Participatory Engagement | Learning by doing

Co-creation of LTES with communities from local to global, farmers to presidents

Dr James Glynn
Senior Research Scholar of Energy Systems Modeling and Data Analytics | ESMA Platform Lead at CGEP

IRENA, Bonn, GERMANY | December 7th 2022
Outline | Mapping the Journey of this Trilogy

1. IRELAND+EU
   - Publishing First Net Zero scenarios for Ireland
   - Development of TIMES IRELAND Model (TIM)
   - LTES Dialogue with Gov Climate-Action committees
   - Co-Creation of relevant scenarios to communities
     - “IMAGINING2050”
     - ucc.ie/en/imagining2050/
   - Carbon Budgets are now enshrined in Law using TIM

2. IEA-ETSAP
   - Development of global ESOM + LTES research communities.
   - Teaching Modeling tools for decision makers – creates iterative long-term relationships

3. CGEP in NYC
   - Development ESOMs as tool for dialogue at CGEP.
   - Honest independent broker of dialogue on energy transition, energy security, science-based policy targets using data driven dialogue.
DELiberative Futures Workshop

To learn more view our animation at www.ucc.ie/en/imagining2050
EXCHANGE POINTS AND QUESTIONS:

• What forms of community engagement relative to climate action have you been involved? And how did the process evolve?

• Are there plans to run or be involved in further community engagement work? If so, what will these look like?

• With respect the future thinking tools, which aspects would be useful and in what context?

• What form of impact do you expect to draw from community engagement initiatives?
BENEFITS OF ADOPTING A FUTURES-THINKING APPROACH

Futures-thinking is a growing field which enhances trust and collective visioning. It widens the debate over the future of society under growing uncertainty due to climate and other major societal issues. It suggests innovative co-creative tools which reinforce ties between civil society, policy makers and researchers.

ITS USEFUL FOR EXPLORING ISSUES SUCH AS:

1. problematic trends,
2. influences stemming from the past,
3. the problem and timing of making crucial decisions,
4. emergent dynamics,
5. the likelihood of unforeseen events,
6. agency and stakeholder influence for promoting alternative preferred futures,
7. anticipating the need to evaluate, monitor and revisit existing scenarios
1. **DIVERSITY**
   - Open Invitation
   - Time & Place
   - Caring
   - Accessibility

2. **VOICE**
   - Gender
   - Social inequality
   - Values & experiences

3. **CONSIDERED JUDGEMENT**
   - Fact sharing
   - Empathy
   - Dialogue facilitation

**KEY QUESTIONS:**
- How are participants recruited?
- How is the topic chosen?
- How is the information and expertise presented chosen?
- Are the discussions facilitated?
- How are decisions made?

**PROCESS INVOLVES**
- Listening,
- learning,
- discussing,
- co-creating,
- deciding

**GUIDING PRINCIPLES**
- Deliberative & future-oriented approach

**TOOLS FOR ENGAGING WITH**
- Local community organizations
- Social enterprise partnerships
- Environmental activists
- Local decision-makers
- Researchers
ABOUT THE TOOLS:
In establishing tools for future-thinking based on deliberative processes we tackle difficulties and uncertainties associated with the future as volatile, unstable and unpredictable.

To support the application of these tools we showcase the work carried out by the Imagining2050 project, which includes clear examples of how each tool was employed in the project.

You can adapted, mix and match these tools and processes to create an exciting menu of creative communication and engagement to suit your needs.

FUTURE-ORIENTED & DELIBERATIVE TOOLS

Tools have been rated by level difficulty, based on materials needed, preparation time, experience and ease of participant involvement.

- Future-oriented
- Deliberative Engagement
- Sense-making
- Empathy Mapping
- Storyboarding
- Community Mapping
- Audience Polls
- Ballot
- Evaluation
OTHER PROJECTS/INITIATIVES?

- Key Strengths?
- Resources?
- Engagement opportunities?
ENERGY TECHNOLOGY SYSTEMS ANALYSIS PROGRAMME

an IEA - TECHNOLOGY COLLABORATION PROGRAMME
ETSAP in a nutshell

• One of 39 IEA Technology Collaboration Programmes
  www.iea.org/tcp/

• 40 years international cooperation on energy systems modelling.

• Developing and maintaining MARKAL and TIMES model generators.

• Assisting policy decisions by modelling possible future energy pathways.

• Focus on key role of technology to meet energy and environmental goals.

• Organising biannual workshops and training on the use of TIMES.
ETSAP in a nutshell

A multilateral international agreement.
The contracting parties are the governments of twenty countries, the European Commission and two sponsor foundations.

Unique network of Energy Modelling teams from almost seventy countries use the MARKAL/TIMES family of models to support decision making in energy policy and analyse energy systems development.
The work of ETSAP is directly linked with policy making. ETSAP tools are currently used by:

- EU-JRC-IET to analyse technology development.
- IEA in the ETP publication.
- National teams informing national Governments.
- Energy Modelling Forum (EMF) researchers examining robust transition policies towards climate sustainable systems after 2100.
- MARKAL/TIMES is listed as one of the four selected modelling tools in the UNFCC guide for preparing the national communications for non-Annex I parties.

Some examples of applications can be found here:

http://www.iea-etsap.org/index.php/applications
http://www.iea-etsap.org/index.php/workshops
TIMES- Ireland Model (TIM)
Energy systems modelling to inform climate mitigation policy: Feasibility & mapping of detailed decarbonised energy pathways

**Given**
- Climate policy constraints
- Energy demand dynamics
- Future technology evolution
- Geopolitical outlook – energy prices
- Feasible growth rates

**TIM calculates**
- Energy flows & investment needs
- Emissions trajectories
- Total system cost
- Energy imports & exports
- Marginal energy & CO₂ prices
- Unmitigated emissions: “Backstop” technology at €2k/tCO₂

**Transparency & accessibility**
- Model is freely available on GitHub: [https://github.com/MaREI-EPMG/TIMES-Ireland-model](https://github.com/MaREI-EPMG/TIMES-Ireland-model)
- Documentation paper is peer-reviewed and open source: [https://gmd.copernicus.org/preprints/gmd-2021-359/](https://gmd.copernicus.org/preprints/gmd-2021-359/)
- Interactive results dashboard: [https://tim-carbon-budgets-2021.netlify.app/results](https://tim-carbon-budgets-2021.netlify.app/results)
TIM development process

- Model fully open-source
- “Best-practice” development approach – Git used for version control and integration, open web app for results analysis & diagnostics
- Developers with international expertise and links with global TIMES community, allowing knowledge-sharing
- Using TIMES framework – well-proven, high quality, continuously developed/maintained, open source code
- Flexible integration – Simultaneously maintaining “stable, policy-ready” model and development of research variants, allowing innovations in ESOMs, pushing state-of-the-art – leveraging across projects
- Strength of systems approach – automatic “sector coupling” by design – where is the best use of resources? What are sectoral trade-offs?
- Extensive stakeholder review
- Training PhDs, interns etc. & wider engagement integral for national capacity-building
- A focus on alternate scenarios, sensitivities, “what if” analyses
- Dynamic integration with national data sources and other national models (where possible)
Center on Global Energy Policy’s Engagement with Decision Makers

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IMPACTS ON POLICY

Direct Access and Participatory Engagement with Government Committees & Councils

- Published the first net-zero energy system pathways for Ireland.
- Invited Expert to provide expert witness testimony to the Joint Oireachtas Committee on Climate Action.
- Iterate with government departments, Advisory councils and economic research institute – be generous and open with time and data
Senior research scholar Jonathan Elkind greets Senator Lisa Murkowski following a "Hearing on the Use of Energy as a Tool and a Weapon" in March 2021.

Senator Bill Cassidy meets with Jason Bordoff and other CGEP experts to present his latest climate and energy proposal and to get feedback from scholars.

Dr. Melissa Lott and Jason Bordoff brief Los Angeles Mayor Eric Garcetti, and incoming chair of C40 Cities on future policy priorities for climate action.

Columbia Climate School Deans Jason Bordoff, Alex Halliday, and Ruth Defries meet with former US President Barack Obama at COP26 for a roundtable discussion with President Obama (CC’83) and a group of young climate activists.
Senior research scholar Jonathan Elkind testifies at the Energy and Natural Resources hearing on “the Use of Energy as a Tool and a Weapon,” where he conveys the United States’ and its allies’ energy security position, and emphasizes the importance of delivering both near-term energy security and on-time climate solutions.

Jason Bordoff testifies before the Senate Committee on Energy and Natural Resources on the factors that have affected oil prices over the last several years.
Connecting Decisionmakers

• Dialogue with several of world’s largest energy and finance companies on strategies for energy transition
• Engagement with several leading financial institutions on how to adjust strategies in response to climate change
• Chairing coalition of companies, NGOs, academics advancing best practices and policy support to reduce methane leakage
• Building effort to curb flaring in Texas, drawing on CEO-level participation of companies, NGOs, academics, policymakers
• CGEP organized an executive workshop drawing together leaders from government, academia, energy and climate think-tanks and industry to discuss the role of State-owned enterprises in driving emissions and low-carbon alternatives
THANK YOU!
TOWARD A FUTURE-ORIENTED PROCESS OF DELIBERATIVE DIALOGUE TO ADDRESS CLIMATE CHANGE
Sense-making can be used to explore how people come to define complex and unfamiliar issues. It is a means to grasp group reasoning around a topic, formed in support of new, future-oriented and less familiar issues. In the past it has been employed to consider the use and acceptance of new technologies, such as food technologies or renewable energy technologies.

**DIFFERENT USES:**

- Exploring public perceptions, opinions and representations of unfamiliar issues;
- Finding prevailing anchors sustaining meaning, to examine their role as empowering or disempowering anchors for action;
- Anticipate emerging controversies or tensions from a local, social or ethical standpoint;
- Consider knowledge gaps as well as trust in, and depth of interaction with existing information sources;
- Scrutinize changes of meaning overtime and scan the horizon for short and long-term trends.

**LEVEL OF DIFFICULTY**

EASY

**MATERIALS**

- Paper
- Pens/Markers
- Sticky Notes

**OPTIONAL EXTRAS**

Transferable to the online environment, by using a live wordcloud application such as Mentimeter.

**METHOD**

1. On a table, prepare a range of photographs such as cut-outs from magazines and newspapers, postcards, or other pictures. These should cover a wide variety of cultures, landscapes and human emotions.
2. Ask the participants to choose a picture that depicts their priorities or concerns.
3. In groups, discuss the choice of picture and reasoning behind it.
4. Remaining in the same groups put the pictures aside and discuss the meaning of climate change. This can be framed around personal, community or wider impacts. During the discussion, notetakers should gather meanings on a large sheet, clustering similar meanings together.
5. Tying the two pieces together, discuss in the groups how the impacts suggested will affect the priorities and concerns previously outlined.
6. Discuss and deliberate what insights became apparent during the activity.
An Empathy Map is a great human-centred tool for moving us from our own world view. During this project it helped us see climate change from the perspective of others within our community. However, Empathy Mapping can be used for everything from product and service design to counselling and teaching.

DIFFERENT USES:

- Draw out unexpected insights about your audience or users
- Conflict or crisis resolution; by creating empathy towards others we can broaden our individual perspective, as well as shape and transform societies.
- Synthesise, categorise and make sense of existing or qualitative research (research notes, survey answers, user-interview transcripts)
- Discovering gaps in your current knowledge and identifying the types of research needed to address it. For example, a sparse empathy map can indicate a need for more research.
- Understand and empathise with others in your ecosystem, helping you improve your overall relationships and your results.

LEVEL OF DIFFICULTY

EASY

MATERIALS

- Paper
- Pens/Markers
- Sticky Notes

OPTIONAL EXTRAS

Coloured markers and other creative materials to enhance the creative experience.

METHOD

1. Identify different ‘citizens’ (gender, age, job, location, disability, economic status etc)
2. Discuss who might be most affected by climate change.
3. Ask each group to draw an outline of a citizen. (Best at larger scale).
4. Ask each group to choose a citizen to map. Each creating a character including their hopes, fears, priorities, behaviours, influences, ability to influence, interests, climate concerns etc.
5. Ask each group to present their citizens, inviting others to review and add.
6. Discuss and deliberate what insights became present during this activity.
**Storyboarding**

Storyboarding has a long history, with professionals producing comics and films. In recent years its use has significantly widened to advertising, computer science, digital learning environments and the social sciences. It was originally developed as an early-stage low fidelity prototyping technique which was used to refine and develop ideas. Some common elements present in the use of storyboarding involve: a sequence of panels, a representation of the passage of time, inclusion of people and inclusion of text.

**Different Uses:**

- Breakdown a vision into smaller and more detailed elements;
- Explore user system interactions;
- Development of new technologies and practices;
- Situated development of future-oriented scenarios.

**Materials**

- Pre-printed storyboard template (larger A1 or A0 size is ideal to enable group collaboration).
- Paper of other sizes A4-A2 for notes and activities.
- Range of multicoloured pens, biros, pencils, sharpies.
- Post-its different colours including large colour post-its.

**Method**

The methodology for storyboarding is flexible and can be adapted to fit specific needs and objectives. One of the main points to consider involves the development of a blank template. In developing a storyboard template, it is important to decide on the ideal number of panels needed and their sequencing. The most common template would be a blank horizontal comic-strip type template. A simple variation of this template could include a sequence of three panels looking at past-present-future.

The Imagining2050 template has three layers, the inner circle considers ‘why we care’ for 2050 in light of climate change, the middle circle draws out some ‘focus areas’ or priorities linked to the core concern and the outer layer identifies action strategies and visual depictions of the changes the group aspires to formulation of scenario of ‘how it will look like’.

**Draw Toast**

This fun activity was created by Tom Wujec for his Wicked Problem Solving™ toolkit. Check it out for further resources and to peep his ever-popular TED Talk.
Community mapping is a relatively quick and accessible approach to inform spatially explicit climate change management at the local scale. Community maps provide a visual representation of what a community perceives as "its place" and the significant features within it. For the purposes of planning for climate action, participatory community mapping provides a means for communities to share their knowledge about the past, present and future impacts of climate change.

DIFFERENT USES:

- Engaging communities in planning for climate action;
- Raising awareness about ongoing and potential future climate change issues;
- Developing a common understanding of climate change risks;
- Providing a platform to explore and deliberate on potential solutions; and
- Empowering local communities.

LEVEL OF DIFFICULTY

MEDIUM

MATERIALS

- Pre-printed local map template,
- Markers, pens,
- High level maps of the area with key points of interest identified/highlighted,
- Sticky notes

METHOD

1. Identify recent weather events and/or periods of climate variability that have impacted upon the local area and outline impacts;
2. Highlight existing preventative or defence measures and green assets;
3. Consider projected information on how the climate of the area is expected to change in the future and other social, economic and environmental plans/trends.
4. On the basis of the weather events identified in Step 1, outline additional areas that might be exposed as a result of projected changes in climate on the map.
5. Site areas of concern, proposed changes;
6. Consider energy use.
AUDIENCE POLLS

AUDIENCE POLLS can be a powerful tool to open up discussion around future energy choices. Although everyone uses energy (electricity, heat, transport), energy transitions are often framed as macro events over long time-scales in which large-scale technology switching issues dominate. In this framing, the link between the energy transition, people’s daily lives and decision-making is obfuscated or simply framed as a technology diffusion problem, which typically closes down discussion to a limited number of topics such as barriers and costs.

DIFFERENT USES:

- Interactively explore about the implications of individual decisions on collective or common good goals
- Compare individual/group decisions in the context of specific preferences which might or might not align with their own personal preference.
- Develop scenarios based on specific group trends
- Establish levels of consensus around specific issues

LEVEL OF DIFFICULTY

MEDIUM

MATERIALS

- Audience engagement app
- audience smart phones
- overhead projector

OPTIONAL EXTRAS

Transferable to the online environment, by using a live Polling service such as Slido
https://www.sli.do/videos

METHOD

Exercise based on questions and live feedback and reflection. The following questions worked well but group-appropriate variations are encouraged:

Q 1. How do you commute now?
Car (petrol or diesel); Car (hybrid or electric); Cycling; Public Transport; Walking; Other

Q 2. How will you commute in 10 years?
Car (petrol or diesel); Car (hybrid or electric); Cycling; Public Transport; Walking; Other

Q 3. What determined your choice?
Cost, Convenience (e.g. time), Environment impact, Personal well-being (e.g. health, social), Logistical needs, Habit, Advice or recommendations (e.g. from government, colleagues, family, friends)

INDIVIDUAL DECISIONS

Consider your energy choices now and into the future

TRENDS

Compare choices with that of others and establish any strong patterns

REFLECT

How my decisions affect the future? Existing trends?
Citizen engagement processes can use a variety of methods to decide their final recommendations, report, actions plan and so forth. Future workshops may culminate in the development of an action plan employing consensus methods while others have been used to collect ideas and/or visions alone. In some cases, questionnaires have been circulated to participants to anonymously gather their opinions on the vision statements that have stemmed from the workshops.

DIFFERENT USES:
- Develop recommendations;
- Establish levels of consensus around core themes;
- Collect further ideas on visions of change;
- Use ballot anonymity to facilitate inclusion and voice.

LEVEL OF DIFFICULTY
HARD

METHOD
Steps used by Imagining 2050 on 2-weekend long events:
1. Draft papers were prepared by the team (based on emergent themes) in advance of final meeting;
2. On the Saturday evening of weekend 2, the research team convened once again to amend the draft paper;
3. On the Sunday morning of weekend 2, the group were presented with the draft and asked to review/amend;
4. Once content agreed, members were asked to complete it privately and to place it in ballot box;
5. Completed ballot papers were collected, counted in full view of the group and preliminary results returned to the group.

MATERIALS
- Copies of Draft Ballot Papers
- Pens.
- Ballot Box.
- Ballot Papers.

OPTIONAL EXTRAS
Transferable to the online environment, by using a live Polling service such as Slido
https://www.sli.do/videos

<table>
<thead>
<tr>
<th>Question 9: Please consider the following suggestions and rank in order of your preference a climate initiative you believe would be most impactful for Ballincollig in the next 10 year period</th>
<th>Rank in order of your preference (1, 2, 3...)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoning land for energy and community projects</td>
<td></td>
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<tr>
<td>Power purchase contract for Ballincollig (Micro-generation, feed-in tariff)</td>
<td></td>
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<tr>
<td>Food growing initiatives (community gardens and allotments, community supported agriculture garden)</td>
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<tr>
<td>Improved bus transport system</td>
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<td>Fleets of small bus carriers</td>
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<tr>
<td>Segregated cycling routes</td>
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<tr>
<td>Carbon Neutral agriculture</td>
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<tr>
<td>Community-led housing projects</td>
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<tr>
<td>Park and Ride (East and West of Ballincollig, with shared mobility facilities and EV points)</td>
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<tr>
<td>Pedestrianised town centre</td>
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<tr>
<td>Set-up of local energy co-op</td>
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</tbody>
</table>
## DELIBERATIVE ENGAGEMENTS ONLINE

<table>
<thead>
<tr>
<th>SETTING THE STAGE</th>
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<tbody>
<tr>
<td>• Instructions;</td>
</tr>
<tr>
<td>• Selection of focused and quiet place;</td>
</tr>
<tr>
<td>• Experienced Facilitator;</td>
</tr>
<tr>
<td>• Time for reflection and discussion;</td>
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<tr>
<td>• Trust and rapport;</td>
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<tr>
<td>• Build-in breaks.</td>
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</tbody>
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<tr>
<th>INFORMATION GIVING</th>
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<tbody>
<tr>
<td>• Media rich content;</td>
</tr>
<tr>
<td>• Interactive elements</td>
</tr>
<tr>
<td>• Welcoming messages &amp; ice breakers;</td>
</tr>
<tr>
<td>• ‘Rules of engagement’/ ‘netiquette’</td>
</tr>
<tr>
<td>• Attention building through visually rich/interactive materials;</td>
</tr>
<tr>
<td>• Mix of synchronous and asynchronous communication;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DELIBERATIVE ACTIVITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mix of formal and informal interactions;</td>
</tr>
<tr>
<td>• Mix of voice exchange, chats and messages;</td>
</tr>
<tr>
<td>• Roadmap with clear objectives and tasks to help assess progress;</td>
</tr>
<tr>
<td>• Instruction, guidance and feedback through multiple means;</td>
</tr>
<tr>
<td>• Moderator/facilitation strategy (either hands on/off)- (i.e. enforcement of netiquette, stimulation of discussion, conflict resolution, filter of chat comments, other problem solving);</td>
</tr>
<tr>
<td>• A shorter and more spread-out programme.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DELIBERATIVE INTERFACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Overview of interactive functions, audio and video, basic problem solving and contact details for technical support;</td>
</tr>
<tr>
<td>• Interface accessibility and user friendly tools;</td>
</tr>
<tr>
<td>• Safety protocols and data management practices;</td>
</tr>
<tr>
<td>• Display cues that allow self-directed time management and regular progress cues;</td>
</tr>
<tr>
<td>• Break-out rooms, quiet rooms and private chats;</td>
</tr>
<tr>
<td>• Dedicated live Interface management</td>
</tr>
<tr>
<td>• Personalization of online environment (font size, background colours etc.)</td>
</tr>
</tbody>
</table>
Further readings and references

**Deliberative tools**

- Democracy Cookbook
- Enhancing Citizen Engagement On The Climate Crisis: The Role Of Deliberation
- UNESCO: Futures Literacy Labs
- The Long Time Tools

**Future-Thinking Tools**

- Involve
- Participedia
- Nordkapp: Actionable Futures Toolkit
- UK The Government Office for Science (GO-Science) The Futures Toolkit
Benefits and cost of joining IEA-ETSAP

**Benefits:**

- Participants have the right to be represented at the Executive Committee and to participate with one vote in all decisions including accepting new members, setting the research agenda, management of the budget, interaction with the IEA and other TCPs;
- Free access to the ANSWER, VEDA users’ interfaces, updates and related preferential assistance;
- Participation in the annual calls for proposals of research projects funded by ETSAP;
- Access to the global multi-regional TIMES Integrated Assessment Model - TIAM (with endogenous trade of energy and CO₂ permits, stochastic variables and climate equations) and continuous updates;
- Networking with other institutions at the cutting edge of the application of TIMES;
- Free access to the training courses (offered at least twice a year);
- Increased chances to be part of consortia coordinated by ETSAP members for submitting projects to international funding agencies.

**Participation Cost:**

€20,000 per annum for contracting parties (Governments and Institutions appointed by governments), €30,000 for sponsors (private companies).
The ETSAP community

- Two workshops per year, one organized together with IEW.
- 3-5 TIMES model training sessions around the world.
- More than 25 research institutions involved.
- Access to support and discussion forums.
- New tools and analyses are shared.
- Close collaboration with IEA, IRENA, World Bank and many more.

Documentation:
ENERGY SYSTEMS AND SUSTAINABLE DEVELOPMENT GOALS

Research and Development

ETSAP will support research and development activities in order to advance the state-of-the-art of energy systems analysis. A non-exhaustive list of topics includes:

1. Pathways to net zero GHG emissions systems;
2. Interaction of energy systems with materials use, land use, water and agriculture;
3. Integrate issues of sustainability of biomass in the analyses (e.g. biomass GHG overshoot problem);
4. Improved modelling of variable renewables and short-term system operational issues in long term energy systems modelling;
5. Improved modelling of the consumption side of energy systems, demand side flexibility, integrating human behaviour and societal aspects into energy systems modelling;
6. Improved modelling of the interactions between the energy system and social systems, structural changes, circular economy and SDG’s;
7. Energy Technology Data Source (E-TechDS) updates. Focus on negative emission and renewable fuel technologies;
8. Opening TIMES by continuing the development towards open data, software and web based solutions;
9. Continued development and improvement of the Global Integrated Assessment ETSAP-TIAM model
Discussion Points

• Interest to join ETSAP

• Participation in the next ExCo as an observer

• Paperwork for joining ETSAP-TCP
More information available on ETSAP’s website [www.iea-etsap.org](http://www.iea-etsap.org). Contacts:

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**Project Head:**
Dr George Giannakidis
[mailto:ggian@etsap.org](mailto:ggian@etsap.org)

Books on the use of ETSAP tools for Policy formulation

Available at:

Available at:
IEA drivers of scenario outcomes

It is important to understand drivers of model outcomes and emergent properties of energy system dynamics e.g. Is Energy demand intensity to GDP an input or an output?

CO2 Intensity Vs Energy Demand

Percentage Difference from 2020
IEA drivers of scenario outcomes

It is important to understand drivers of model outcomes and emergent properties of energy system dynamics e.g. Energy demand intensity?
Shared-Socioeconomic Pathways

IPCC Working Group 1,2 & 3 coordinate their input assumptions by using the Shared Socio-economic Pathways (SSP) Narratives (SSPx-RCPx)

Data Source: https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
IEA Data Sources - WBIG

IEA publishes a comprehensive data base of global extended energy balances, that include all energy commodity flows within all NACE economic categories globally for ~147 countries – “WBIG” is the foundation of all global energy system models.
IEA Data Sources - WBIG

IEA publishes a comprehensive data base of global extended energy balances, that include all energy commodity flows within all NACE economic categories globally for ~147 countries – “WBIG” is the foundation of all global energy system models.
IEA Data Sources WBIG, WIND

More recently in the last 5 years or so IEA has put significant effort in also publishing harmonized macroeconomic, environmental and demographic data indicators for all regions on an annual basis.
Linking the IEA WBIG and WIND databases by harmonized region names enables quick insights into historical dynamics of the energy system.
IEA Data Sources **WBIG + WIND**

Linking the IEA WBIG and WIND databases by harmonized region names enables quick insights into historical dynamics of the energy system.
Reminder – Energy access, Income, and Wellbeing go hand in hand

Total final energy consumption per capita (toe/capita) vs GDP per capita, 1960-2000
ML Extrapolation of IEA drivers

It is important to understand drivers of model outcomes and emergent properties of energy system dynamics e.g. Energy demand intensity?
Wind and Solar Installed Capacity

China far outpaces all other countries in cumulative installed capacity and recent rate of new capacity installation.
IPCC 6th Assessment Report Decarbonisation Pathways

Projected global GHG emissions from NDCs announced prior to COP26 would make it likely that warming will exceed 1.5°C and also make it harder after 2030 to limit warming to below 2°C.
Current Distribution of Wind and Solar Operational (OPR) and Planned (PLN) Capacity as of June 2022

Planned and Operational Distribution of Solar PV and Wind onshore, Offshore and floating capacity (MW) in China

Source: SPGlobal Capital IQ – World Electricity Power Plant Database
SPGlobal World Electricity Power Plant (WEPPS) database also publish current status of plants, in planning, construction, operation, retired...
Open Source Powerplant DB WRI

Increasingly there are open access power plant databases available such as World Resources Institute (Below) and Global Energy Monitor (GEM)
US-EIA historical & scenario data

US EIA Publishes a wealth of US focused historical energy balances, energy trade, technology cost outlooks and very often geolocated which enables useful analysis – IRA co-location of mine closure subsidies with retired coal plants.
EIA binding model constraints

EIA also publish a wealth of engineering and operational data at the individual plant level often at hourly time resolution such as emissions per plant and capacity factors that are binding constraints on IAM & ESM model dynamics.
IRENA Renewable Energy Project auction prices per technology type

Figure 5.3 The LCOE for projects and global weighted average values for CSP, solar PV, onshore and offshore wind, 2010-2022

Note: Each circle represents an individual project or an auction result where there was a single clearing price of auction. The center of the circle is the value for the cost of each project on the Y axis. The thick lines are the global weighted-average LCOE, or auction values, by year. For the LCOE data, the real WACC is 7.5% for OECD countries and China, and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.
# NREL Future Technology Costs DB

NREL/IEA/NETL/DEA/IRENA/IEAGHG/IAMC* all public future technology databases for energy systems modeling construction & analysis

E.G. Source: 2022 Annual Technology Baseline (ATB) from NREL - [https://atb.nrel.gov/](https://atb.nrel.gov/)

<table>
<thead>
<tr>
<th>Offshore Wind Wind Speed Classes</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Year:</strong></td>
<td>2020</td>
</tr>
</tbody>
</table>

All values are given in 2020 U.S. dollars, using the Consumer Price Index (BLS, 2021) for dollar year conversions where source dollar years don’t match 2020.

## Wind Speed Classes

<table>
<thead>
<tr>
<th>Wind Speed Class</th>
<th>Average Water Depth (m)</th>
<th>Average Distance Site to Cable Landfall (km)</th>
<th>Average CAPEX ($/kW)</th>
<th>Average OPEX ($/kW/yr)</th>
<th>Average Net CF (%)</th>
<th>Average Wind Speed (m/s) @ 100m</th>
<th>Potential Wind Plant Capacity (GW)</th>
<th>Potential Wind Plant Energy (TWh)</th>
<th>Share of total fixed-bottom / floating capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-Bottom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Speed Class 1</td>
<td>23</td>
<td>35</td>
<td>3,484</td>
<td>108</td>
<td>45%</td>
<td>8.74</td>
<td>14</td>
<td>55</td>
<td>2%</td>
</tr>
<tr>
<td>Wind Speed Class 2</td>
<td>24</td>
<td>35</td>
<td>3,555</td>
<td>111</td>
<td>44%</td>
<td>8.62</td>
<td>14</td>
<td>53</td>
<td>2%</td>
</tr>
<tr>
<td>Wind Speed Class 3</td>
<td>25</td>
<td>40</td>
<td>3,076</td>
<td>113</td>
<td>45%</td>
<td>8.64</td>
<td>27</td>
<td>105</td>
<td>4%</td>
</tr>
<tr>
<td>Wind Speed Class 4</td>
<td>32</td>
<td>45</td>
<td>3,187</td>
<td>114</td>
<td>44%</td>
<td>8.67</td>
<td>54</td>
<td>214</td>
<td>9%</td>
</tr>
<tr>
<td>Wind Speed Class 5</td>
<td>32</td>
<td>65</td>
<td>4,006</td>
<td>117</td>
<td>44%</td>
<td>8.99</td>
<td>169</td>
<td>419</td>
<td>16%</td>
</tr>
<tr>
<td>Wind Speed Class 6</td>
<td>33</td>
<td>74</td>
<td>3,977</td>
<td>115</td>
<td>36%</td>
<td>7.63</td>
<td>217</td>
<td>752</td>
<td>32%</td>
</tr>
<tr>
<td>Wind Speed Class 7</td>
<td>30</td>
<td>77</td>
<td>4,013</td>
<td>110</td>
<td>28%</td>
<td>8.78</td>
<td>244</td>
<td>634</td>
<td>36%</td>
</tr>
</tbody>
</table>

| Floating         |                         |                                              |                       |                        |                    |                              |                                  |                                 |                                  |
| Wind Speed Class 8 | 159                     | 45                                           | 4,865                 | 60                     | 52%                | 9.59                         | 33                              | 120                             | 2%                               |
| Wind Speed Class 9 | 177                     | 54                                           | 5,045                 | 80                     | 51%                | 9.42                         | 35                              | 123                             | 2%                               |
| Wind Speed Class 10 | 167                    | 58                                           | 5,157                 | 84                     | 50%                | 9.30                         | 55                              | 241                             | 4%                               |
| Wind Speed Class 11 | 128                    | 90                                           | 5,521                 | 81                     | 48%                | 9.33                         | 110                             | 477                             | 8%                               |
| Wind Speed Class 12 | 193                    | 122                                          | 5,757                 | 85                     | 46%                | 9.05                         | 221                             | 919                             | 16%                              |
| Wind Speed Class 13 | 686                    | 137                                          | 5,910                 | 89                     | 37%                | 7.96                         | 442                             | 1,495                           | 32%                              |
| Wind Speed Class 14 | 635                    | 101                                          | 5,979                 | 89                     | 30%                | 7.04                         | 497                             | 1,340                           | 36%                              |
| **Total**        |                         |                                              |                       |                        |                    |                              | 2,058                           | 6,835                           |                                  |

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IEA WEO & Net-Zero Flagship reports

To understand these reports we must understand the models used which underpin the evidence base for these outlooks and pathways.
To understand these reports we must understand the models. Go to the Annexes to extract data, input assumptions and read the small print.
IEA WEO input driver assumptions

Thinking of the KAYA identity, Population, Economic Activity, Carbon intensity of resources and consumption are key initial conditions.

B.1 Population

Table B.1 Population assumptions by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Compound average annual growth rate</th>
<th>Population (million)</th>
<th>Urbanisation (share of population)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000-20</td>
<td>2020-30</td>
<td>2050</td>
</tr>
<tr>
<td>North America</td>
<td>0.9%</td>
<td>0.7%</td>
<td>0.5%</td>
</tr>
<tr>
<td>United States</td>
<td>0.8%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>C &amp; S America</td>
<td>1.1%</td>
<td>0.7%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Brazil</td>
<td>1.0%</td>
<td>0.5%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Europe</td>
<td>0.3%</td>
<td>0.0%</td>
<td>-0.0%</td>
</tr>
<tr>
<td>European Union</td>
<td>0.2%</td>
<td>-0.1%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Africa</td>
<td>2.6%</td>
<td>2.3%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Middle East</td>
<td>2.2%</td>
<td>1.6%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Eurasia</td>
<td>0.4%</td>
<td>0.3%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Russia</td>
<td>-0.1%</td>
<td>-0.2%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>1.0%</td>
<td>0.6%</td>
<td>0.4%</td>
</tr>
<tr>
<td>China</td>
<td>0.5%</td>
<td>0.2%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>India</td>
<td>1.3%</td>
<td>0.9%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Japan</td>
<td>-0.0%</td>
<td>0.5%</td>
<td>-0.6%</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>1.2%</td>
<td>0.8%</td>
<td>0.6%</td>
</tr>
<tr>
<td>World</td>
<td>1.2%</td>
<td>0.9%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

Notes: C & S America = Central and South America. See Annex C for composition of regional groupings.

Sources: UN DESA (2018, 2019); World Bank (2021a); IEA databases and analysis.

B.3 Fossil fuel resources

Table B.3 Remaining technically recoverable fossil fuel resources, end-2020

<table>
<thead>
<tr>
<th>Resource</th>
<th>Proven reserves (trillion cubic metres)</th>
<th>Resources (trillion cubic metres)</th>
<th>Conventional crude oil</th>
<th>Tight gas</th>
<th>Shale gas</th>
<th>Coalbed methane</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>1.753</td>
<td>6.206</td>
<td>2.109</td>
<td>536</td>
<td>622</td>
<td>1.866</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Proven reserves (trillion cubic metres)</th>
<th>Resources (trillion cubic metres)</th>
<th>Conventional crude oil</th>
<th>Tight gas</th>
<th>Shale gas</th>
<th>Coalbed methane</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>17</td>
<td>140</td>
<td>50</td>
<td>30</td>
<td>81</td>
<td>7</td>
</tr>
<tr>
<td>Central and South America</td>
<td>8</td>
<td>84</td>
<td>28</td>
<td>15</td>
<td>41</td>
<td>-</td>
</tr>
<tr>
<td>Europe</td>
<td>5</td>
<td>46</td>
<td>18</td>
<td>5</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Africa</td>
<td>19</td>
<td>101</td>
<td>51</td>
<td>10</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Middle East</td>
<td>81</td>
<td>121</td>
<td>101</td>
<td>9</td>
<td>11</td>
<td>-</td>
</tr>
<tr>
<td>Eurasia</td>
<td>70</td>
<td>169</td>
<td>131</td>
<td>10</td>
<td>17</td>
<td>-</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>21</td>
<td>139</td>
<td>45</td>
<td>21</td>
<td>53</td>
<td>20</td>
</tr>
<tr>
<td>World</td>
<td>221</td>
<td>809</td>
<td>425</td>
<td>80</td>
<td>233</td>
<td>49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resource</th>
<th>Proven reserves (trillion tonnes)</th>
<th>Resources (trillion tonnes)</th>
<th>Coking coal</th>
<th>Steam coal</th>
<th>Lignite</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>257</td>
<td>8.389</td>
<td>1.031</td>
<td>5.839</td>
<td>1.519</td>
</tr>
<tr>
<td>Central and South America</td>
<td>14</td>
<td>60</td>
<td>3</td>
<td>32</td>
<td>25</td>
</tr>
</tbody>
</table>
Increasingly the IEA WEO and IEA ETP publish their technology databases, which strongly influences model outcomes – in Annexes.
IEA Global Policies database

The Small Print - Policies represent constraints to the evolution to the energy system under standard solutions of the model's objective function. Exploring dominant policies is key to understanding scenario outcomes. Source: https://www.iea.org/policies
Net-Zero and 1.5 are now the goalpost

Key milestones on the pathway to net-zero
IPCC 6th Assessment Reports

IAM & ESM Scenario databases for many IAMC projects are hosted by IIASA, including IPCC AR5 and AR6 - https://data.ece.iiasa.ac.at/ar6/

AR6 Scenario Explorer and Database hosted by IIASA

The scenario ensemble is protected by EU Slj generic database rights.

Summary
This Scenario Explorer presents an ensemble of quantitative, model-based pathways underlying the Sixth Assessment Report (AR6) of Working Group I by the Intergovernmental Panel on Climate Change (IPCC), entitled Climate Change 2022: Mitigation of Climate Change. For more information on the scenarios in the AR6 Scenario Database, please see the About tab.

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The scenario data available on this page has been compiled to support the assessment of quantitative pathways in the IPCC AR6. The copyright of the scenario data is held by the respective institutions and modeling teams with permission to make the data on this website. The scenario data may be reused and reproduced in accordance with the license.

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The scenario ensemble is made publicly available to ensure reproducibility and transparency with respect to the dataset that has been used in AR6. The Scenario Explorer allows for the re-use of scenario data by other research communities. Please read the guidance note and the license terms on the license page before downloading data or figures.

Background of the Scenario Explorer
As part of the IPCC’s Sixth Assessment Report (AR6), authors from Working Group I on Mitigation of Climate Change undertook a comprehensive exercise to collect and assess quantitative, model-based scenarios related to the mitigation of climate change. Building on previous assessments, such as those undertaken for the Fifth Assessment Report (AR5) and the Special Report on Global Warming of 1.5°C (SR15), the calls for scenarios in AR6 have been expanded to include energy, emissions, and sectoral scenarios from global to national scales, thus more broadly supporting the assessment across multiple chapters (see Annex VIII, Part 2 of the WG I Report and the About tab for more detail).

The compilation and assessment of the scenario ensemble was conducted by authors of the IPCC AR6 report, and the resource is hosted by the International Institute for Applied Systems Analysis (IIASA) as part of a cooperation agreement with Working Group I of the IPCC. The scenario ensemble contains 1.5K quantitative scenarios with

IAMC Integrated Assessment Modeling Consortium

Climate Change 2022
Mitigation of Climate Change

Working Group I contribution to the 6th Assessment Report of the Intergovernmental Panel on Climate Change

WMO
UNEP
Who and what are the IAMC?

The Integrated Assessment Consortium (IAMC) is an organization of scientific research institutions that pursues scientific understanding of issues associated with integrated assessment modeling and analysis. https://www.iamconsortium.org/membership/members/…
IAMC Model Documentation

Integrated Assessment Modelling Consortium host their documentation here: https://www.iamcdocumentation.eu/index.php/Electricity_-_MESSAGE-GLOBIOM

Electricity - MESSAGE-GLOBIOM

MESSAGE covers a large number of electricity generation options utilizing a wide range of primary energy sources. For fossil-based electricity generation technologies, typically a number of different technologies with different efficiencies, environmental characteristics and costs is represented. For example, in the case of coal, MESSAGE distinguishes subcritical and supercritical pulverized coal (PC) power plants where the subcritical variant is available with and without flue gas desulfurization/denox and one internal gasification combined cycle (IGCC) power plant. The supercritical PC and IGCC plants are also available with carbon capture and storage (CCS) which also can be retrofitted to some of the existing PC power plants. Table 1 below shows the different power plant types represented in MESSAGE.

Four different nuclear power plant types are represented in MESSAGE-GLOBIOM, i.e. two light water reactor types, a fast breeder reactor and a high temperature reactor, but only the two light water types are included in the majority of scenarios being developed with MESSAGE in the recent past. In addition, MESSAGE includes a representation of the nuclear fuel cycle, including reprocessing and the plutonium fuel cycle, and keeps track of the amounts of nuclear waste being produced.

The conversion of five renewable energy sources to electricity is represented in MESSAGE-GLOBIOM (see Table 1). For wind power, both on- and offshore electricity generation are covered and for solar energy, photovoltaics (PV) and solar thermal (concentrating solar power, CSP) electricity generation are included in MESSAGE (see also sections on non-biomass renewables of MESSAGE-GLOBIOM and Grid, pipelines and other infrastructure of MESSAGE-GLOBIOM).

Most thermal power plants offer the option of coupled heat production (CHP, see Table 1). This option is modeled as a passout turbine via a penalty on the electricity generation efficiency. In addition to the main electricity generation technologies described in this section, also the co-generation of electricity in conversion technologies primarily devoted to producing non-electric energy carriers (e.g., synthetic liquid fuels) is included in MESSAGE (see sections on Liquid fuels of MESSAGE-GLOBIOM and Gaseous fuels of MESSAGE-GLOBIOM).

Table 1: List of electricity generation technologies represented in MESSAGE-GLOBIOM by energy source

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Technology</th>
<th>CHP option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>subcritical PC power plant without desulfurization/denox</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>subcritical PC power plant with desulfurization/denox</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>supercritical PC power plant with desulfurization/denox</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>subcritical PC power plant with desulfurization/denox and CCS</td>
<td>yes</td>
</tr>
</tbody>
</table>
It is also important to remember that all Integrated Assessment Models do not contribute the same number of scenarios to the IAMC databases. This can lead to a handful of influential models having more impact on the outcome statistics than other models. IPCC database is largely dominated by (6-10) techno-economic optimization models based in institutions in Europe.
Global decarbonization pathways under declining carbon budgets

Projected global GHG emissions from NDCs announced prior to COP26 would make it likely that warming will exceed 1.5°C and also make it harder after 2030 to limit warming to below 2°C.
Global low carbon technology deployment and cost reductions

The unit costs of some forms of renewable energy and of batteries for passenger EVs have fallen, and their use continues to rise.
REMINDER! Temperature increases linearly with cumulative emissions so the pathways to net-zero are important

Breakdown of contributions to global net CO₂ emissions in four illustrative model pathways

These pathways show a range of potential mitigation approaches and vary widely in their projected energy and land use, as well as their assumptions about future socio-economic developments, including economic and population growth, equity and sustainability.

IPCC 6th Assessment Report Technology Cost Summary

The unit costs of some forms of renewable energy and of batteries for passenger EVs have fallen, and their use continues to rise.