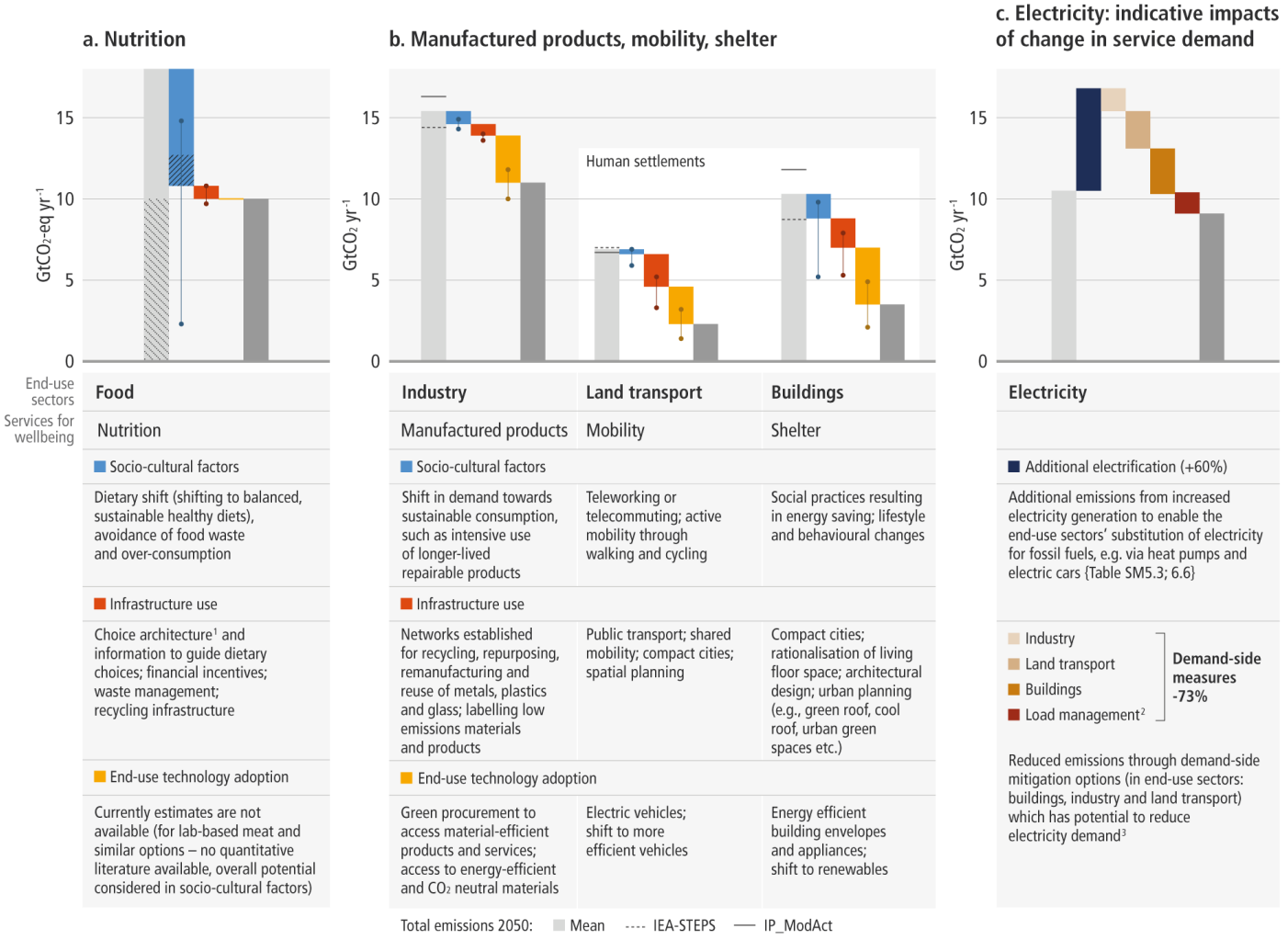




Technology transfers allow to accelerate transitions (leapfrogging)

Strong and rapid action is possible, including demand-side mitigation

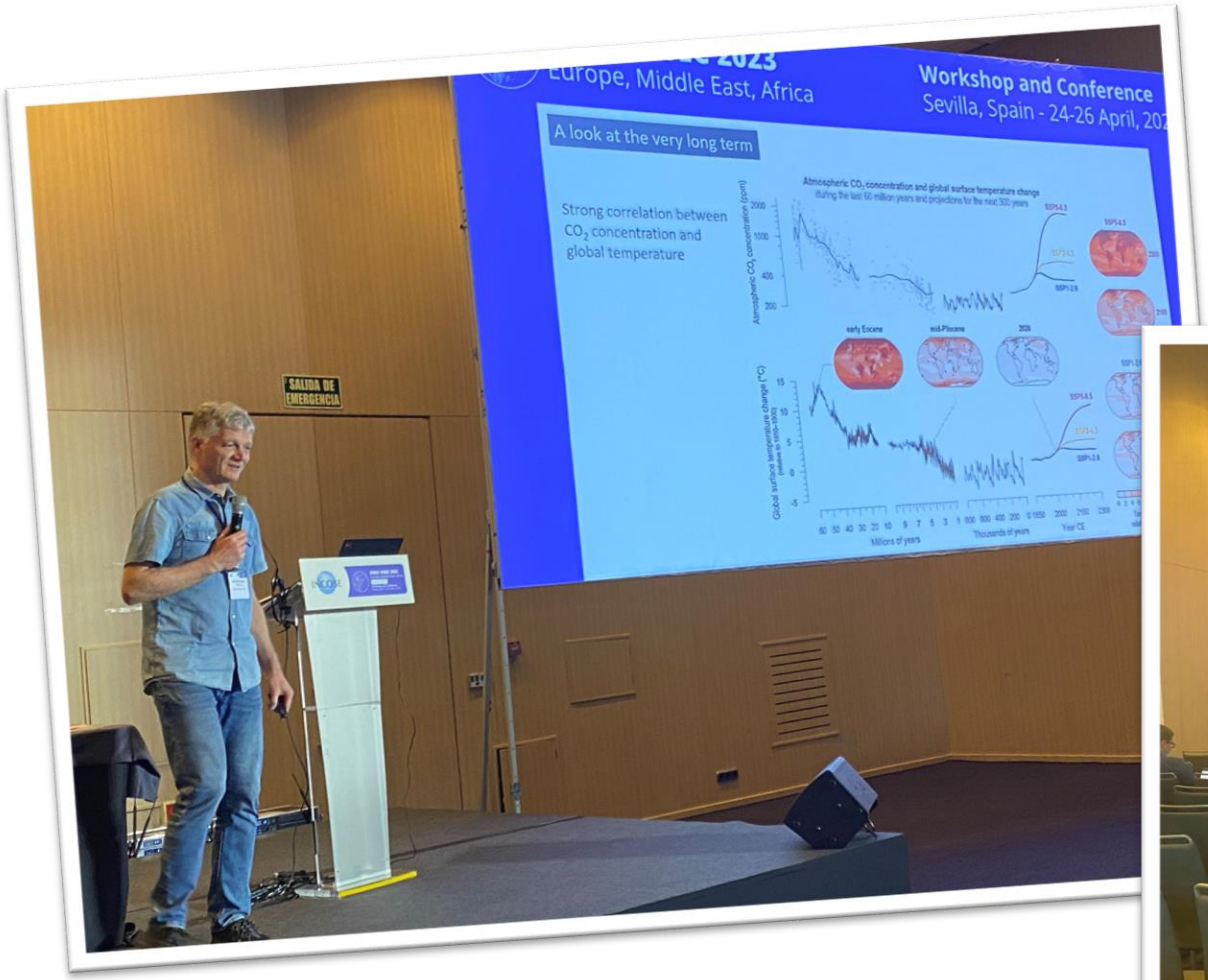
Demand-side mitigation can be achieved through changes in socio-cultural factors, infrastructure design and use, and end-use technology adoption by 2050.



[1] The presentation of choices to consumers, and the impact of that presentation on consumer decision-making.

[2] Load management refers to demand-side flexibility that cuts across all sectors and can be achieved through incentive design like time of use pricing/monitoring by artificial intelligence, diversification of storage facilities, etc.

[3] The impact of demand-side mitigation on electricity sector emissions depends on the baseline carbon intensity of electricity supply, which is scenario dependent.


Europe, Middle East, Africa
Workshop and Conference
Sevilla, Spain - 24-26 April, 202
A look at the very long term
Strong correlation between CO_2 concentration and global temperature
SALIDA DE EMERGENCIA


EMEA WSEC 2023
Europe, Middle East, Africa
Workshop and Conference
Sevilla, Spain - 24-26 April, 2023

FuSE Workshop: Extending SE to address climate change

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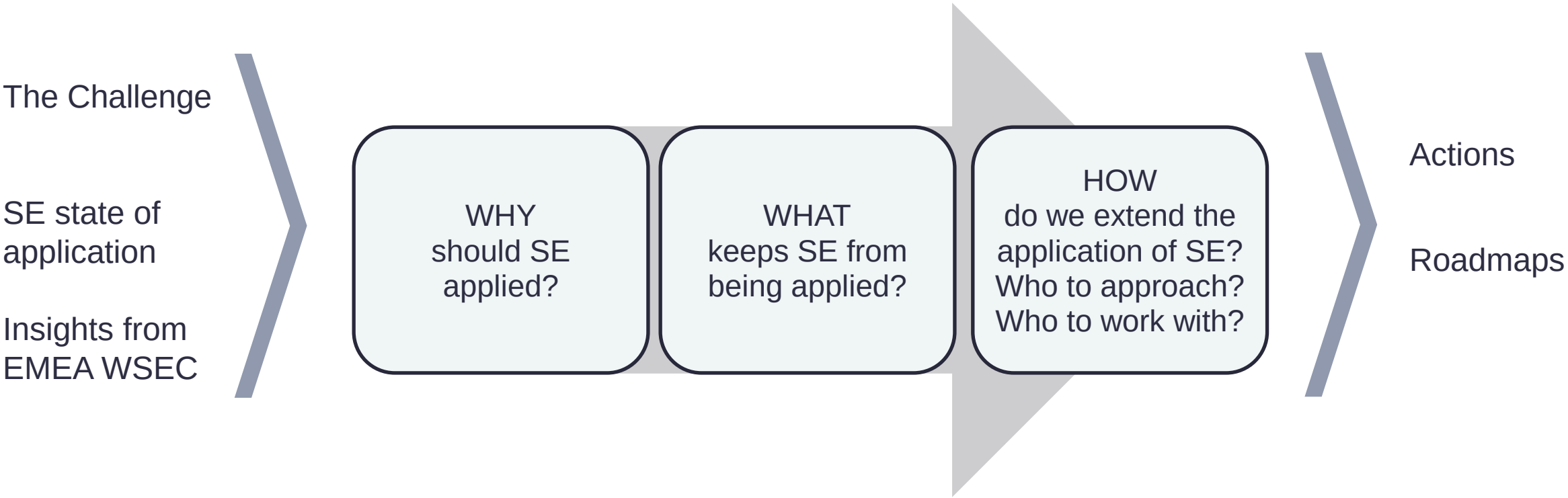
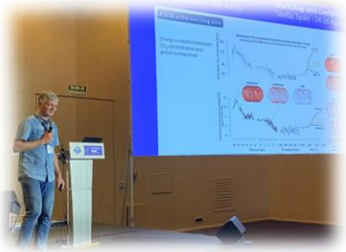
Workshop

Extending SE to address climate change



FuSE Workshop Summary

Extending SE application to address climate change



The Challenge

SE state of application

Insights from EMEA WSEC

WHY
should SE applied?

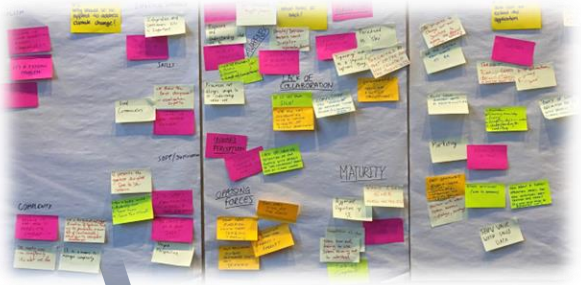
WHAT
keeps SE from being applied?

HOW
do we extend the application of SE?
Who to approach?
Who to work with?

Holistic approach to problem solvning

Communication

Educate!
Collaborate!
Language

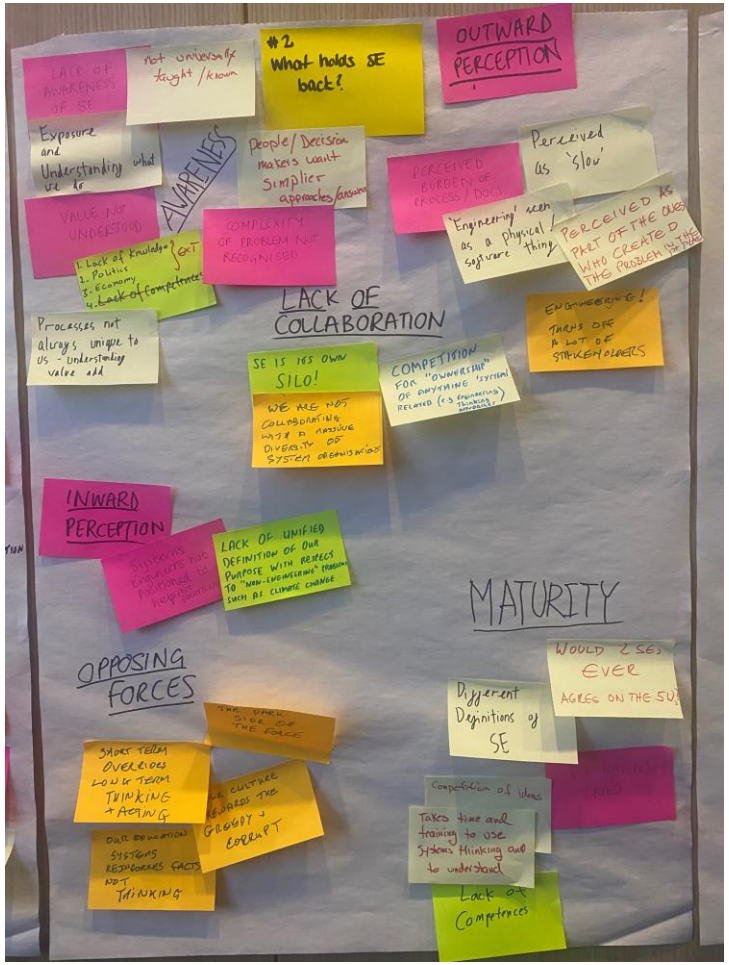


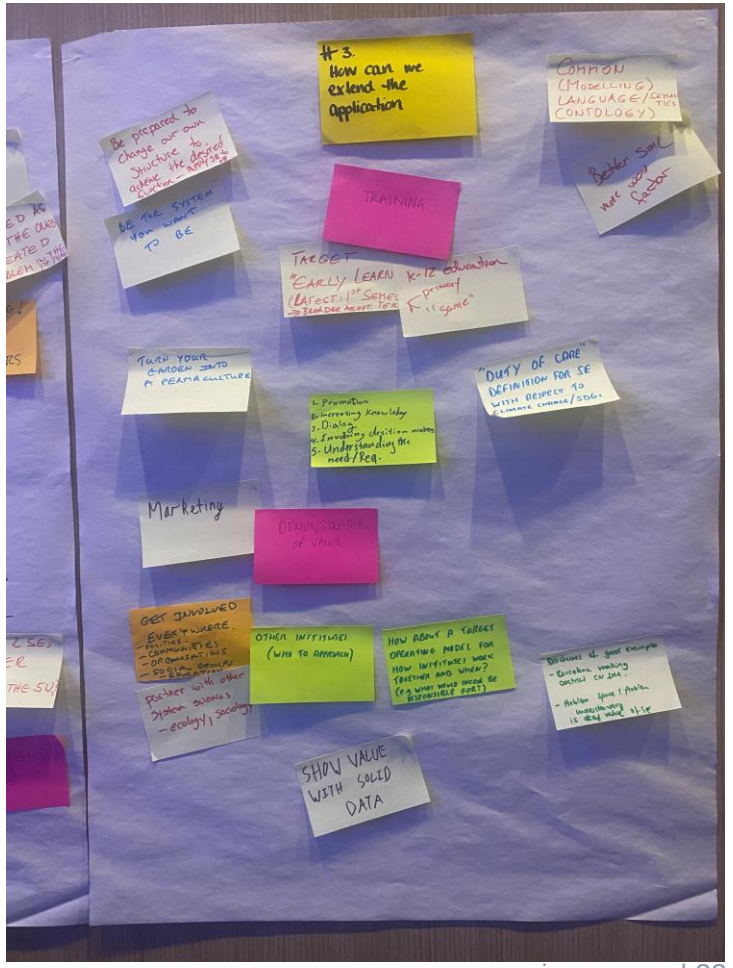
Actions

Roadmaps

Photo Documentation

Team 1





Workshop: *Extending SE to address climate change*

Team 2 (1/2)

WHY
should SE be applied?

WHAT
keeps SE from being applied?

HOW
do we extend the application of SE?
Who to approach? Who to work with?

Holism
- BECAUSE WE MAKE CONNECTIONS ACROSS STAKEHOLDERS
- IT'S A SYSTEMIC PROBLEM
- HOLISTIC VIEW OF ALL FACTORS

Lifecycle Approach
- Integration and Continuous V / V is Important
- TO UNDERSTAND MEASURES OF SUCCESS / EFFECTIVENESS

Skills
- we draw the Best diagrams? Visualization experts
- Good Communicators
- BECAUSE WE ARE HUMBLE LEADERS

Complexity
- BECAUSE WE ARE ABLE TO APPRECIATE COMPLEXITY
- SE is the (practical) application of Systems Thinking by to generate a number of (sustainable) solutions to complex challenges
- SE roots are in complexity it's what we do
- SE is a means to manage complexity

Awareness
- not universally taught / known
- LACK OF AWARENESS OF SE
- Exposure and Understanding OF what we do
- People / Decision makers want simpler approaches / answers
- VALUE NOT UNDERSTOOD
- COMPLEXITY OF PROBLEM NOT RECOGNISED
- 1. Lack of Knowledge; 2. Politics; 3. Economy--> EXT
- Processes not always unique to us – understanding value add

OUTWARD PERCEPTION
- Perceived as "slow"
- PERCEIVED BURDEN OF PROCESS / DOCS
- PERCEIVED AS PART OF THE ONES WHO CREATEDTHE PROBLEM IN THE FFIRST PLACE
- "ENGINEERING" SEEN AS A PHYSICAL / SOFTWARE THING
- ENGINEERING ! TURNS OFF A LOT OF STAKEHOLDERS

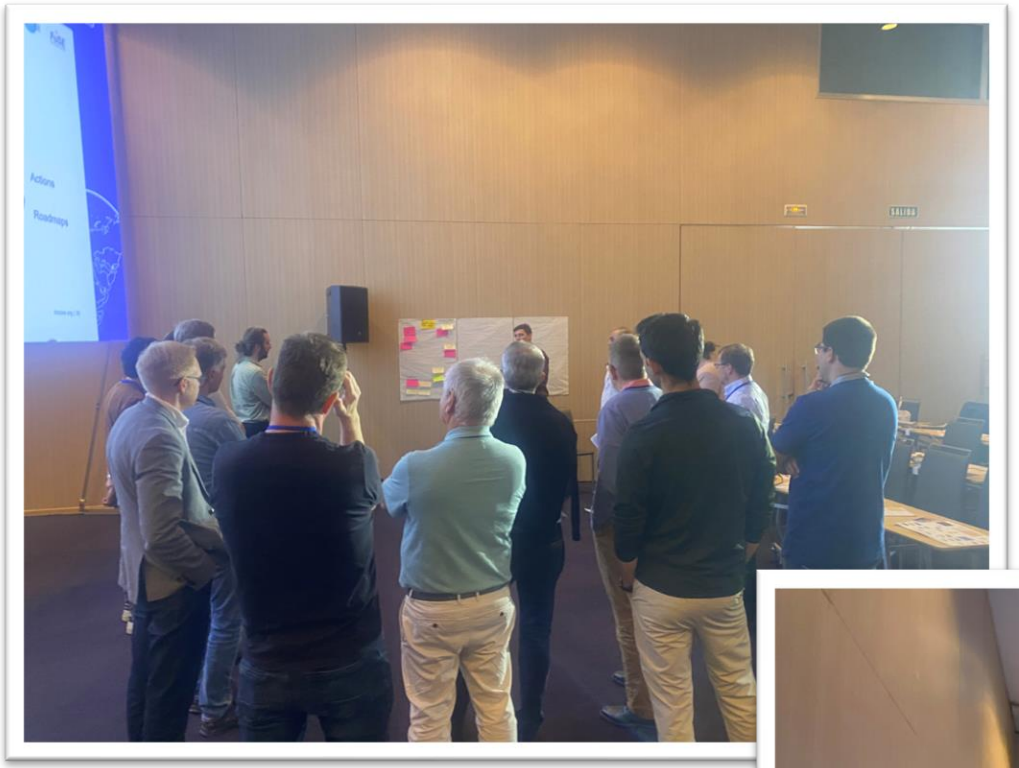
- COMMON (MODELLING LANGUAGE / SEMANTIC
- ONTOLOGY
- Be prepared to change our own Structure to the desired function APPLY SE to SE
- Better SML more wow factor

Training
- TRAINING BE THE SYSTEM you WANT BE
- TARGET EARLY Learning (LATEST : 1st semester) BROADER ACCEPTANCE
- K- 12 education – primary "same "
- TURN YOUR GARDEN INTO A PERMACULTURE
- DUTY OF CARE DEFINITION FOR SE WITH Respect To CLIMATE CHANGE / SDGS
- 1- Promotion; 2- increasing knowledge; 3 – Dialog; 4- Involving decision makers; 5 - Understanding the need / Req

Workshop: *Extending SE to address climate change*

Team 2 (2/2)

WHY should SE be applied?	WHAT keeps SE from being applied?	HOW do we extend the application of SE? Who to approach? Who to work with?
Soft / Justification • CC presents the greatest disruptive force to SE Systems • ITS VERY REWARDING TO MAKE A REAL DIFFERENCE • 1 - for a better world; 2- Reducing Co2; 3 - Save Lives; 4- Save The Planet • BECAUSE IT IS A GOOD IDEA ! • Unique Perspective	**Lack of Collaboration** • COMPETITION FOR " OWNERSHIP “ OF ANYTHING ' SYSTEMS RELATED (e.g., Engineering, Thinking) • SE is its own silo • WE ARE NOT COLLABORATING WITH A MASSIVE DIVERSITY OF SYSTEM ORGANISATIONS **INWARD Perception** • Systems Engineers not positioned to help politicians • LACK OF UNIFIEDDEFINITION OF OUR PURPOSEWITH RESPECS TO "NON - ENGINEERING " PROBLEMSAS CLIMATE CHANGE **OPPOSING FORCES** • THE DARK SIDE OF THE FORCE • SHORT TERM OVERRIDES LONG TERM THINKING + ACTING • OUR CULTUREREWARDS THEGREEDYCORRUPT • OUR EDUCATION SYSTEMS REINFORCES FACTS NOT THINKING **Maturity** • WOULD 2 Ses EVER AGREE ON THE 5 Ws • Different Definitions of SE • Competition of Ideas • WE HAVENT TRIED • Takes time and training to use Systems thinking and to understand • Lack of Competences	**Marketing** • DEMONSTRATION OF VALUE • GET INVOLVED EVERYWHERE - POLITICS – COMMUNITIES – ORGANISATIONS – SOCIAL GROUPS – EDUCATION • OTHER INSTITUTES (WHO TO APPROACH) • HOW ABOUT A TARGET OPERATING MODEL FOR HOW INSTITUTES WORK TOGETHER AND WHEN? e.g WHAT WOULD INCOSE BE RESPONSIBLE FOR? • brochures of good example - Barcelona making district car free • partner with other System sciences: Ecology, sociology • SHOW VALUE WITH SOLID DATA

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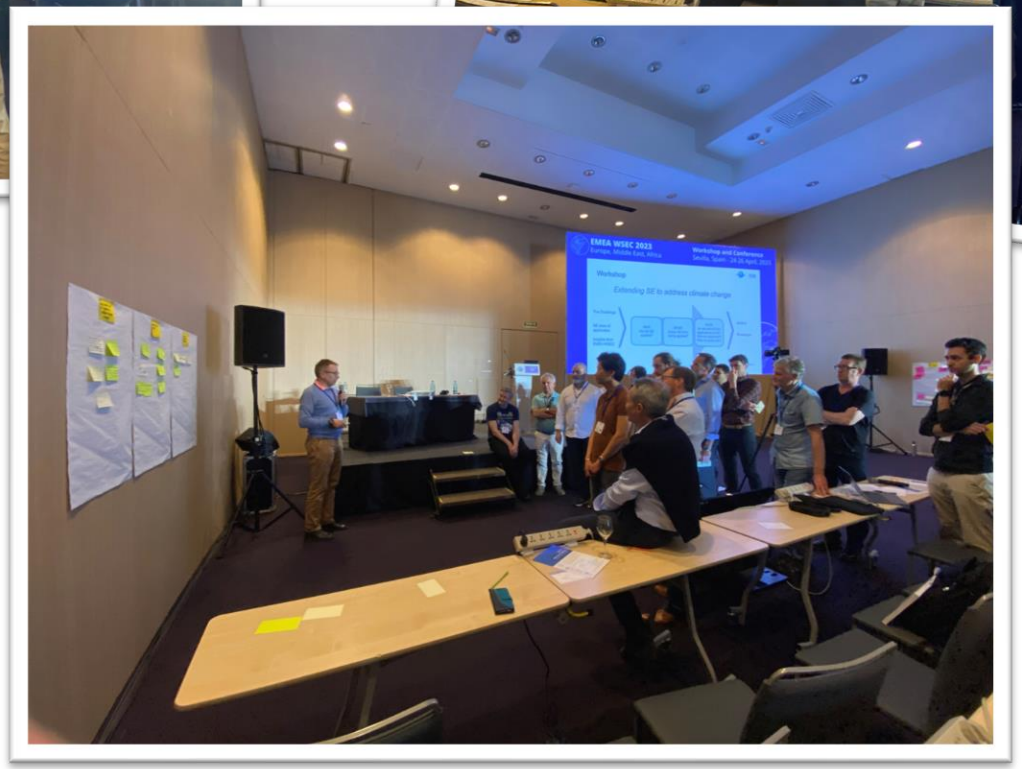
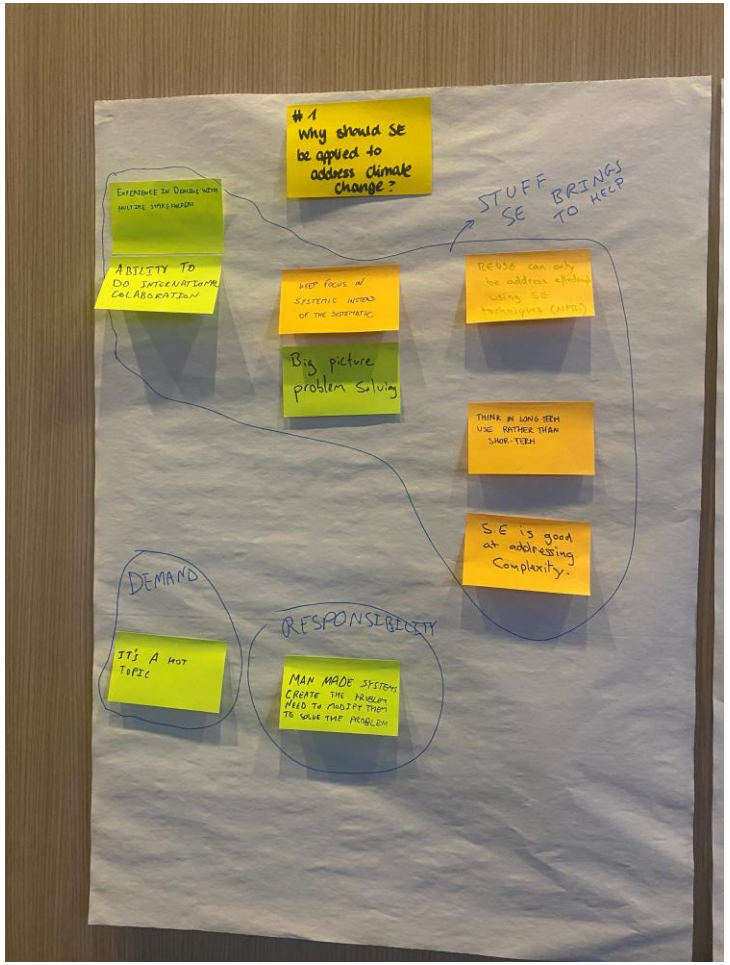
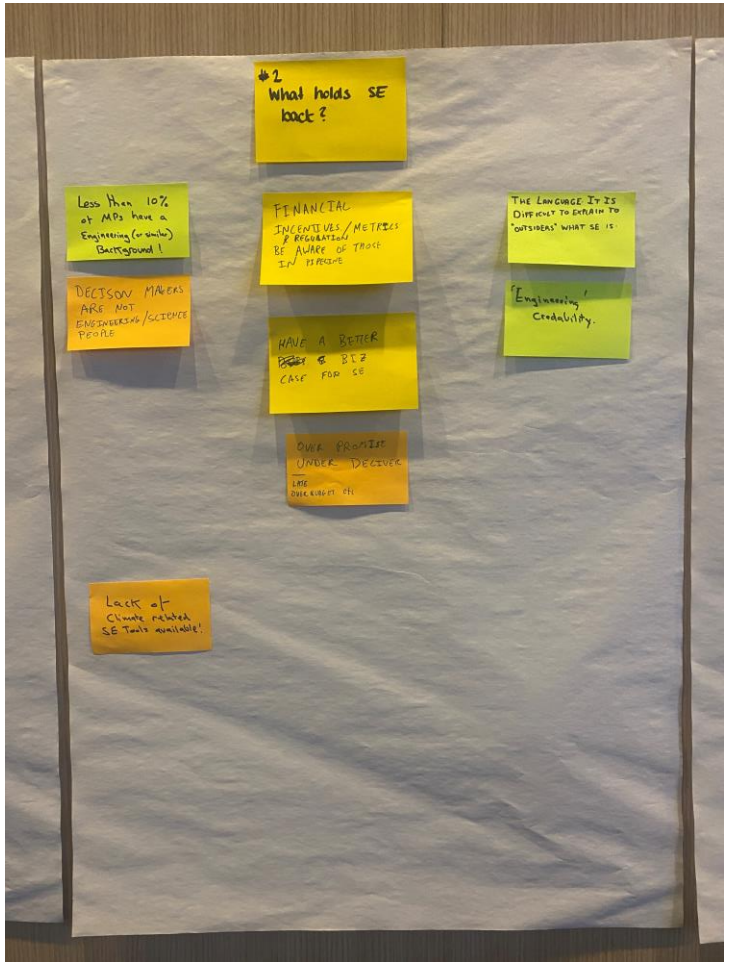
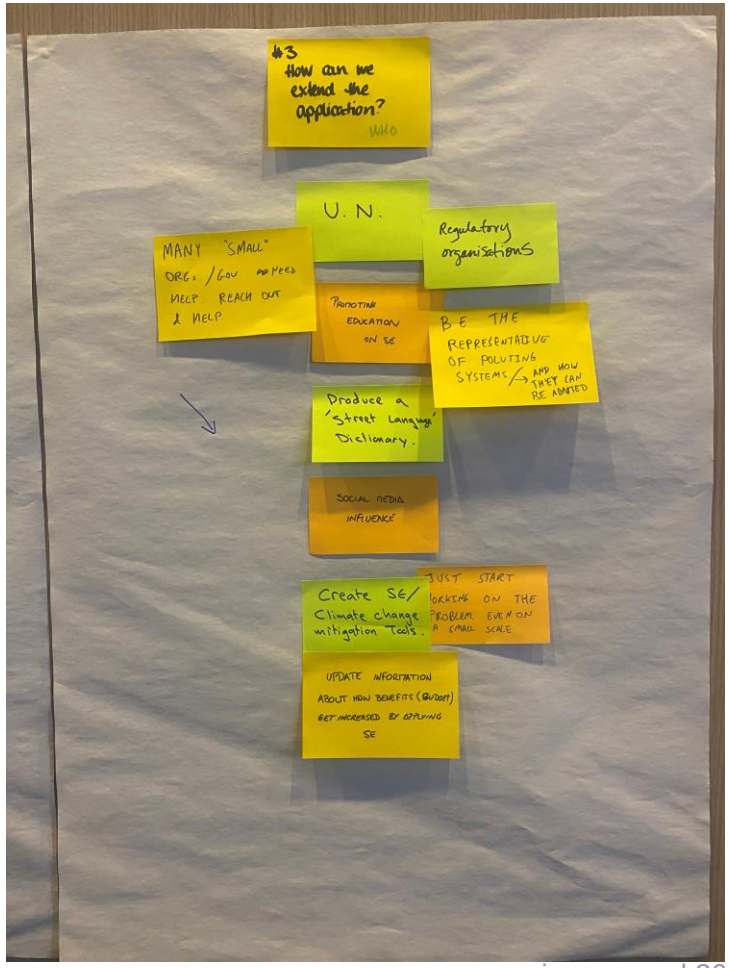


Photo Documentation

Team 2







Workshop: *Extending SE to address climate change*

Team 2

WHY
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WHAT
keeps SE from being applied?

HOW
do we extend the application of SE?
Who to approach? Who to work with?

Stuff we bring to help
- EXPERIENCE IN DEALING WITH MULTIPLE STAKEHOLDERS
- REUSE can only be address effectively using SE techniques (NFR .)
- KEEP FOCUS IN SYSTEMIC INSTEAD OF THE SYSTEMATIC
- ABILITY TO DO INTERNATIONAL COLABORATION
- Big picture problem solving
- THINK IN LONG-TERM USE RATHER THAN SHOR-TERM
- SE is good at addressing Complexity

Demand
- IT'S A HOT TOPIC

Responsibility
- MAN MADE SYSTEMS CREATE THE PROBLEM NEED TO MODIFY THEM TO SOLVE THE PROBLEM

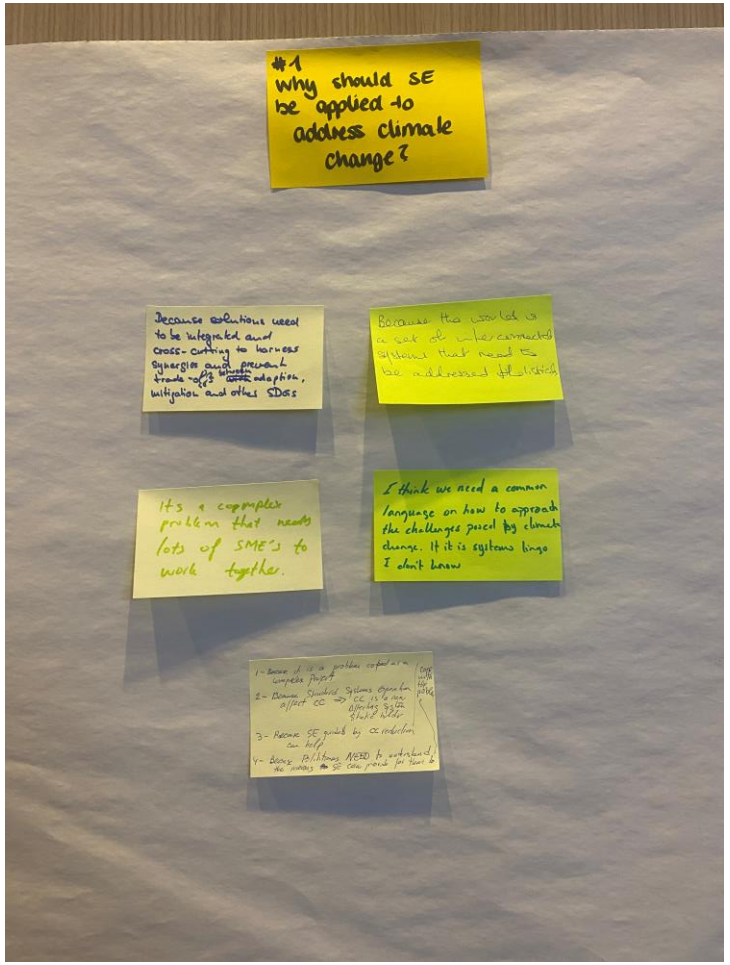
- Less than 10% of MPs have an Engineering (or similar) Background !
- THE LANGUAGE IS DIFFICULT TO EXPLAIN TO "OUTSIDERS" WHAT SE IS .
- FINANCIAL INCENTIVES. / METRICS REGULATION BE AWARE OF THOSE IN PIPELINE
- DECISION MAKERS ARE NOT ENGINEERING / SCIENCE PEOPLE
- Engineering Credibility .
- HAVE A BETTER BIZ CASE SE
- OVER PROMISE UNDER DELIVER e.g., LATE OVER BUDGET etc.
- Lack of Climate related SE Tools available!

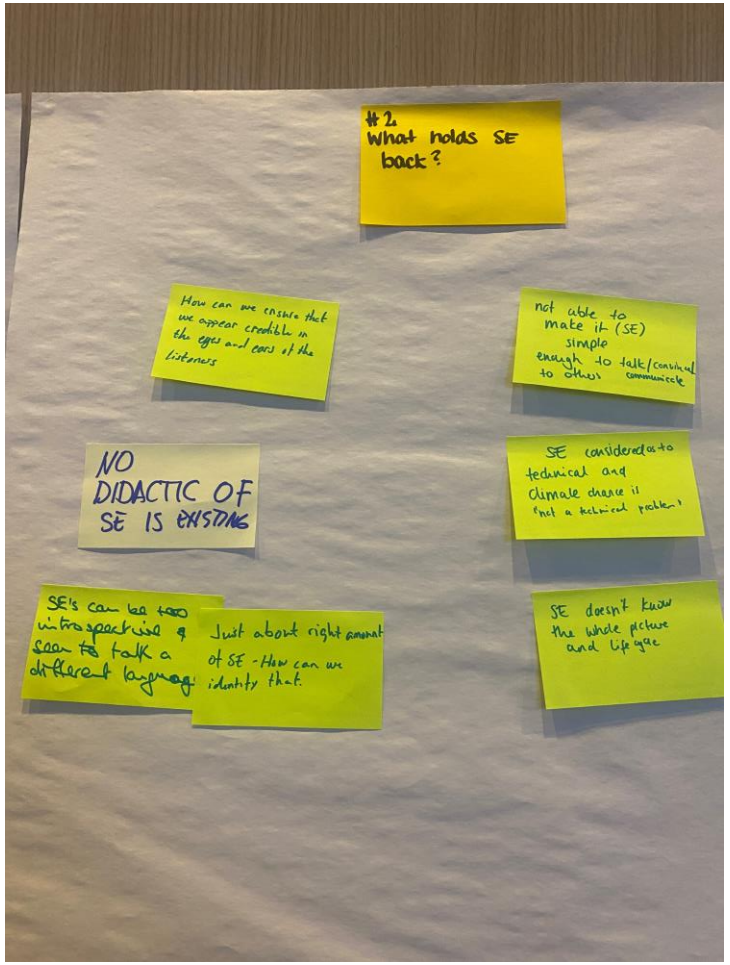
Whom do approach
- U. N.
- Regulatory organizations
- MANY "SMALL“ ORGS / GOV NEED HELP. REACH OUT & HELP

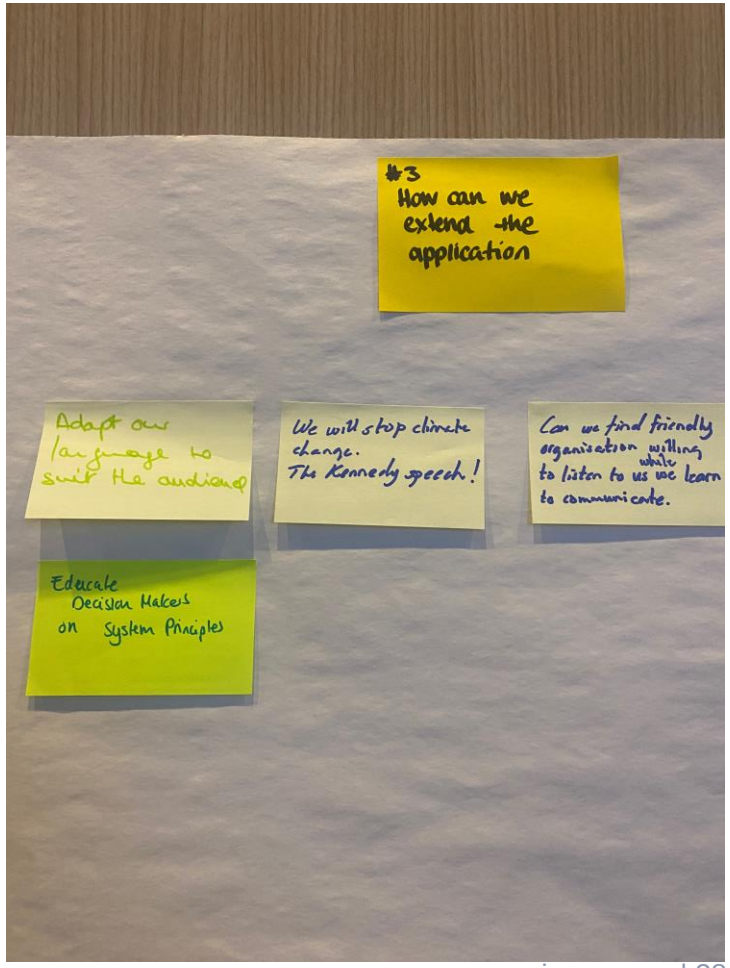
What to do
- PROMOTING EDUCATION ON SE
- BE THE REPRESENTATIVE OF POLUTING SYSTEMS. AND HOW THEY CAN BE ADAPTED
- Produce a "Street Language “ Dictionary.
- SOCIAL MEDIA INFLUENCE
- JUST START WORKING ON THE PROBLEM . EVEN ON A SMALL SCALE
- Create SE/ Climate change mitigation Tools
- UPDATE INFORMATION ABOUT HOW BENEFITS (BUDGET) GET INCREASED BY APPLYING SE

Photo Documentation

Team 3



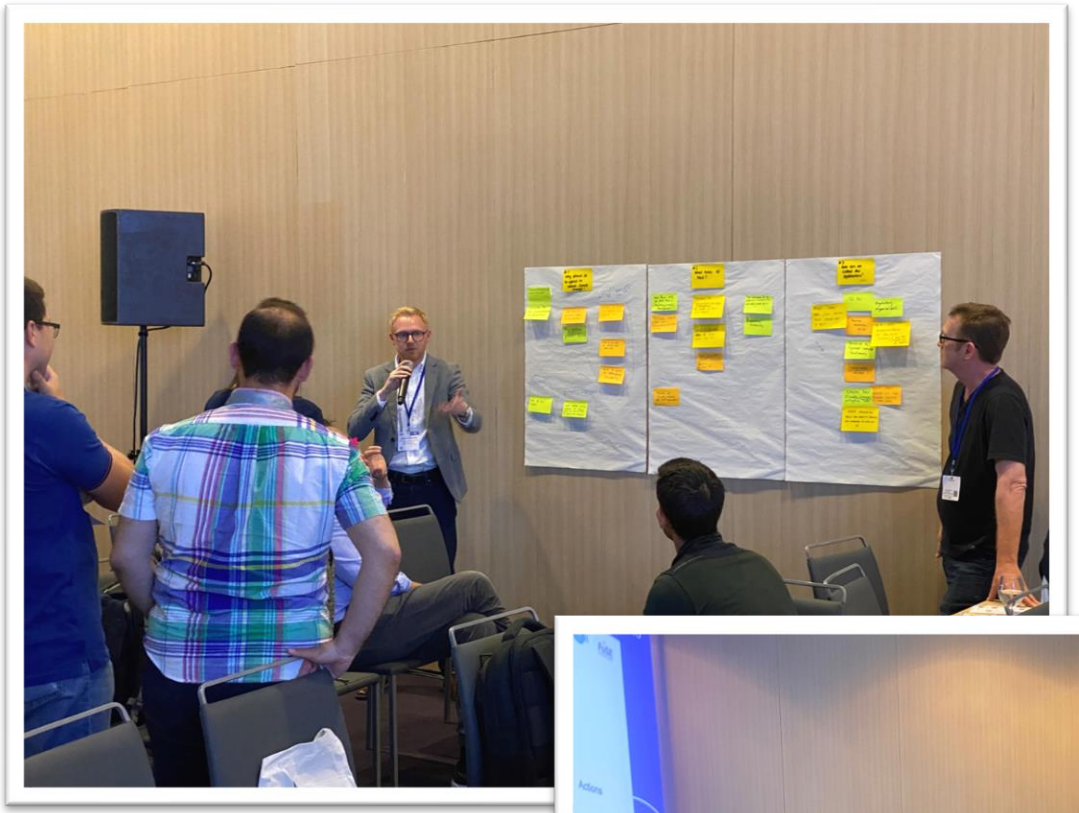


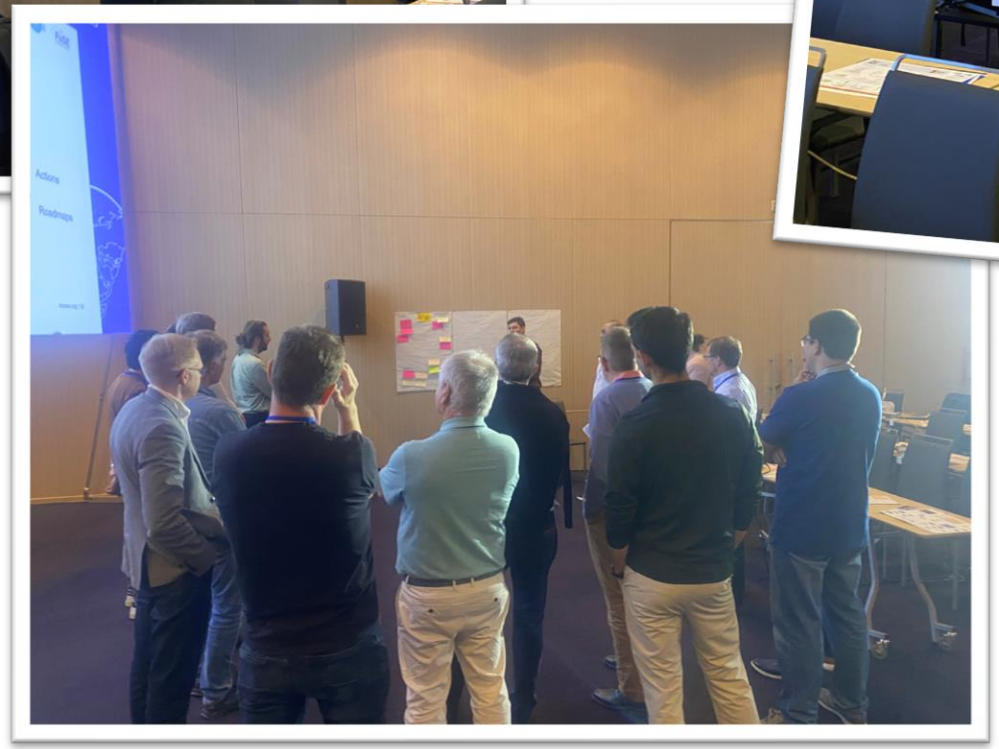


Workshop: *Extending SE to address climate change*

Team 3

WHY should SE be applied?	WHAT keeps SE from being applied?	HOW do we extend the application of SE? Who to approach? Who to work with?
• Because solutions need to be integrated and cross - cutting to harness synergies and prevent trade-offs between adaption, mitigation, and other SDGS • Because the world isa set of interconnected systems that need to be addressed holistically • I think we need a common language on how to approach the challenges posed by climate change. It is systems lingo I don't know • Its a complex problem that needs lots of SME'S to work together. • Because it is a problem coped ass complex Project • Because standard Systems Operation affect CC = > CC is a new affecting system stakeholder • Because SE guided by CC reduction can help • Because Politicians NEED to understand the means SE can provide for than to cope with the problem	• How can we ensure that we appear credible in the eyes and ears of the listeners • not able to make it (SE) simple enough to talk / convinced to others communicate • SE considered as to technical and climate chance is " not a technical problem " • NO DIDACTIC OF SE IS EXISTING • SE doesn't know the whole picture and life cycle • SE's can be too introspective &seems to talk a different language • Just about right amount of SE - How can we identity that.	• Adapt our language to suit the audience • Can we find friendly organization willing to listen to us while we learn to communicate. • We will stop climate change . The Kennedy speech ! • Educate Decision Makers on system Principles




Actions
Roadmaps

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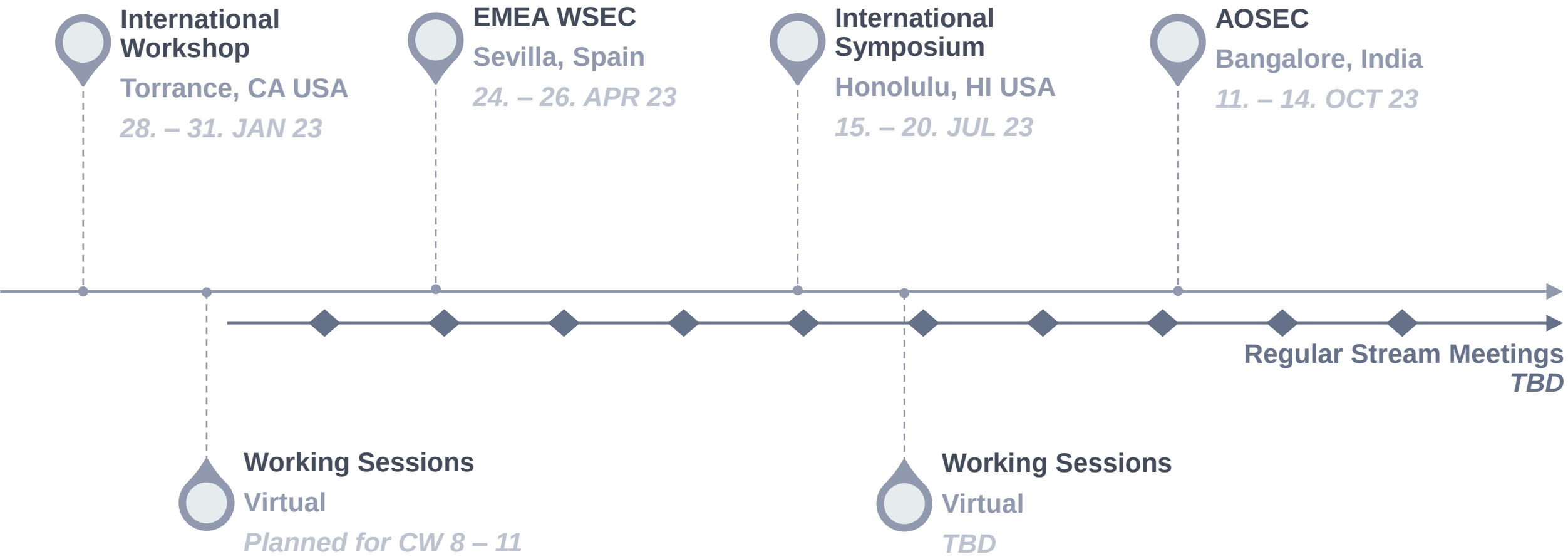
Follow up

Documentation will be sent to all the registered for the event with notes on how to stay in touch

FuSE Targeted Events in 2023

Where to engage



Let's connect.

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