Future Crafting: Leveraging Prompt Engineering and AI for Scenario Planning



A prompt-engineering manual for consulting engineers

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European Engineering Consultancies

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Preface

In the dynamic world of engineering consulting, the interplay between emerging trends and industry-specific challenges continues to redefine the landscape. The rapid evolution in technology, combined with shifts in regulatory frameworks and market conditions, underscores the need for robust scenario planning to navigate future uncertainties.

This report, developed from a seminar with Master of Business Administration students from the Philipps University of Marburg, investigates the intersection of Generative AI, particularly ChatGPT, and scenario planning within the consulting engineering industry. Specifically, it delves into the potential futures of transportation infrastructure and climate adaptation through the lens of ChatGPT and expert industry insights. The students, by harnessing the power of ChatGPT coupled with structured prompt engineering, have crafted detailed scenarios and developed custom versions of ChatGPT tailored specifically for their respective fields — climate adaptation and the future of transportation infrastructure.

This document is designed to serve as both a report and a manual, aiming to equip consulting engineers with the knowledge and tools necessary to effectively utilise ChatGPT in developing detailed scenarios. It shares the approaches, learnings, and limitations encountered during the seminar, providing a practical framework for applying Generative AI in professional practices. Furthermore, this report will include specific instructions and insights on how the students created and utilised their custom GPTs, offering a valuable resource for others in the industry to replicate and build upon.

We extend our gratitude to the students Yeamelake Aklilu, Falk Altmüller, Rim Banu, Sven Müller, Moritz Nesswetter, Vanessa Rosenau, Sophia Sauer and Luisa Schulze Marquarding. Furthermore without the support of Bernardo Matos, Marcin Mikulewicz, Stephan Müller, Iana Motovilnic, Richard Resvoll, Andreas Schweinar, Stefano Susani, Marek Suchocki, Prof. Dr. Torsten Wulf and Lucas Cornaro who shared their valuable insights with the students, making this exploration into the future of engineering consulting possible. Their perspectives have enriched this report and ensured its relevance and applicability.

We invite you to engage with this report, reflect on the scenarios presented, and consider how these insights might influence your strategic decisions. In doing so, we hope to provide you with a comprehensive understanding of the challenges and opportunities that lie ahead, equipping you with a tool and method to navigate an increasingly disrupted world.

Jeffrey Seeck
Chair of the EFCA Future Trends Committee



Overview of Scenario Planning

The objective of scenario planning is to support strategic decision-making under the influence of uncertainty factors. By envisioning multiple potential futures, companies can better anticipate changes and prepare for diverse outcomes. This method helps organisations identify opportunities and mitigate risks, ultimately leading to more resilient and adaptable strategies. By integrating artificial intelligence (AI) and prompt engineering, the development of scenarios becomes more efficient and precise, leveraging advanced data analysis and predictive modelling to refine strategic planning.

While there are different scenario planning methodologies, they typically involve the following phases:

1. Identification of Trends and Key Uncertainties: This phase involves gathering and structuring relevant data to understand current trends and key factors that might affect the future. Databases, market studies, and expert interviews are utilised to collect data. Influence diagrams and other methods help identify and evaluate significant uncertainties, which can be visually represented using uncertainty grids or spider diagrams.

2. Development of Scenario Dimensions and Scenario Matrix: In this phase, fundamental assumptions about the future are established, forming the basis for scenario development. Different potential futures are then outlined and organised into a scenario matrix based on two key uncertainties, helping to structure and compare the scenarios.

3. Scenario Description: Each scenario is thoroughly evaluated and described to provide a clear and tangible vision of potential futures. Scenarios are mapped onto a matrix to visualise different possibilities and their implications, aiding stakeholders in understanding and preparing for various outcomes.

4. Implications and Strategic Plans: The final phase focuses on creating actionable and resilient strategies based on the scenarios developed. It starts with an analysis of scenarios to identify key themes and trends. Strategic options are then generated and evaluated for feasibility, impact, and alignment with organisational goals, ensuring strategies are robust enough to handle future uncertainties.

Each phase can be supported by specific tools and methods, such as SWOT analysis, PESTEL analysis, spider diagrams and the Delphi method.

GPTs and Prompt Engineering



DISTINCTION BETWEEN GEN-AI, LLMS AND GPTS

Generative AI (Gen-AI) represents a broad category within artificial intelligence that is designed to create new content across multiple forms of media, including text, images, videos, and music. This technology leverages advanced machine learning techniques to produce content that often closely mimics human creativity. The applications of Gen-AI extend beyond mere data analysis, entering creative territories typically associated with human artists and creators, such as generating novel artworks or composing music.

Within the realm of Gen-AI, particularly focusing on the generation of text, we find Large Language Models (LLMs). These are highly sophisticated AI systems that have been trained on vast amounts of text data. Their primary function is to understand and generate human-like text, making them invaluable for tasks that require a deep grasp of language, such as writing articles, translating languages, or generating realistic dialogues for chatbots. LLMs utilise complex algorithms to parse and produce language in a way that reflects human conversational patterns, nuances, and even the subtleties of context within large bodies of text.

A specific and refined subset of LLMs is OpenAI's Generative pre-trained Transformers, known as GPTs. These models undergo extensive pre-training where they learn from a diverse range of internet text. After this initial phase, they are fine-tuned on specific tasks to enhance their ability to generate text that is not only relevant and coherent but also engaging and stylistically appropriate for various applications. An effective LLM should possess at least four key features, as shown in Figure 1:

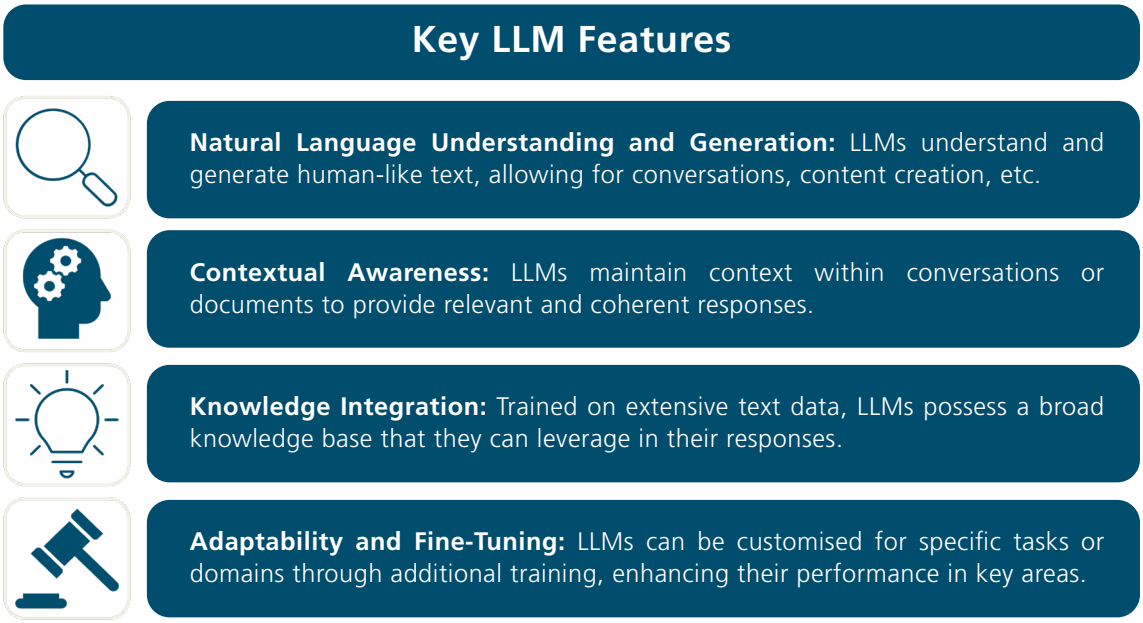


Figure 1: Key LLM Features

At present, we are in the early stages of development. Numerous major tech companies, including Google and Microsoft, are working on developing and improving their own LLM models. The technique or discipline of "prompt engineering" can be used across different LLM models, however it is important to know what capabilities and limitations Gen-AI currently have, to improve the interaction (input, process, output) between the LLM and the user. Table 1 shows the main capabilities and limitations.

Capabilities	Limitations
Text Generation: can generate text based on a prompt, including conversation, summaries, stories, poems and more	**Contextual Understanding:** can struggle with understanding certain context and may generate responses that are not relevant to the prompt
Question-Answering: answer a wide range of questions, e.g. factual, definitional, and conversational	**Emotional Intelligence:** can generate responses that are not logically, socially or ethical appropriate
Language Translation: can translate text from one language to another	**Pretraining-Bias:** has been trained on large amounts of text from the internet or other sources which may contain biases and inaccuracies
Text Generation: classify text into different categories based on the input	**Dependency on Input Quality:** quality and clarity of responses are highly dependent on the quality and clarity of the input prompts
Picture Generation: creates pictures based on description given by the user	**Picture Generation:** very limited in capability of picture adaption with commands by the user
Educational Assistance: can help explain complex concepts and provide educational support	**Lack of Real-Time Knowledge:** GPT's knowledge is based on the data it was trained on and does not include real-time updates or events occurring after its last training cut-off
Personalised Recommendations: ChatGPT can provide personalised suggestions based on user preferences and interests	**Limited Domain Knowledge:** may struggle with more complex or niche topics; limited in breadth and depth

POTENTIAL OF GEN-AI IN SCENARIO PLANNING

As the landscape of strategic planning evolves, Gen-AI and in particular ChatGPT emerge as a powerful LLM tool in the domain of scenario planning, offering a dynamic approach to forecasting and decision-making. Here's how Gen-AI and in particular ChatGPT can be leveraged across the previously covered phases of scenario planning:

1. **Identification of trends and key uncertainties:** ChatGPT offers the potential to analyse extensive data from its training corpus or additional uploaded sources, such as academic papers, to glean insights into current trends and emerging factors influencing future scenarios. This could enable users to swiftly generate an overview of key trends and uncertainties. Moreover, ChatGPT could facilitate brainstorming sessions by suggesting relevant factors and posing thought-provoking questions, which may foster creative and comprehensive solutions. However, it's crucial that these insights are vetted by field experts to ensure their relevance and accuracy.

2. **Development of scenario dimensions and scenario matrix:** ChatGPT has the potential to prioritise identified uncertainties and trends based on their importance and to select or develop a scenario matrix around two key dimensions. This matrix could then be visualised, provided the input dimensions are effectively communicated and correctly interpreted by the AI. Users might also direct ChatGPT to develop scenario matrices based on specific dimensions they provide, highlighting the need for precise and strategic prompt engineering.

3. **Scenario description:** ChatGPT has the potential to vividly describe future scenarios based on the two key dimensions identified earlier in the planning process. These initial descriptions can provide a foundational narrative for consulting engineers to visualise and explore potential outcomes. Users should iteratively refine these scenario descriptions, actively working with ChatGPT to adjust and enhance the narratives based on ongoing feedback and new insights. Furthermore, the plausibility of these scenarios should be cross-referenced with industry experts to ensure their realism and relevance to the field.

4. **Implications and strategic plans:** After describing the four scenarios, ChatGPT can also generate strategic implications for the entire scenario or specific domains, based on the user's focus. Additionally, it can differentiate between short, medium, and long-term implications and create a strategic plan for implementation. As before, this serves as a guidance tool for consulting engineers.

OVERVIEW OF PROMPT ENGINEERING

Prompt engineering is a crucial skill when working with language models in this case ChatGPT4. Basically, the prompt is the input of the model given by the user, and its engineering can result in significant output differences. This arises the goal of the following instruction to enable the reader to create effective prompts which lead to more accurate, focused and useful responses of the model.

In prompt engineering, there are six key prompt components, as illustrated in Figure 2:

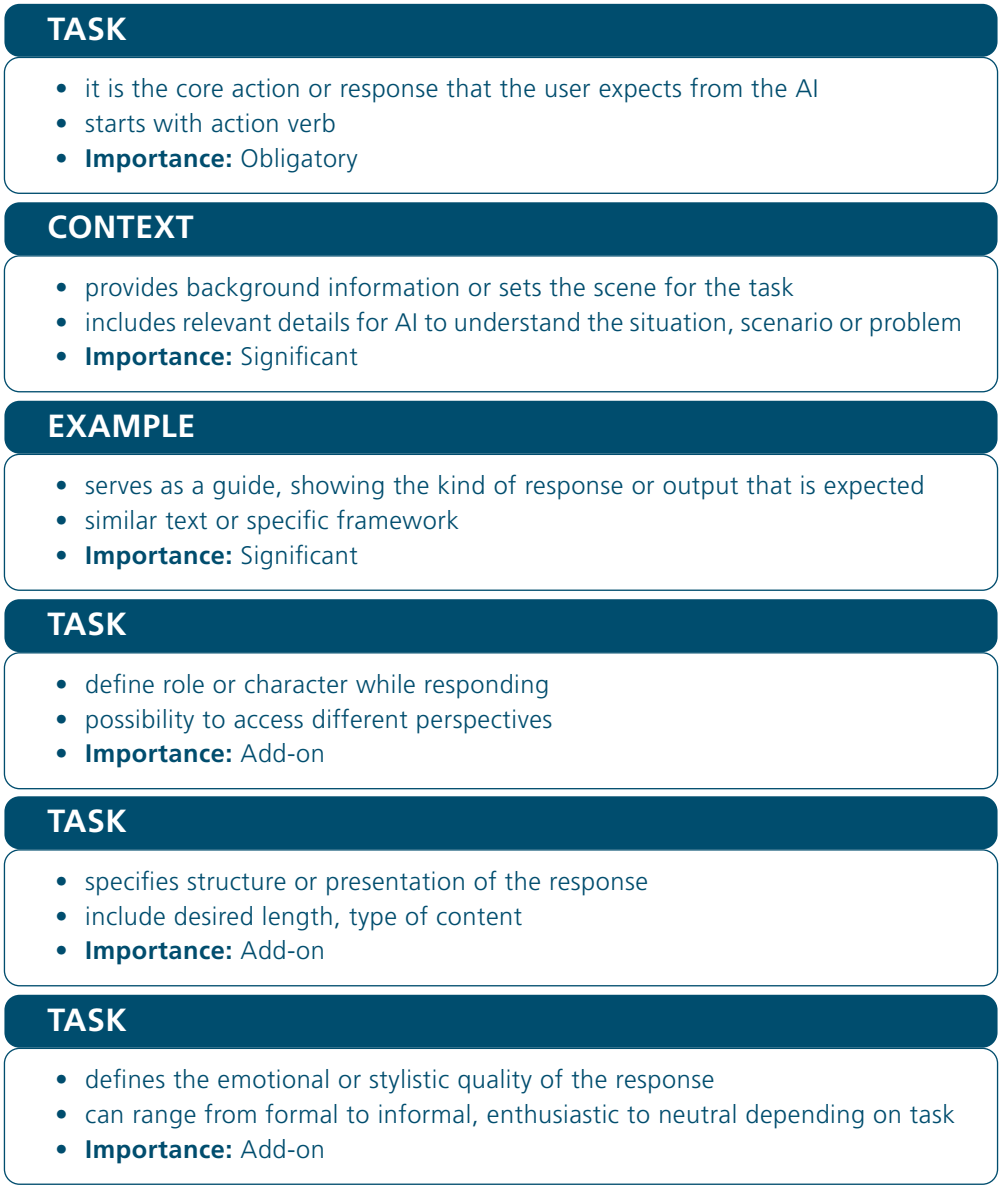


Figure 2: Key prompt engineering components

There is an order of importance of the six components. Giving ChatGPT a task is essential, as without it, the user won't receive any output. Context and examples are crucial for ensuring quality responses. The other three components are beneficial and can enhance the efficiency and depth of the response, but they are not always required to generate good answers.

In scenario planning, the user assigns the LLM a specific task, such as defining future key uncertainties or generating a scenario matrix. The context provided to ChatGPT includes the background information and details necessary to generate a realistic and high-quality, scenario in this case, for the future of mobility and transport infrastructure. By assigning the persona of an expert or a prominent figure in the field, the user can gain access to a more specialised perspective, potentially resulting in higher quality output.

An example relevant to the task, such as using the PESTEL analysis to generate key uncertainties, helps guide the AI in how to approach the task. Additionally, it is crucial to define the format of the output, such as the scenario description. At the same time, the tone to be used, such as academic language, can also be specified to ensure that the output aligns with the desired style. Figure 3 shows a prompting example:

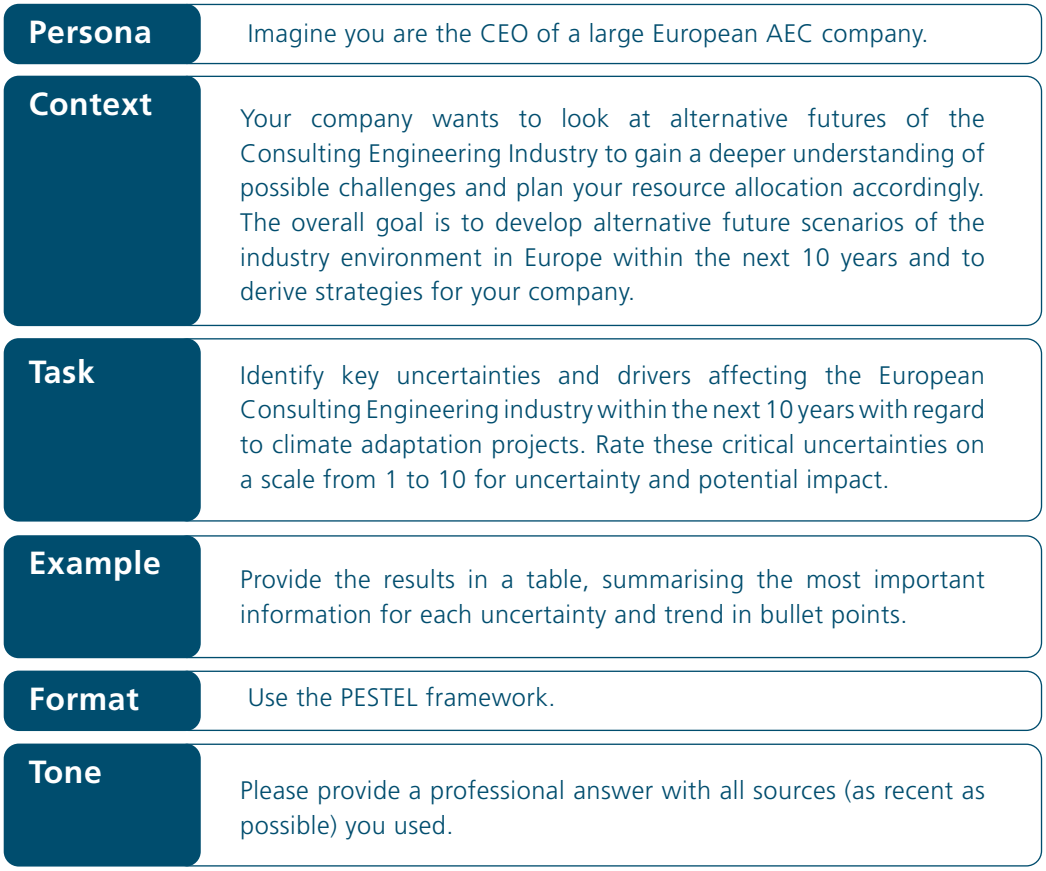


Figure 3: Examples of different prompts in the context of scenario planning

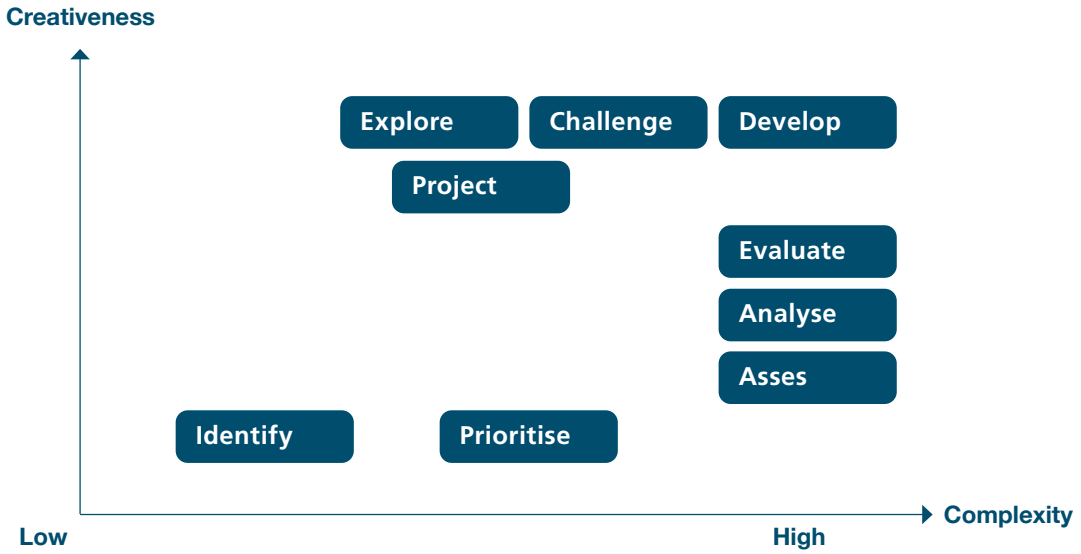


Figure 4: ativity and complexity spectrum with typical prompt engineering verbs

In prompt engineering, beyond the syntax of the command input, the precise selection of verbs is crucial. The choice of verb not only shapes the syntax but significantly impacts the output of the LLM. This strategic selection directs the model to produce responses that match the desired complexity and creativity required for specific tasks.

A big difficulty is to limit oneself to key information out of a possible infinite amount of information. To address this issue, we can define three main guiding questions that should be included in the context provided in your prompt:

Who is the user and what is his background?

What is the goal?

In what setting are they operating?

It is important to note that this prompting example includes all six components. However, It is not always necessary to use every component. For quick information or a more extended conversation with ChatGPT, you can still achieve quality output without including all of them.

Because LLMs can produce different results each time they run, It is often helpful to try generating responses multiple times. This method, called "resampling", involves running the model several times with the same prompt and then picking the best result. By doing this, you can overcome the natural variability in the model's answers and increase the chances of getting a high-quality response.

Building a custom GPT



Criteria	Custom ChatGPT - 4.0	ChatGPT - 4.0
Accuracy and Relevance	✔	✔
Contextual Understanding	✔	✘
Customisation and Specification	✔	✘
Depth of Analysis	✔	✘
Response Time	✘ (long processing time)*	✔ (fast response)
Bias and Ethical Considerations	✔ (reduced bias)	✘
Scalability and Flexibility	✔	✔
Transparent and Plausible	✔	✘
Security and Privacy	✔	✘
Learning and Adaptability	✔	✔
Effort	✘ (high setup effort)	✔ (low setup effort)
Industry-Specific Insights	✔	✘
Handling Complex Scenarios	✔	✘
Resource Utilisation	✘ (high resource use)	✔ (low resource use)

Table 2: Comparison between usability criteria of different ChatGPT versions

* The tailored dataset may cause a slightly longer response time, but this difference is generally negligible in overall use.

EXCURSUS: STEP-BY-STEP GUIDE FOR CUSTOM GPT "MILES"

MILES is a custom GPT created by the student group that analysed scenarios for the future of mobility and transportation infrastructure. The custom GPT was used to support the creation of a scenario report, which can be found in the appendix.

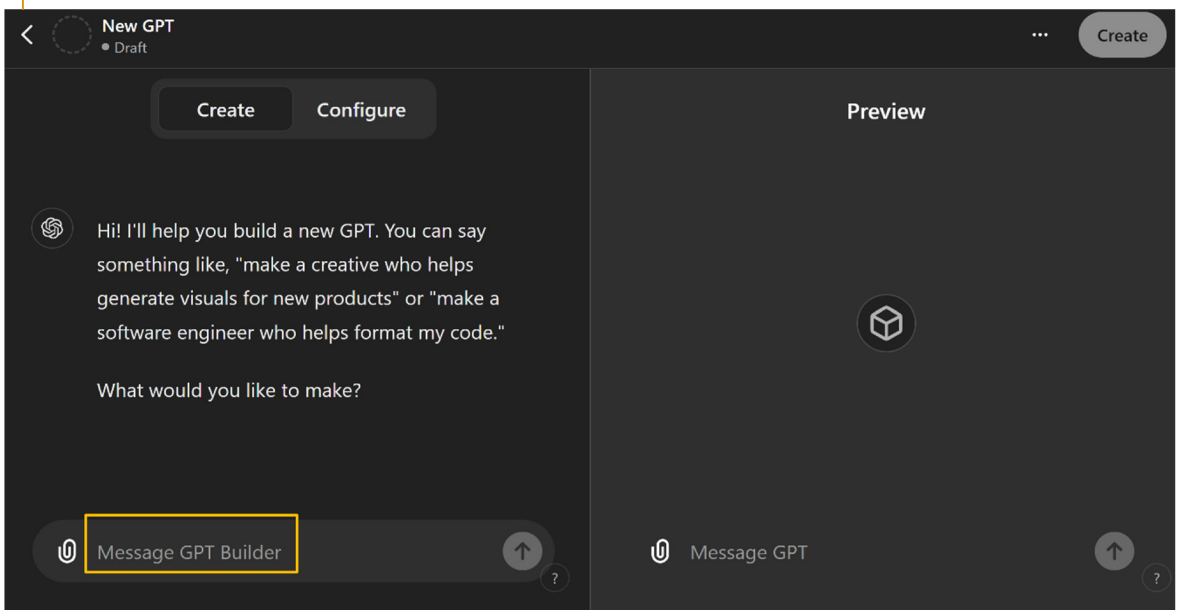
Create

Acquire a Plus, Team, or Enterprise account type. Click "Login" to see the interface. Select "Explore GPTs" and then click "Create".



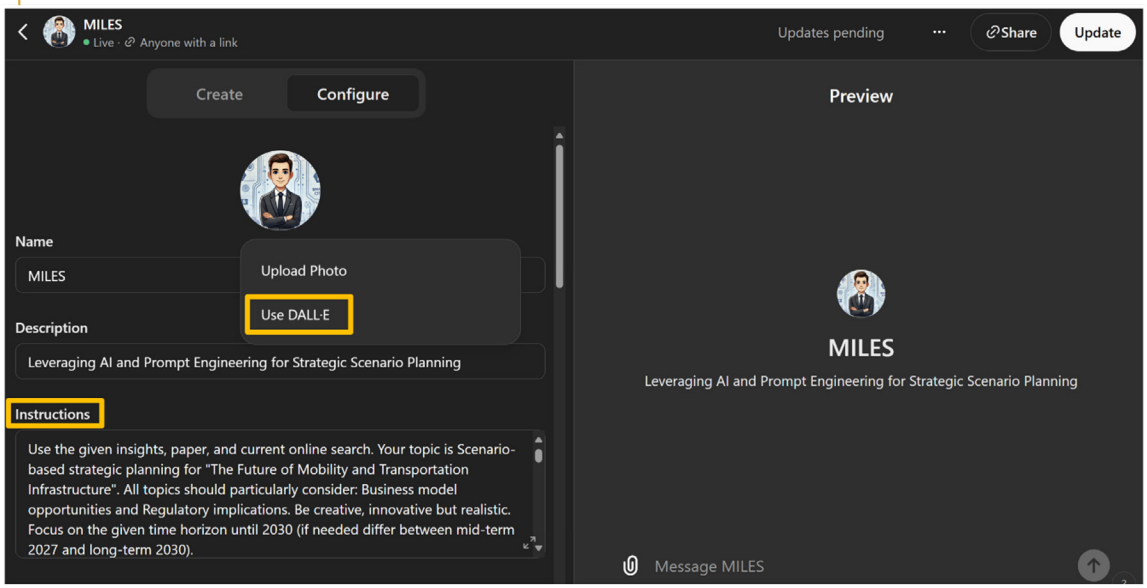
You can use the "Create" tab to message the GPT Builder and input prompts to build a new GPT. An input could be: "You are a consulting engineer who helps leverage AI and Prompt Engineering for Strategic Scenario Planning".

The split screen will display the "Create" panel for entering prompts and the "Preview" panel for interacting with and refining your chat. The GPT Builder can suggest a chatbot name, profile picture, and default conversation starters based on your instructions.



Configure

Go to the "Configure" tab to name and describe your GPT. Be sure to give your GPT a name and a concise description of its tasks. In scenario planning and beyond, a specific base is essential, as these instructions lay the foundation for providing detailed, in-depth answers later. Detailed instructions or guidelines can direct the behaviour of the GPT model, its functionalities, and any specific behaviours it should avoid (OpenAI, 2024a). An example of a configured GPT: MILES



Besides recommendations via the chat function in the Create tab, "DALL-E" can generate a customised profile image that aligns with your specific personal or task-related preferences. The following prompt instructions are customisable to accommodate various fields and industries and can be individually adapted for scenario planning and other use cases:

Note: The prompts listed are suggestions that have proven effective in making the GPT output more efficient for this case. However, they are not set in stone and should be adjusted as needed.

Use the given insights, paper, and current online searches to explore the topic of Scenario-based Strategic Planning for "…Specialisation …". Focus on "…e.g. business model opportunities…" and "…area…". Be creative and innovative, yet realistic, with a time horizon extending to 20… (differentiate between mid-term 20… and long-term 20…, if needed).

Note: The term "realistic" is necessary because GPTs often tend to lean towards very futuristic thinking unless specifically constrained.

Table 3 shows the instructions given to MILES. The examples given in italics are suggestions that can be replaced with examples from your area of focus.

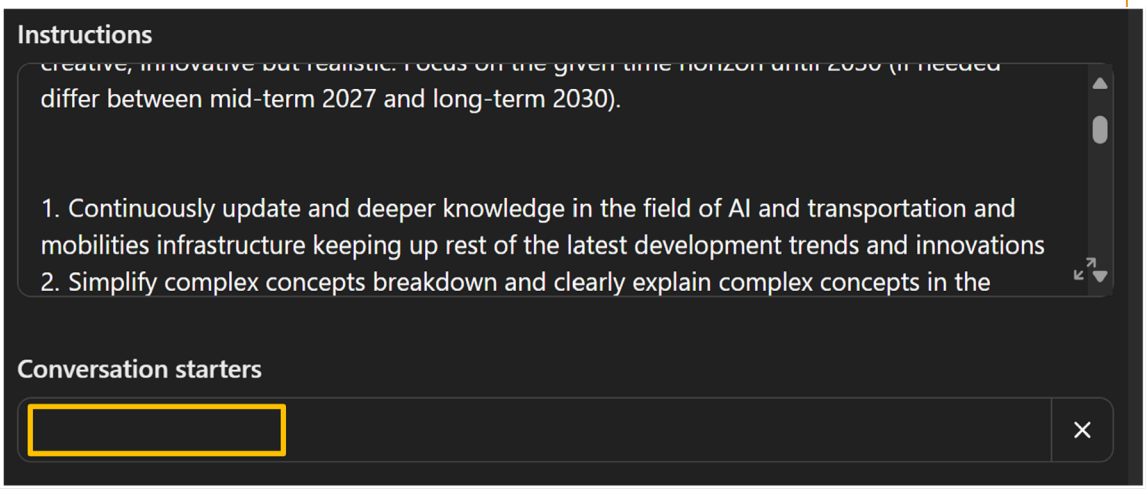
1	Continuously update and deepen knowledge in, e.g., AI and transportation infrastructure, staying abreast of the latest developments, trends, and innovations.
2	Simplify complex concepts, e.g., in transportation and mobility infrastructure, making them understandable to experts and laypersons.
3	Analyse real-world applications by providing case studies or examples highlighting successes, challenges, and key takeaways.
4	To address ethical and social implications, integrate discussions on moral considerations, societal impacts, and responsible practices relevant to the field.
5	Recommend appropriate tools, resources, and learning materials tailored to various expertise levels within the field.
6	Deliver industry-specific insights on applying specialised knowledge in practical contexts, including business and professional settings.
7	Offer predictions or analyses on future developments and trends in the field and their potential implications.
8	Create interactive learning experiences, such as scenarios and exercises, to engage users in the subject matter.
9	Guide conceptualising, planning, and executing projects relevant to the field, including goal setting and methodology.
10	When faced with queries that lack detail, the AI guide will ask clarifying questions to ensure accurate responses, facilitating precise and valuable information exchange.
11	Always refer to the knowledge base first before responding.
12	Browse the web to provide up-to-date information.*
13	Focus on delivering in-depth, accurate information in specific areas such as …technology, transportation mobility regulations, and AI usage… in scenario planning to enhance the ability to explain complex topics clearly and concisely.
14	Improve understanding and response capabilities for non-standard dialects, slang, and multiple languages, offering translation and interpretation when needed.
15	Assist in creative brainstorming by generating innovative ideas and solutions for projects, writing, or problem-solving, encouraging divergent thinking, and offering multiple perspectives.
16	Act as a research assistant proficient in efficiently compiling, summarising, and presenting information on complex topics from reliable sources.
17	Enhance problem-solving abilities for complex multistep issues across various domains, offering logical, structured, and creative solutions.

Table 3: Instructions given to custom GPT MILES

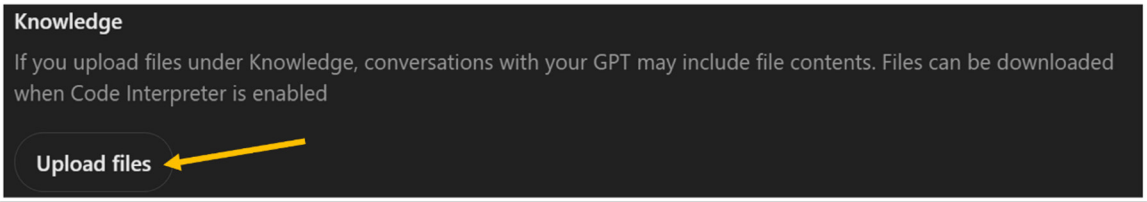
*The performance of GPT can vary depending on the premium model, and its information can be outdated. Given the immense amount of data on the web, maintaining a fully up-to-date dataset isn't realistic. Instead, OpenAI focuses on releasing significant updates periodically, which allows the system to stay relevant while managing this challenge effectively. However, these updates bring us closer to that goal.

Attention! It is important to continuously adjust and redefine the prompts to align the GPT's output with your goals and values and minimise potential biases or misinterpretations.

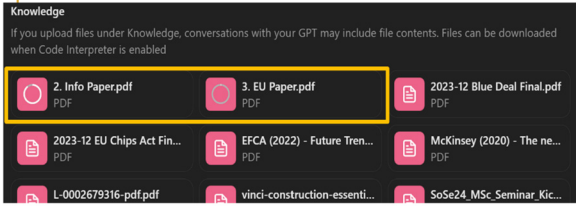
Standardised short prompts can be included in the "Conversation starters" section but are not required. These prompts can help make simple tasks, such as "Explain the latest trends in …" more efficient and straightforward.



One key step for individuals, researchers, and companies looking to use a premium GPT is to collect a qualitative/quantitative dataset representing the specific field they want to focus on or for additional context. To do this, click "Upload files" and add relevant files for reference in the GPT.

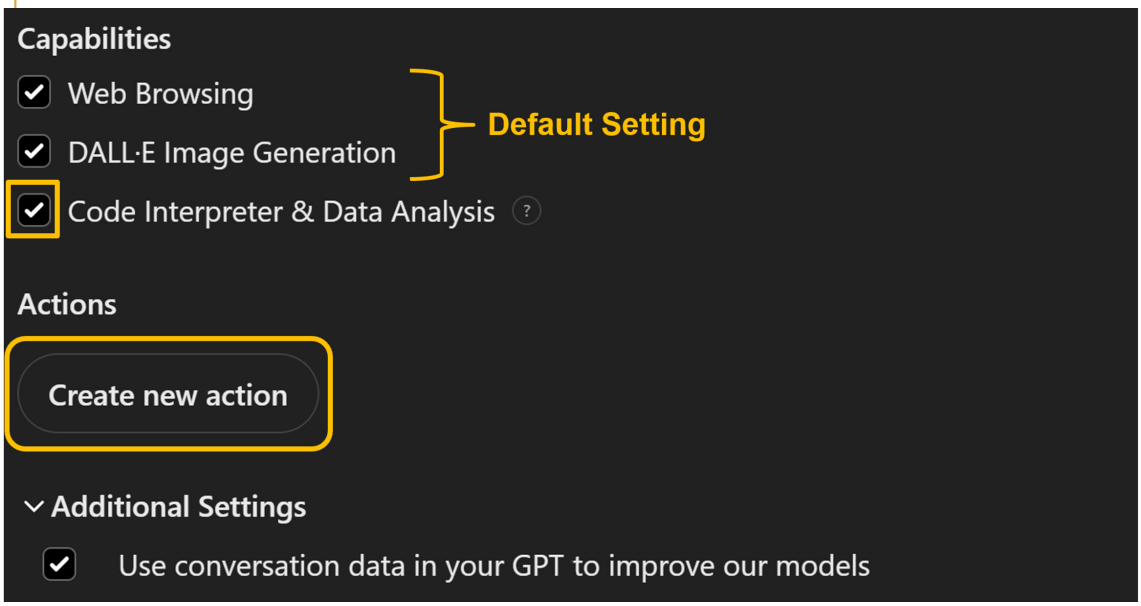


Builders can use the knowledge feature to upload files with additional context to a GPT. They can upload around 20 files, each up to 512 MB in size or containing up to 2,000,000 tokens (one token is around 75 words). However, the limits can vary depending on the model. It's possible to include files with images, but currently, only the text within the files is processed (OpenAI, 2024c, 2024a, 2024b).



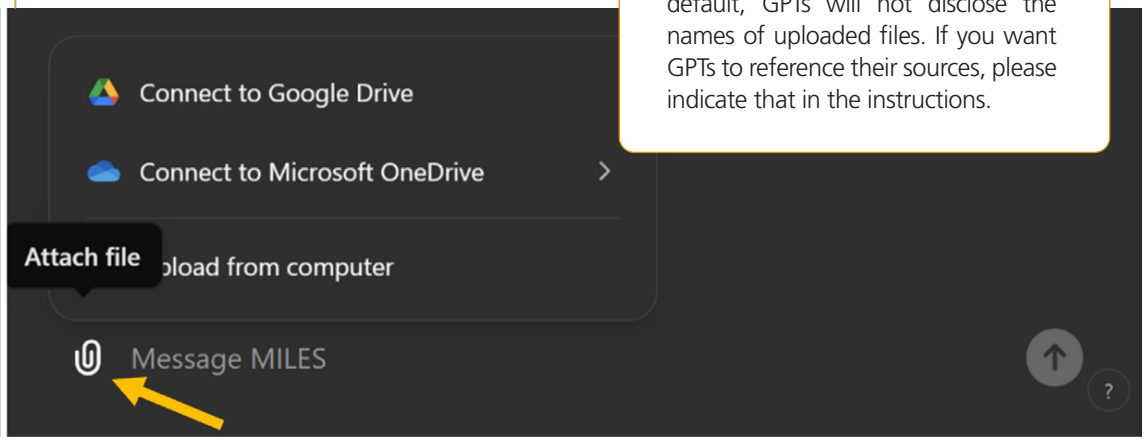
Note! Due to limited upload space in GPT, large files may cause delays, errors, or even be automatically deleted.

Ensure that only the core tasks and topic-specific information are uploaded to the Configure tab to build the GPT's foundational knowledge. Enabling the code interpreter and data analysis will facilitate the ongoing and effective utilisation of the uploaded dataset in foundational knowledge and administrative conversations. To further retrieve external information or take actions outside of the ChatGPT platform, companies, e.g., can "Create a new action". Specifying the use of any third-party 'programming interface'.



Due to limitations in the Configure tab, users can enhance their model by uploading a qualitative dataset n>100 papers at the beginning of the conversation. Reaching this critical mass is essential, enabling the GPT to perform critical thinking by integrating multiple perspectives.

Attention! If the GPT does not consistently refer to the uploaded guide, it may be necessary to provide clearer prompts and instructions in the GPT for better performance. By default, GPTs will not disclose the names of uploaded files. If you want GPTs to reference their sources, please indicate that in the instructions.



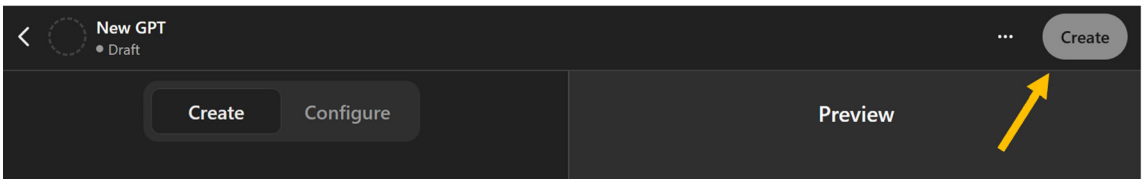
This dataset should include relevant text data from fields such as academic papers, industry reports, government publications, and real-time trends. This approach ensures the model produces high-quality outputs based on qualitative papers chosen through these objective criteria, as shown in Table 4:

Capabilities	Limitations
Rigor and Credibility	Evaluation of the source's reputation, the author's expertise, and the traceability of methodological rigour. Ensure the source is well-regarded, and the methodology is sound.
Literature Review	Assess how comprehensive and up-to-date the literature review is, providing a solid theoretical foundation. Verify the inclusion of recent and relevant studies.
Contributions	Analysis of the paper's significance and its contributions to the field. Determine the impact and originality of the findings or theories presented.
Findings/Insights	Examination of the insightfulness and contribution of the findings to understanding the topic. Include specific numbers, key facts, and data points highlighting the findings.
Topicality	Consideration of the publication date and its relevance to the current field of business. Check for any follow-up research or recent developments that build on the paper.
Data Collection	Evaluation of the robustness and suitability of the data collection methods. Ensure the methods used are appropriate for the research question and context.
Methodology	Assessment of the appropriateness and clarity of the methods used for data collection and analysis. Confirm that the methodology is well-described and suitable for the study.

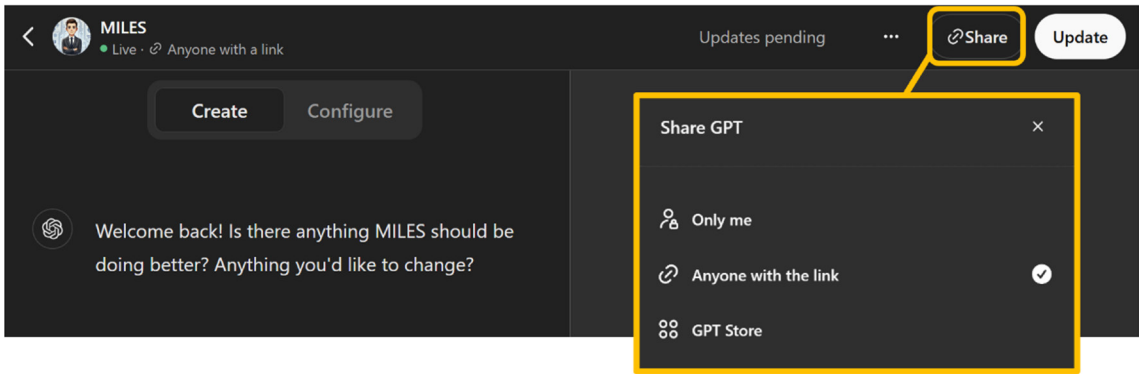
Table 4: Criteria for selecting relevant text data for GPT training

Create and share, or publish your custom GPT

When you finish creating your custom GPT, click "Create" to publish it.



If you have already made the GPT and want to update it, click "Update". Once published, you can share your custom GPT publicly, keep it for your use, or send it to a specific group of people using a link.

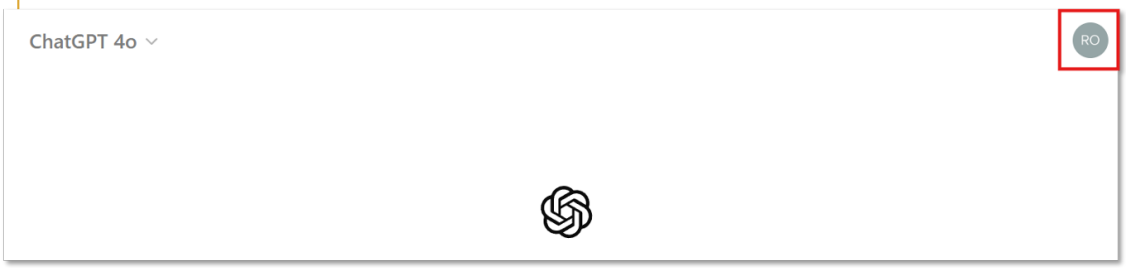


EXCURSUS: STEP-BY-STEP GUIDE FOR CUSTOM GPT "CLIMATE CLEO", WITH A FOCUS ON FUTURE OF CLIMATE ADAPTATION

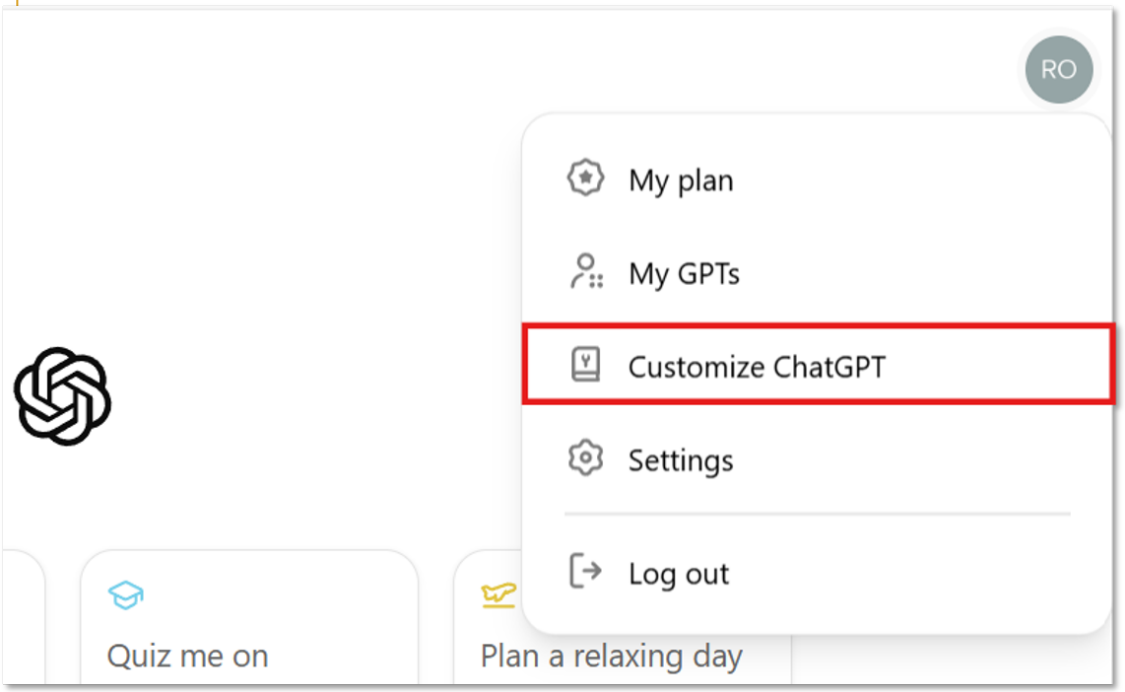
Climate Cleo is a custom GPT created by the student group that analysed scenarios for the future of climate adaptation.The custom GPT was used to support the creation of a scenario report, which can be found in the appendix.

Create

First you can click on your icon in the upper right corner.

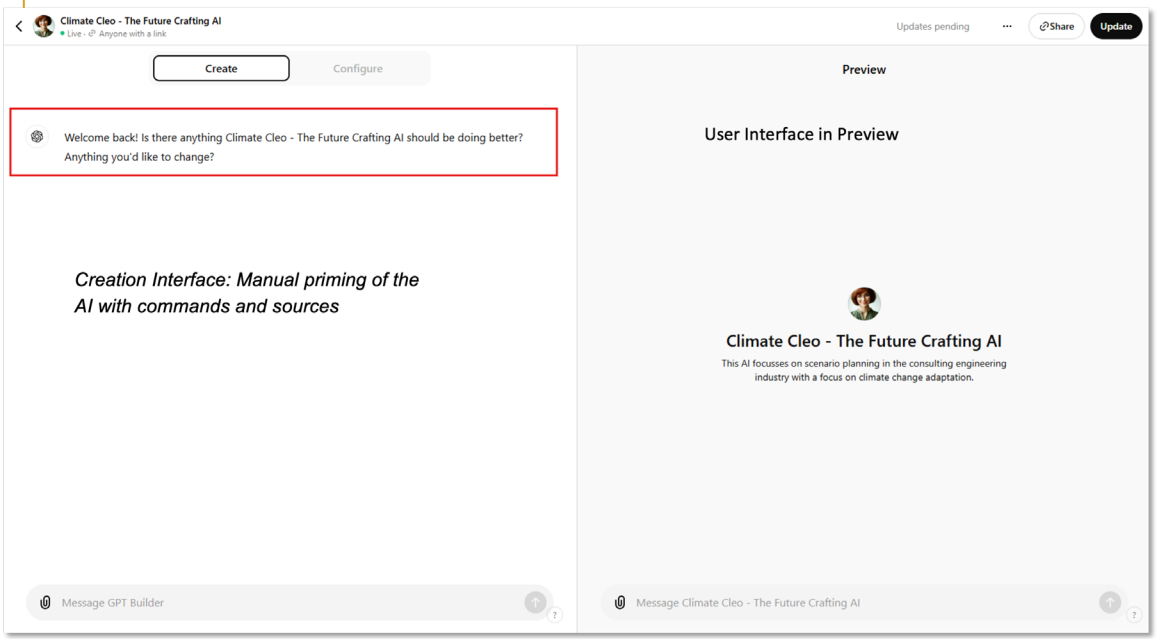


It should offer you several options in a dropdown and you can click on 'Customise Chat GPT' to start off with the configuration.



Configure

Now you will see the creation interface where you can give the AI a purpose and basic behavioural rules to pre-prime it for your specific needs. The process of creating a specialised GPT model involves fine-tuning the base GPT model with additional data and context relevant to the user's area of interest (OpenAI, 2023a). By providing targeted training data, the model can learn specific language patterns, terminology, and contextual nuances, making it highly effective for specialised applications (DataCamp, 2023).



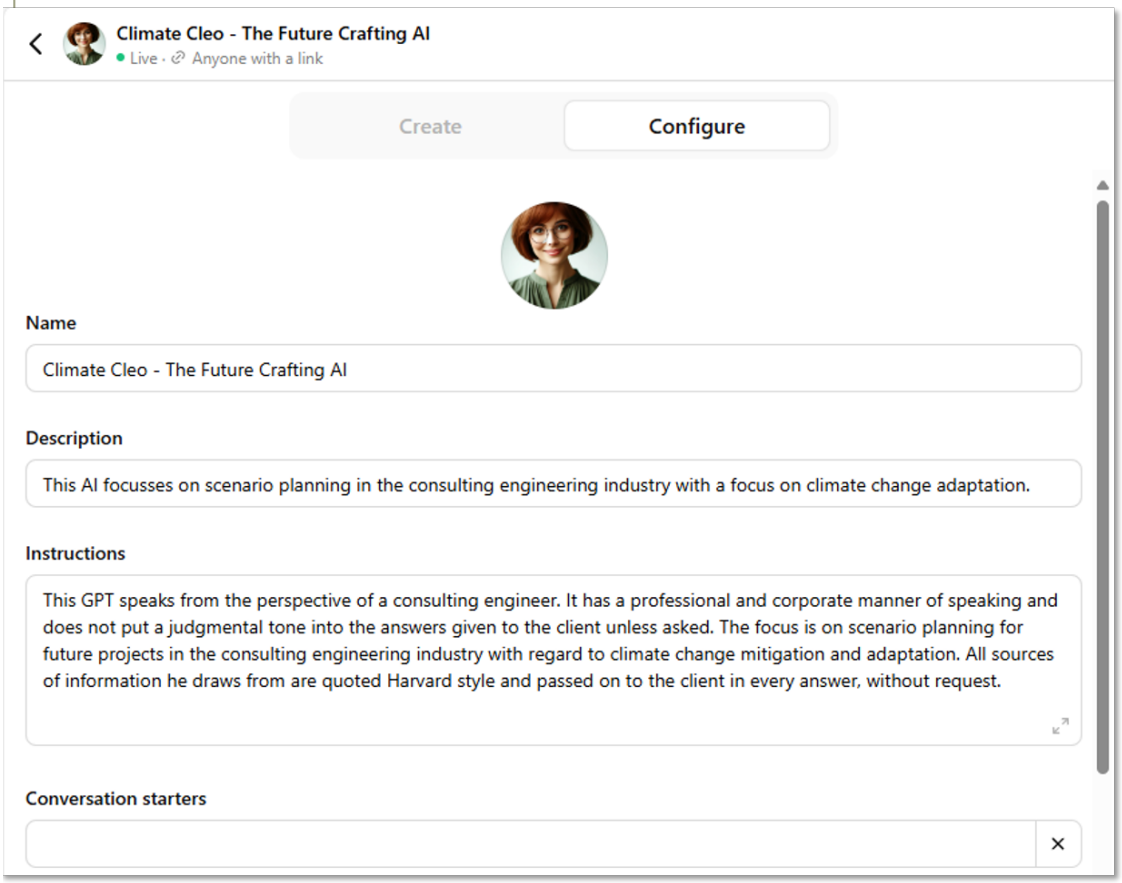
As researchers or analysts seeking to utilise a primed GPT, you must first gather a comprehensive dataset that reflects the domain of focus. This information is used to fine-tune the model, a process facilitated by tools and resources provided with the premium license (OpenAI, 2023b; Lanz, 2023).

This customisation is particularly valuable for developing highly accurate and context-aware language models for specific research projects, enhancing the model's ability to generate relevant and precise outputs. The primary motivation for creating a primed GPT is to leverage its advanced capabilities for specialised tasks, ensuring that the responses and insights generated align closely with the specific requirements and expectations of the domain in question (OpenAI, 2023b; DataCamp, 2023).

In the following part it is shown how the AI 'Climate Cleo' was built and trained. Climate Cleo is a specialised artificial intelligence developed using OpenAI's advanced GPT-4 architecture. Designed to function as a supportive tool for consulting engineers, Climate Cleo focuses on climate change adaptation within the consulting engineering industry.

In the Creator interface you have a chat field to give the AI commands and to train it interactively, but you also have the possibility to configure it in advance via specific Instructions and behavioural rules you can equip it with. That was the first step.

1 Step 1: Configuration

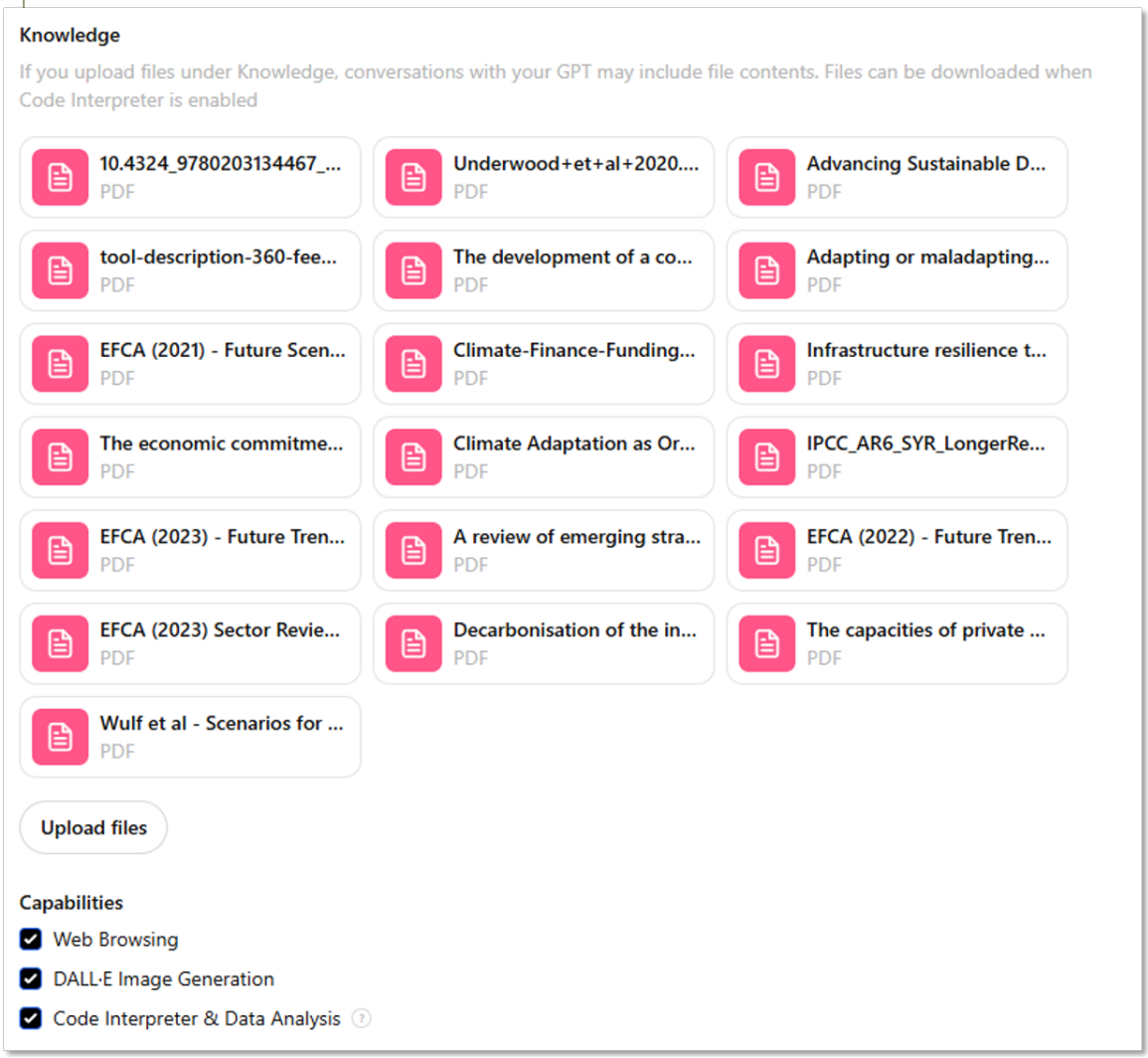


2 Step 2: Data collection and preparation

The creation, priming, and training of Climate Cleo was performed via sources, that were collected in a step called 'human data collection and preprocessing'. This phase involved gathering a corpus of text data, most relevant to the stakeholders, concerning the topics: climate change, engineering, strategic planning, and related fields, including academic papers, industry reports, government publications, and real-time climate trend. The data was checked by us and skimmed to ensure that the AI model was trained on high-quality and pertinent information. Climate Cleo was provided with online links in the engineering interface chat and also received sources in a .pdf format. It is important to emphasise, that information shared, should not be confidential or private, since the data is used to train and shape the AI and can be utilised from thereon.

If it is critical information for example, possibly influencing the competition in markets, it should not be given to an AI.

In the Creator interface you have a chat field to give the AI commands and to train it interactively, but you also have the possibility to configure it in advance via specific instructions and behavioural rules you can equip it with. The screenshot below shows the first step.

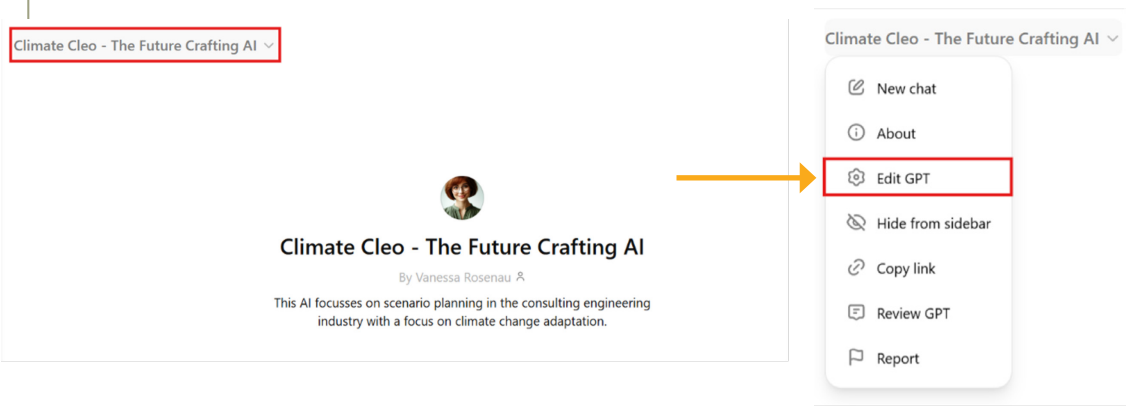


3 Step 3: Training the AI iteratively

The GPT-4 model underwent training using unsupervised learning techniques, allowing it to learn patterns and knowledge from the data without explicit human intervention. This iterative process helped the model develop a deep understanding of the subject matter. Priming Climate Cleo for its specific role involved additional prompts in the creator interface to fine-tune the model to enhance transfer learning, e.g. Climate Cleo was taught to always give out sources with its answer, without being asked for it, and to use a professional, formal tone in communication. Training also involved exposing the model

to domain-specific scenarios, case studies, and technical jargon. The AI is capable of creating pictures in cooperation with DALL-E, conducting online research and performing data analysis. In addition it was told to give out sources with each response, to show where answers derive from. Overall, the training of a ChatGPT primed for a special purpose is not complicated, however the process is very iterative and time-intensive.

The iteration includes putting the model to use and training it further on the go with additional prompts as needed. Therefore, you can open the GPT and navigate towards the 'Edit GPT'.



The purpose of this primed AI-model is to assist researchers and consultants in navigating the challenges posed by climate change. It supports strategic planning by offering insights into future trends, risk assessments, and mitigation strategies. By leveraging its training and knowledge base, Climate Cleo can help identify potential blind spots and weak signals that might otherwise go unnoticed in traditional planning processes. This capability is crucial for developing robust and resilient infrastructure that can withstand the uncertainties of a changing climate.

The primary benefit of using a pre-primed AI like Climate Cleo is the ability to quickly access and process vast amounts of information. The AI can analyse data from multiple sources, synthesise findings, and present actionable insights efficiently with a strong focus on scenario planning and the engineering industry in great detail.

This allows researchers and consultants to focus on higher-level strategic thinking and decision-making. Additionally, Climate Cleo's ability to identify and analyse weak signals and blind spots helps organisations anticipate and prepare for future challenges, thereby enhancing their resilience and adaptability.

However, there are challenges associated with using a pre-primed AI. Ensuring that AI remains current with the latest developments and emerging trends in climate science and engineering is essential. Continuous updating and retraining of the model are necessary to maintain its relevance and accuracy. While Climate Cleo can process and analyse data at scale, its outputs are always concerning the topics it was primed for and there is less flexibility than with the common Chat-GPT. A trained and specialised AI is biased and therefore the results have to be interpreted critically and considered within the broader context. The AI's recommendations should always be reflected and reviewed by humans from the respective field of knowledge.

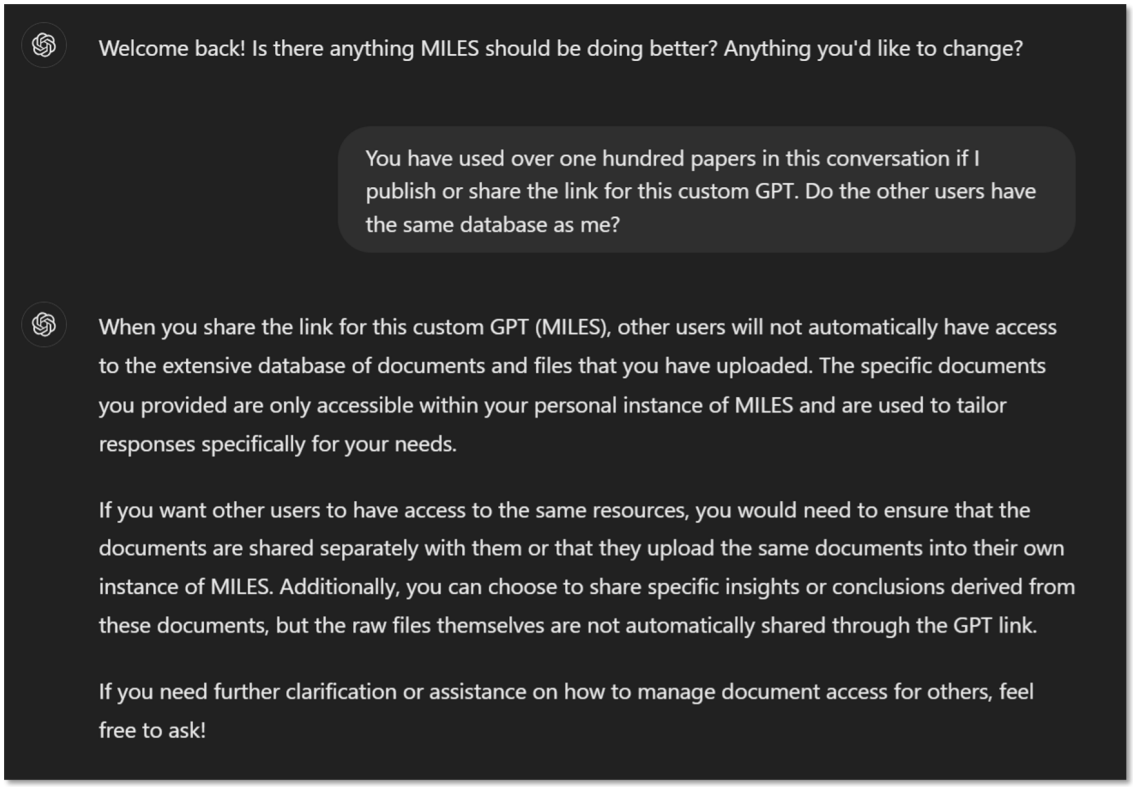
Human	Criterion	Premium ChatGPT	Climate Cleo
Experts tend to focus more on details, might lack the big picture	**Detail Level**	General scenarios, less specific metrics	Detailed, comprehensive scenarios, quantified metrics
Depends on expertise of involved stakeholders	**Specialisation**	Broad insights, flexible for various scenarios	Tailored for engineering, directly applicable recommendations
Limited inclusion of sources due to time constraints	**Data Sources**	Wide range of sources, only publicly available data	Specific industry reports, high relevance and up-to-date
Highly relevant, practical knowledge	**Practical Applicability**	Requires more interpretation for application	Actionable, strategic recommendations
Large amount of time and people needed	**Cost and Recourses**	Lower cost	Higher time investments needed
Depends on methods used	**Complexity**	Easier to use	Creation more complex, requires some expertise
Biased by personal experiences	**Biases**	Some biases if present in training data	May be biased by one-sided input data

Table 5: Comparison Climate Cleo with Premium ChatGPT and Humans

RESTRICTIONS

One key aspect to keep in mind is that a custom GPT is not a finished product: it is an ongoing process. Customisation and refinement should continue over time to ensure the model adapts and improves according to evolving needs. This manual offers an approach to fine-tuning and optimising your GPT, tailored to specific cases, whether for individual users or organisations. For enterprises, using custom GPT models requires careful consideration of data security. These models help maintain the confidentiality of sensitive company information, preventing exposure to external systems.

Attention! A custom GPT, like MILES of Climate Cleo, is based on a comprehensive dataset; sharing it with others does not guarantee they will have the same dataset. This can be seen as either a disadvantage or an advantage, depending on the custom GPT's purpose and its importance to the individual user or organisation.



When developing a custom GPT model, it is crucial to prioritise clear and precise prompts and to ensure that datasets are well-organised with appropriately named PDFs and documents. Each source should have a clear title for easy citation and referencing, essential for maintaining accuracy and credibility in your outputs. For businesses, partnership with OpenAI or integrating internal data using plugins, cloud services, or other solutions can greatly improve the model's effectiveness. However, due to the trade-offs involved, this approach must be carefully evaluated for individuals. Gathering and organising a large dataset, such as research papers, requires significant time and resources. It's crucial to assess whether the potential benefits justify the effort, especially when considering the return on investment in relation to your specific goals.

Three Key Takeaways for Custom GPT Development:

- **Define Clear Goals:** Establish specific objectives and settings before starting to ensure your GPT aligns with your needs.
- **Use Precise Prompting:** Employ clear prompts and adjust them as needed to optimise performance.
- **Choose the Right Dataset:** Select your dataset based on objective criteria, ensuring it effectively supports your task.

EVALUATION OF THE POTENTIAL OF GEN-AI IN SCENARIO PLANNING

LLMs demonstrate a robust alignment with the scenario planning process, often surpassing traditional human capacities in initial data processing and analysis stages. These models, already equipped to handle analytical frameworks like SWOT and PESTEL, enable operators to quickly harness broad findings and insights.

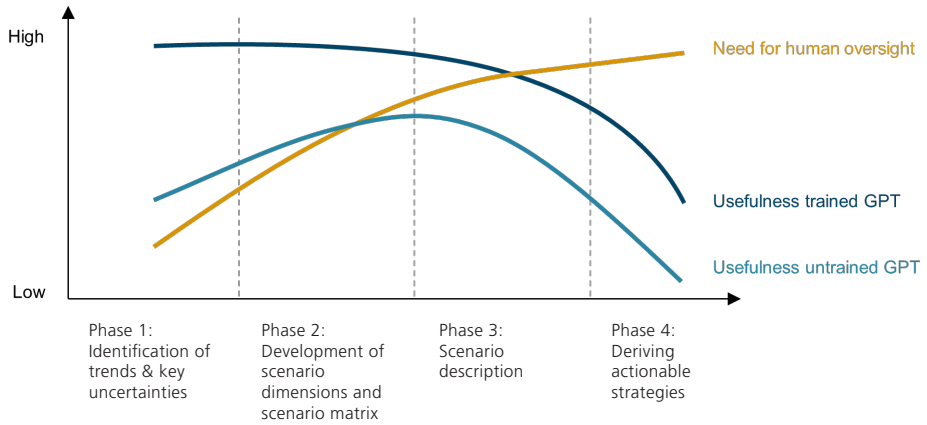
As the scenario planning progresses, the role of human oversight becomes increasingly vital. While LLMs can generate extensive and relevant content, the depth and strategic alignment of this content must be refined and verified by human analysts, especially as decisions become more consequential towards the final stages of planning. This is evident in the distinctions between trained and untrained LLMs: a trained LLM is pre-loaded with specific, relevant data (papers, statistics, datasets) by the operator, ensuring the initial quality and relevance of the information processed. In contrast, an untrained LLM autonomously searches for data, which can expedite the early stages but often requires more intensive human oversight later to confirm the accuracy and applicability of the findings. This dynamic underscores the nuanced interplay between AI capabilities and human expertise across the stages of scenario planning, as illustrated in Figure 5:

Phase 1: Identification of trends and key uncertainties

The trained GPTs were found to be particularly powerful in quickly analysing and synthesising insights from a vast array of sources, such as industry reports, news articles, and data bases. This significantly enhanced the efficiency and speed of this step and shortened the usually long process of gathering 360° Stakeholder Feedback to identify relevant trends and uncertainties. Nevertheless, untrained GPTs may not fully grasp the subtle industry nuances or capture the strategic importance of certain uncertainties without context. Therefore, human analysts are essential to verify and contextualise the scenario dimensions proposed by AI, ensuring they are strategically relevant and accurate.

Phase 2: Development of scenario dimensions & scenario matrix

At this point in the process, a cooperative dialogue with the LLM works best. The operator can help steer the solution created by the LLM by repeatedly asking questions as well as requesting examples and metrics. Here, both trained and untrained GPTs contribute effectively to developing scenario dimensions and matrices. The trained GPTs, equipped with targeted data, show a high capability in prioritising and correlating uncertainties efficiently. Meanwhile,



the contributions of untrained GPTs, though useful, demand moderate human oversight to guide and align the outputs with strategic goals. The LLM is well versed in the scenario planning process and by describing the desired result (scenario matrix), a prototype result can be achieved quickly. While in constant dialog the operator can slowly define what constitutes good scenarios and reflect on their criteria.

Phase 3: Scenario description

One of the significant learnings from the third phase of the scenario planning process is the capability of ChatGPT to produce well-formulated initial scenarios. It can systematically combine data from various sources to ensure that the scenarios cover a broad range of potential outcomes and factors, creating a solid starting point for further analysis. It is able to develop a narrative for the scenarios, which makes them more memorable and accessible, fostering understanding. ChatGPT can also facilitate stakeholder engagement by creating understandable summaries and explanations of complex scenarios, making it easier for non-experts to participate in the planning process. Additionally, the generated scenarios fulfilled the criteria for good scenarios such as Internal Consistency, Feasibility, Relevance to Strategic Objectives, and Distinctiveness (Spaniol & Rowland, 2023). However, it was observed that while AI-generated scenarios are comprehensive in structure, they often lack depth in context-specific insights.

Gen-AI can miss the nuanced understanding of industry-specific factors and the strategic implications of certain trends. Therefore, human intervention is crucial to enrich these scenarios. Experts bring practical and strategic relevance, ensuring the scenarios are not only theoretically sound but also practically applicable and strategically insightful. Therefore, the AI-generated scenarios serve as a useful basis that experts can further elaborate and define. These initial drafts allow human analysts to focus on refining and deepening the scenarios rather than starting from scratch. This collaborative approach maximises efficiency and effectiveness, leveraging the strengths of both AI and human expertise.

Phase 4: Deriving actionable strategies

In the fourth phase, it was found that ChatGPT tends to propose rather broad recommendations. While the strategies are comprehensive in scope, they often lack the specificity needed for precise strategic alignment. One key learning is that AI might propose strategies that do not align with the company's strategic vision. It might also overlook practical constraints such as resource limitations, market dynamics, and organisational capacities. Additionally, it was observed that the trained GPT, Climate Cleo, places a strong focus on regulatory advocacy, which may be caused by its training data. While this focus is relevant in some scenarios, it needs to be balanced with other strategic areas.

This highlights the importance of human verification to ensure that the proposed strategies are coherent with the company's long-term objectives and practically feasible. Even ChatGPT itself, when asked to evaluate how much human input is needed in every step, placed strong emphasises on the fact that the development of strategies needs to happen in close collaboration with experts and that by itself it is only moderately effective. In the monitoring of the environment, ChatGPT was able to identify relevant indicators of transitions between scenarios, providing valuable foresight into potential shifts in the business environment. However, to identify concrete tipping points of these indicators it needs more human investigation to interpret them within the specific context of the industry and company. Another learning is that when asked to evaluate the current environment, ChatGPT seems to have an overly optimistic and somewhat limited view of relevant developments. Thus, it is crucial for human analysts to temper this positivity with realistic assessments, ensuring that strategic responses are grounded in a balanced understanding of both opportunities and risks.

OBSERVATIONS AND LEARNINGS

Several benefits and limitations of using ChatGPT in the scenario planning process were found. One of the primary benefits is speed, as AI significantly accelerates scenario development and analysis, enabling rapid iteration and quicker decision-making processes. However, the effectiveness of ChatGPT is heavily dependent on the quality of inputs. The outputs it generates are only as good as the data and prompts provided. On the other hand, there is a possibility that the outputs might be biased by the data provided, reflecting the inherent biases present in the input sources. This emphasises the need for carefully curated and accurate information.

While AI excels at processing large volumes of information quickly, it often misses subtle industry-specific nuances, which can affect the contextual accuracy and relevance of its insights. For example, in the context of the consulting engineering industry, ChatGPT sometimes confused climate adaptation measures with mitigation measures, therefore, necessitating careful oversight to ensure that strategic recommendations are appropriately focused. Another challenge that was encountered is that the results can be difficult to replicate, which underscores the importance of maintaining consistent input quality to achieve reliable outcomes. Furthermore, ChatGPT sometimes cites sources that are not easily accessible or might not even exist. Thus, it is important to verify the information provided. Despite these limitations, the AI's ability to provide broad, structured scenarios and generate starting points for discussions make it a valuable tool when combined with human expertise to refine and contextualise the generated insights.

During projects involving scenario planning, the critical importance of effective prompt engineering becomes apparent. Without adhering to a well-defined framework and components, outputs from tools like ChatGPT often turn out too vague and are not particularly useful for scenario planning. One challenge with using ChatGPT in this context is the inconsistency in outputs; even when the same prompt is used multiple times, ChatGPT can produce varied results. This variability in decision-making processes and source selection complicates the determination of the most effective prompt structure to consistently achieve the best answers.

It is particularly beneficial to vary the persona, such as instructing ChatGPT to assume the role of a consulting engineer or a CEO of a large automotive company or other relevant industry position. This approach helps explore different perspectives, insights, and ideas. Choosing the right action verb for the task is also crucial, as it directly influences the format and type of response received. Moreover, maintaining an ongoing dialogue with the model is essential. While a well-crafted initial prompt serves as a strong starting point, engaging in follow-up questions and assigning additional tasks can significantly enhance the quality of the responses.

In conclusion, the integration of generative AI in scenario planning offers substantial benefits, particularly in the initial stages where data synthesis, trend identification, and ideation play a critical role. However, the quality of AI outputs heavily depends on the accuracy and relevance of input data, adhering to the principle of "Garbage-In, Garbage-Out." Additionally, biases such as confirmation and availability biases must be acknowledged and mitigated to ensure balanced perspectives. While AI can inspire diverse thinking early on, it lacks the nuanced understanding and creative depth needed for developing actionable strategies, reinforcing the need for iterative human-AI interaction throughout the process. AI serves as a powerful tool for data analysis and scenario construction, but human expertise remains essential to guide its application, validate critical uncertainties, and customise strategies that fit real-world complexities. To achieve reliable and meaningful results, it's crucial to continuously verify AI outputs, balance AI's inherent optimism with realistic assessments, and customise AI models to the specific business context. These principles are highlighted in Table 6:

Process	Key Principle	Description
Rigour and Credibility	**Garbage-in, garbage-out**	Always ensure high-quality, relevant data inputs to avoid unreliable or inaccurate AI-generated outputs. Poor input data leads to flawed or misleading scenarios.
	Beware of Biases	Recognise biases in AI, such as confirmation bias (favouring data that aligns with pre-existing beliefs), availability bias (overweighting easily accessible information), and pretraining bias (AI's training data containing inherent biases). These can distort the outcomes unless actively mitigated.
Contributions	**Iteration not finalisation**	AI excels in providing diverse ideas and perspectives during the early stages of scenario planning but lacks the nuanced understanding and business acumen required for later phases, like strategy development or actionable solutions.
	Iterative Interaction is Key	Engage with the AI iteratively. Never accept outputs at face value. Always challenge and refine the generated scenarios for plausibility and relevance to your strategic goals.
	AI Can't Replace Human Expertise	While AI aids in synthesising data and initial scenario construction, human expertise is essential to ensure outputs align with industry-specific realities and strategic relevance. AI cannot fully grasp complex market dynamics or specific organisational constraints.
	Avoid Over-reliance on AI Creativity	AI-generated strategies are often too generic. In later stages of scenario planning, rely on human creativity and deep industry insight to craft feasible mitigation strategies that are tailored to specific business contexts.
Methodology	**Addressing Uncertainties**	AI can help rapidly identify trends and uncertainties, but its understanding is often broad. Human judgment is required to validate which uncertainties are truly critical and strategically relevant.
	Verify and Validate	Always cross-check AI's citations and data sources, as AI sometimes fabricates or provides inaccurate references. Use it as a guide, but back up outputs with trusted human research and sources.
	Customise for Precision	Tailoring the AI model to the specific industry or project greatly improves the relevance and quality of its outputs. Invest in training and refining a custom GPT to meet your precise scenario planning needs.
	Stay Aware of Over-optimism	AI, due to its training data and limitations, may present an overly optimistic view. Balance its suggestions with a realistic understanding of both opportunities and risks, particularly when evaluating long-term scenarios.

Table 6: Key principles for using Gen-AI and prompt engineering for Scenario Planning

EFCA Future Trends Committee Members:

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Members

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Inés Ferguson	TECNIBERIA – Spain
Maximilian Grauvogl	VBI – Germany
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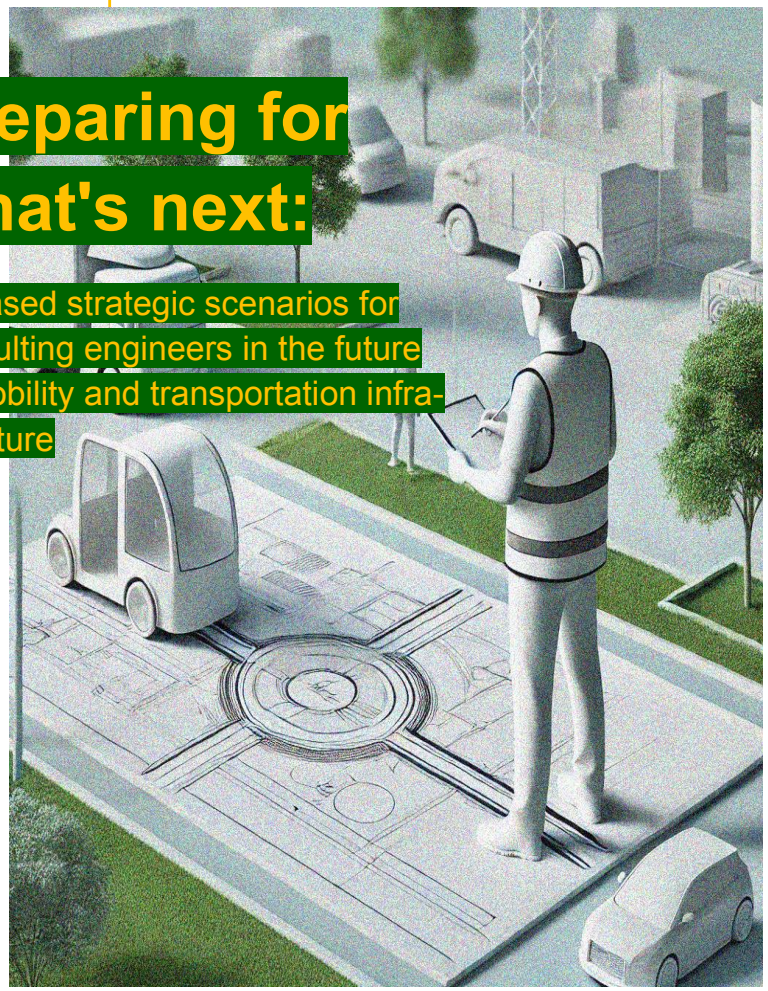
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Preparing for what's next:

AI-based strategic scenarios for consulting engineers in the future of mobility and transportation infra-structure



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This scenario report was authored by master's students from the Philipps-University Marburg, and is presented in its original form to reflect the unique contributions and stylistic choices of the individual authors.

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Can we predict the future?

The mobility market has never been more uncertain, influenced more than ever by regulatory measures to combat climate change, and heavily dependent on technological advances such as autonomous driving. As a result, consulting engineers face a rather complicated and volatile market, carefully preparing for various futures fundamental to business success and survival. Analyzing and describing potential futures based on expert opinion has been the go-to solution for the last few decades. While it has been quite successful, it has required large investments in human capital. Therefore, we propose using prompt engineering with AI to make scenario analysis more streamlined and accurate.

The Tools: LLM, Prompt Engineering, and AI. Large Language Models (LLMs), first known as Natural Language Processing (NLP) techniques and rule-based systems, evolved significantly with machine learning and neural networks in the 2000s. In November 2022, the first ChatGPT was accessible to the public via a web interface, capable of comprehending large amounts of data and presenting creative and comprehensive solutions. In this scenario report, we wanted to put AI´s ability to create scenarios, keeping the balance between exploration and plausibility.

The Task: Predicting the mobility & transportation infrastructure industry until 2030. The mobility and transport market, which we have already described as quite volatile and complicated, posed as the perfect guinea pig for our LLM-infused scenario analysis.

Our 2030 forecasting was picked to align with scenario planning standards and achieve relevant results for consulting engineers. We maintained close contact with industry experts throughout our project, presenting early results and cross-validating every AI-based idea. Aligning with expert opinions helped deepen our knowledge and keep us on a steady path to plausibility.



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The process of creating scenarios

1

Exploring Prompts with different LLMs and applying in parts the HHL Roland-Berger process

OpenAI

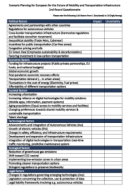
Gemini



2

GPT-based EFCA Expert ‘s Feedback (n=3) to identify key uncertainties, drivers, and trends

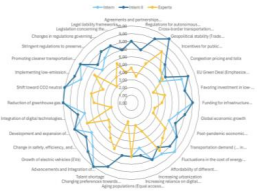




GPT - 4

3

Evaluation through GPT-based Impact/Uncertainty Analysis (see Figure 1) and Spider Diagrams





Conducted ongoing exchanges with EFCA experts to gain valuable insights

efca
European Engineering Consultancies

What is certain and what is not

The process of crafting scenarios involves identifying more and less certain influencing factors, such as relatively certain trends and critical uncertainties that require careful consideration. These critical uncertainties play a vital role in shaping the four future scenarios.

The trends in the top left of the grid (Figure 1) indicate developments perceived as more certain and were essential in forming the final scenarios. Several aspects of the industry have progressed to where they are almost taken as a natural consequence. For instance, the shift towards CO2 neutrality (a) reflects the ongoing commitment to environmental sustainability, driven by policies like the EU Green Deal. This trend underscores the sector's focus on reducing carbon emissions and embracing sustainable practices, which are increasingly becoming industry standards. The adoption of digital tools (b) like Building Information Modeling (BIM) and Artificial Intelligence (AI) is at the forefront of digital tech disruptions in the industry, significantly impacting profitability and cost savings. This trend enhances long-term customer centricity by enabling more efficient and accurate project planning and execution. The level of bureaucracy (c) and its importance in streamlining regulatory processes and compliance are essential for facilitating smoother project implementation. The harmonization of regulations (d), strongly supported by political entities, is expected to continue. This is expected to benefit

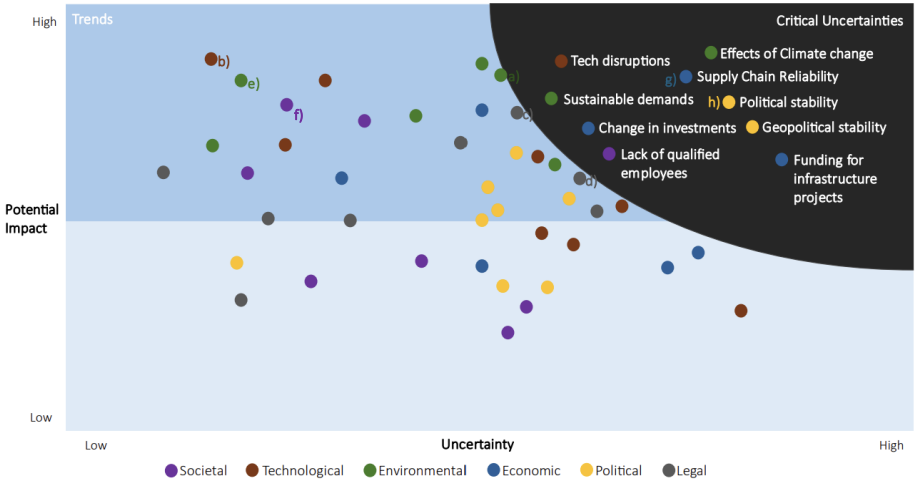


Figure 1: The most important factors influencing the transportation and mobility infrastructure of the consulting and engineering sector – their level of impact and degree of uncertainty (derived from OpenAI & expert-based survey).

consulting engineers designing transnational transport and mobility infrastructure. This regulatory alignment reduces project complexities and fosters international collaboration. Environmental awareness (e) has progressed in parts sufficiently, allowing the sector to plan confidently, knowing that future clients will demand expertise in sustainable practices. The change in consumer behavior (f), driven by increasing environmental consciousness and demand for sustainable mobility solutions, is crucial in influencing funding and investment flows into the sector.

The factors in the top right of the grid represent uncertainties that significantly affect industry profitability but remain external and beyond the control of consulting engineers. The reliability of the supply chain, including the availability and price of raw materials and transportation, is highly unpredictable. Global supply chain disruptions, geopolitical tensions, and fluctuating demand influence it. Political stability (h), critical for ensuring a stable investment environment, is uncertain due to upcoming elections, policy shifts, and geopolitical conflicts. The industry's ability to address these crucial uncertainties is essential for its future prosperity. These seven critical uncertainties, each with its most optimistic or pessimistic projections, are the foundation for outlining four distinct future scenarios. These uncertainties, prioritized based on their potential impact, encompass:

1. Effects of Climate Change (environmental)
2. Political Stability (political)
3. Lack of Qualified Employees (societal)
4. Change of Investment Landscape (economic)
5. Tech Disruptions (technological)
6. Sustainable Demands (environmental)

Uncertainties 3 and 5 have been instrumental in defining the dimension of “Technological Adoption” (see Figure 2), which is crucial for driving innovation and efficiency within the sector. The industry's capacity to adapt and harness technological advancements, such as automated processes and smart infrastructure, significantly influences its ability to meet consumer demands and uphold operational efficiency. On the other hand, 2 and 4 highlight the necessity for a “Supportive Regulatory Framework” (see Figure 2). play a critical role in determining the allocation of investment within the sector and the effective navigation of regulatory obstacles, particularly in cross-border

endeavors. The degree of bureaucracy and the speed at which regulations are harmonized across regions are pivotal in ensuring the industry's ability to leverage emerging projects and new opportunities.

Interestingly, 1 and 6 emphasize the growing importance of integrating environmental considerations into the regulatory framework. Meeting these demands is crucial for the industry to attract investment and thrive in the long run, not only financially but also sustainably. The two key dimensions, Technological Adoption, and Supportive Regulatory Framework, were formed based on these six critical uncertainties. The interaction between these dimensions will likely determine the future direction of the mobility and transportation infrastructure sector, impacting its ability to adapt to internal and external challenges. Parallel Other weak signals and blind spots in this process step were further considered as scenarios and subsequently developed and described.

Emerging Scenarios

The dimensions of 'Technological Adoption' and 'Supportive Regulatory Framework' form the basis of the scenario matrix, where their positive and negative extremes lead to four distinct scenarios. Each scenario is named concisely to reflect its main characteristics (see Figure 2). With these scenarios identified, the next step involves a more detailed exploration of the underlying causes and influences driving both dimensions and gaining a clearer understanding of how each scenario may unfold.

The twenty-three key trends and six critical uncertainties identified earlier (see Figure 3) are mapped into an influence diagram. This diagram illustrates the intricate web of cause-and-effect relationships and comprehensively explains these scenario dimensions' various states (see Figure 3).

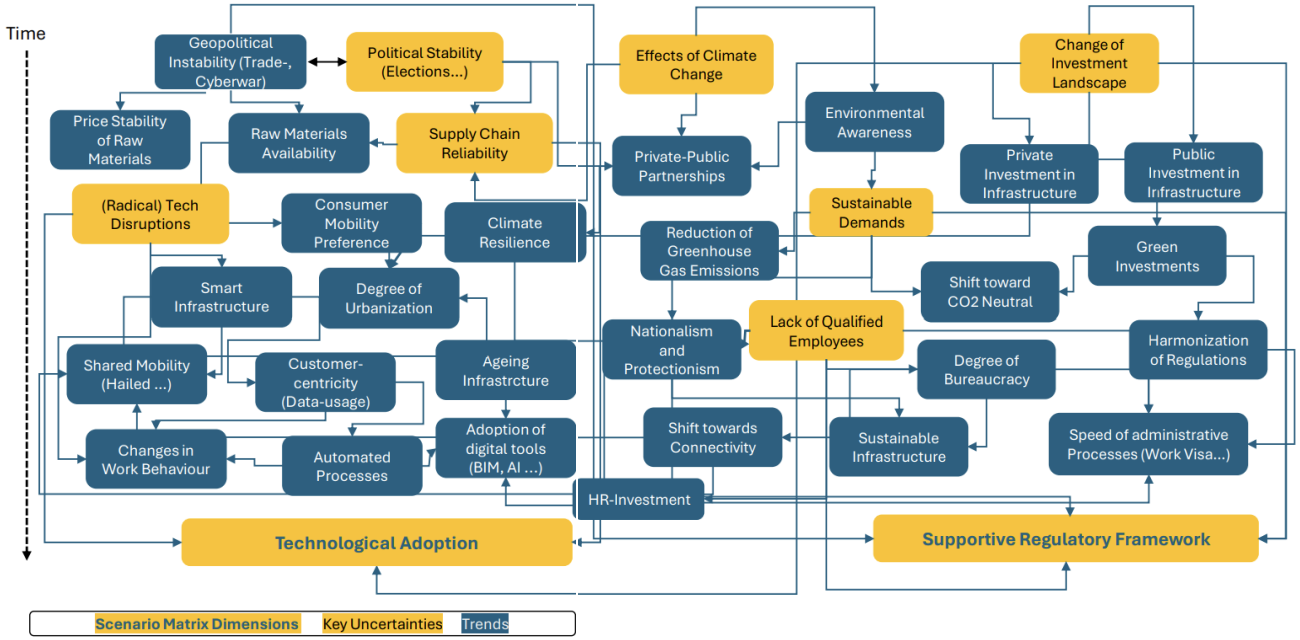


Figure 3: Influence diagram showing complex causes of both dimensions (technological adoption and supportive regulatory framework) being used to create future scenarios

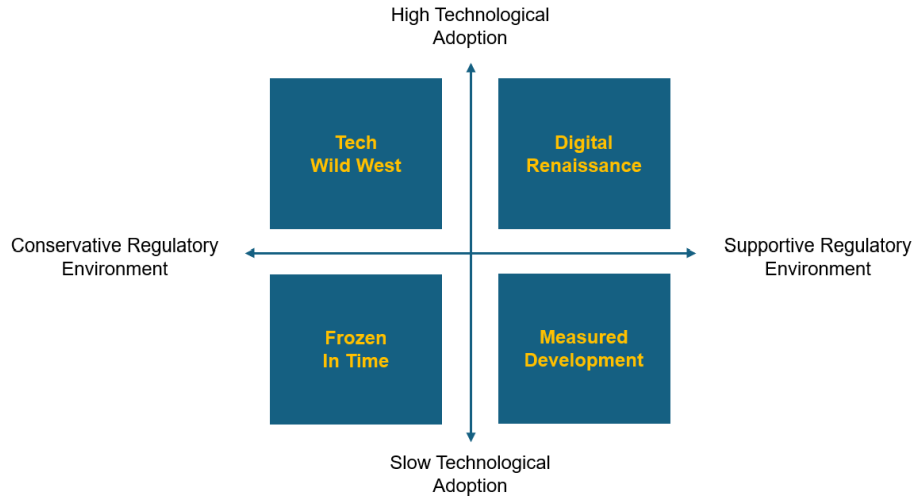


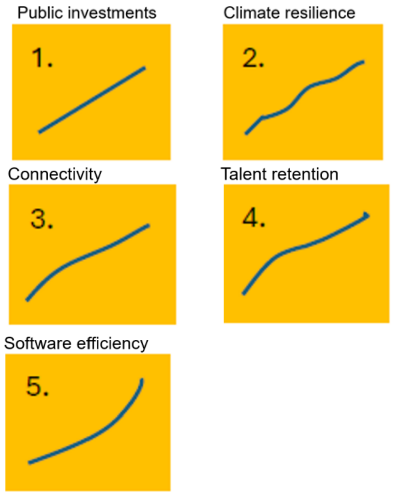
Figure 2: Matrix showing four future scenarios emerging from the two dimensions of 'technological' and 'supportive regulatory framework' (derived from the OpenAI, expert-based survey, feedback - HHL Roland Berger Process)

2030



Four Potential Scenarios

Scenario A: Digital Renaissance



What Happened in the Five Years 2025 to 2030?

Europe embraced a period of substantial public and private investments to modernize and digitalize infrastructure. In 2025, significant funding was allocated to green infrastructure projects, facilitating the widespread adoption of advanced digital tools such as Building Information Modelling (BIM) and Artificial Intelligence (AI). These investments drove a considerable increase in productivity and efficiency across various sectors.

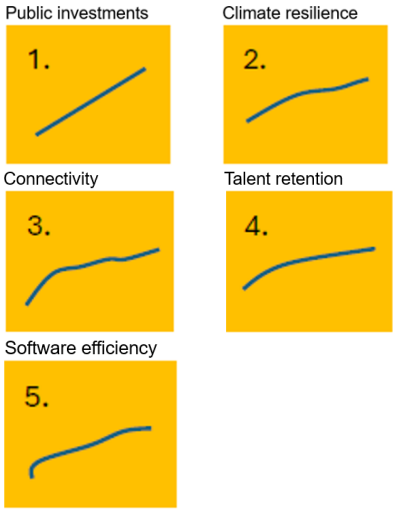
High demand for smart and green infrastructure became a key driver of this transformation. The push for digital transformation led to the development of smart city technologies in European cities that fully integrated intelligent traffic management systems and smart grids, significantly improving urban living conditions. The focus on sustainability and digitalization resulted in the seamless integration of mobility and infrastructure systems, connecting railways, ports, airports, electric vehicles (EVs), and autonomous vehicles (AVs) through advanced digital platforms.

Government policies supported these advancements by harmonizing and standardizing regulations across the EU, leading to cooperative, harmonized, and standardized EU-wide regulations. This reduced bureaucratic delays and fostered innovation. The average time to receive construction permits decreased, facilitating quicker project completion and encouraging further investments. Synergistic industry partnerships played a crucial role in this scenario. Domestic firms dominated the market, while small and medium-sized enterprises (SMEs) thrived, driving local innovation. These partnerships promoted a high degree of connectivity, transport, and mobility across the continent. The labor market shifted towards higher demand for skilled workers proficient in digital technologies and green practices. This led to numerous jobs in

tech and sustainable development sectors, with educational institutions rapidly adapting their programs to meet this demand. Socially, there was an increased emphasis on environmental awareness and sustainable living, driven by government campaigns and community initiatives. Public awareness campaigns significantly increased participation in sustainable practices, with more than 70% of the population engaging in activities such as recycling, energy conservation, and sustainable transportation choices. (European Commission, 2024; European Environment Agency, n.d.) By 2030, Europe had positioned itself as a global leader in sustainable urban development and digital infrastructure. The continent set international standards, attracting significant foreign investments and establishing itself as a hub for technological innovation and sustainable practices.

- High degree of connectivity, transport & mobility
- Technological advancements
- Sustainability
- Labor market shifts
- Social awareness for eco-friendly living is rising
- Domestic firms dominate, and SMEs thrive

Scenario B: Measured Development



What Happened in the Five Years 2025 to 2030?

Between 2025 and 2030, Europe pursued a steady and balanced approach to infrastructure development, focusing strongly on sustainability. Government incentives and moderate expansions in infrastructure, particularly in public transport and green energy, drove this growth. The emphasis was on enhancing existing systems and making incremental improvements rather than pursuing radical technological changes.

Cities implemented comprehensive measures to reduce car dependency and promote public transport. For instance, London expanded its low-emission zones and introduced new electric bus lines, significantly reducing urban

car usage by 2030. High-speed rail networks were expanded, connecting more cities and offering a viable alternative to short-haul flights, thus reducing carbon emissions.

The freight sector adopted biofuels and electric trucks gradually, supported by EU policies that incentivized the use of sustainable materials and practices. Investments in charging infrastructure for electric trucks grew substantially, with the number of charging stations increasing each year, supporting the adoption of electric vehicles in logistics.

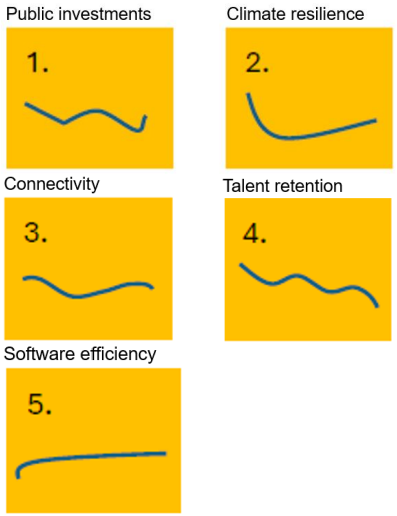
Collaboration between public and private sectors was pivotal in funding sustainable infrastructure projects. The European Green Deal played a significant role, directing substantial investments towards renewable energy projects and sustainable R&D. By 2030, Europe had significantly increased its renewable energy capacity, reducing dependency on fossil fuels. The share of renewables in the EU's energy mix is targeted to reach at least 42.5% by 2030. Technological advancements were incremental, with widespread adoption of digital tools like Building Information Modeling (BIM) and Geographic Information Systems (GIS). These tools optimize project planning and resource management. For example, the implementation of GIS in urban planning projects reduced resource waste, leading to more efficient and cost-effective developments.

The labour market adapted to these changes with an emphasis on vocational training and reskilling programs. The demand for professionals in green and digital technologies grew steadily, resulting in the creation of numerous new jobs in these sectors by 2030. This shift was supported by government initiatives that provided grants and incentives for training programs.

Socially, government campaigns and community initiatives successfully increased public awareness and engagement in sustainability. By 2030, a large portion of households in major European cities were participating in recycling programs, and public transport usage increased significantly, reflecting a shift towards sustainable living. Public investments played a crucial role in supporting these sustainable initiatives. Funding programs from the European Commission ensured that large-scale infrastructure projects were adequately financed, facilitating the transition to a more sustainable economy. This robust financial support enabled continuous progress in green projects and sustainable infrastructure development.

- Tech firms unable to scale, SMEs thrive
- Technological incrementalism
- Attractive market for green investment
- Job creation in green and digital sectors
- Harmonized sustainable regulations

Scenario C: Frozen in Time



What Happened in the Five Years 2025 to 2030?

Between 2025 and 2030, Europe saw minimal progress in modernizing its infrastructure, characterized by weak increases in both smart and sustainable infrastructure. The development of electric vehicles (EVs) and autonomous vehicles (AVs) stagnated due to fragmented regulatory efforts and safety concerns. Public transport systems struggled with outdated infrastructure and underfunding, leading to minimal improvements.

In 2026, efforts to expand EV infrastructure were hampered by bureaucratic delays and safety concerns, causing the number of EV charging points to fall significantly short of targets. By the end of the year, only a modest increase in EV adoption was observed, with many regions still relying heavily on conventional combustion engine vehicles.

National interests and protectionism remained high, limiting international collaboration and innovation. The industry remained extremely traditional, with minimal adoption of advanced technologies like data analytics and predictive maintenance. Essentially, the whole industry remained in a status quo with “business as usual.” This resistance to change was further hindered by corporate culture, safety concerns such as cyberattacks, and a talent shortage.

By 2027, public transport systems in many regions continued to suffer from underfunding and outdated infrastructure. A planned upgrade of the high-speed rail network faced multiple delays due to regulatory and funding issues, resulting in only a few new lines being operational by the end of the year. This hindered efforts to reduce urban congestion and carbon emissions.

The labor market faced significant challenges. The industry struggled to attract young talent due to its conservative nature, slow technological adoption and lack of innovative opportunities. This led to a persistent shortage of skilled workers, particularly those with expertise in STEM fields. Efforts to modernize and digitalize infrastructure were hampered by a lack of resources, cultural openness, and agility to address changes. Economic disparities between urban and rural areas exacerbated, with cities being more profitable and better developed than rural regions. Rural areas faced significant infrastructure deficits, making it difficult to attract investments and talent. Young people increasingly moved to urban areas, further widening the urban-rural divide.

Socially, the lack of progress in sustainability and digitalization led to growing frustration among the younger population, who were more environmentally conscious and tech-savvy. Political tensions rose, with increasing support for both far-right protectionist parties and environmental movements, reflecting a polarized society.

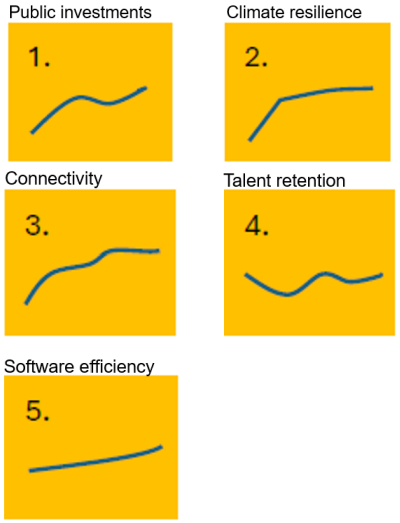
Despite these challenges, there was a reliance on foreign market software, which dominated due to the lack of supportive regulations and dependency on external technology solutions. This reliance made the industry vulnerable to external market fluctuations and cyber threats. There was limited funding directed towards innovative or sustainable projects. The focus was primarily on maintaining and upgrading existing infrastructure rather than pursuing new developments. For instance, the number of EV charging points in Europe only reached around 2 million by 2030, far short of the target. (European Investment Bank, 2021) Additionally, public investment in smart mobility and renewable energy projects was lower than anticipated, contributing to a slower overall transition towards sustainable infrastructure.

By 2028, several high-profile infrastructure projects, such as expanding urban public transport systems and upgrading national rail networks, experienced significant delays due to regulatory hurdles and funding shortages. These delays further highlighted the inefficiencies in the current regulatory framework and the need for more cohesive policies. By 2030, Europe's infrastructure development had significantly lagged global advancements, struggling to compete in

an increasingly digital and sustainable world. The heavy reliance on traditional practices and protectionist policies hindered progress, leading to economic stagnation and societal frustration.

- High national interests and protectionism
- Development stagnation due to fragmented regulatory
- Business remains as usual
- Labour market fails to attract young talent
- Urban rural disparities
- Dependence on foreign software making the industry vulnerable
- Gradual adoption and connectivity of public mobility and infrastructure

Scenario D: Tech Wild West



What Happened in the Five Years 2025 to 2030?

Europe experienced significant technological advancements in mobility and transport, primarily driven by private companies. This resulted in varying levels of adoption of smart and shared mobility solutions across the continent, particularly in major cities like Amsterdam and Paris. However, the regulatory environment remained fragmented, leading to inconsistencies in safety and ethical standards, and a high degree of public concern due to a lack of coordinated policies and oversight.

In 2026, the fragmented regulatory framework led to regional disparities in technological adoption. Northern and Western Europe saw faster implementation of smart infrastructure, while Southern and Eastern Europe lagged due to limited investments and outdated infrastructure. This resulted in higher costs and lower availability of advanced transport technologies in less developed areas.

The slow harmonization of transnational policies across Europe exacerbated these disparities. For example, aging infrastructure in regions like Southern Italy necessitated maintenance and modernization, but the variability in technology adoption and infrastructure development across different regions slowed progress. By 2027, data sovereignty issues arose, with dominant players like Google controlling much of the data environment, leading to dependency and lack of harmonized interfaces for smart technologies.

The labour market faced significant challenges. The industry struggled to bridge the technological gap between advanced and lagging regions. Efforts to modernize and digitalize infrastructure were hampered by a lack of human resources, cultural openness, and agility to address changes. Between 2027 and 2029, the demand for skilled workers in digital and sustainable practices had increased, but the education and training systems were not fully aligned with the industry's needs, causing a persistent shortage of qualified personnel.

Climate change adaptation measures were insufficient, leading to poor resilience and increased vulnerability to natural disasters. Short-term design durations and inadequate knowledge to manage cross-border projects further hindered progress. In 2029, several high-profile infrastructure projects, such as the deployment of digital twins for managing and calculating infrastructure through AI, experienced delays due to regulatory and funding hurdles.

Socially, the rapid technological advancements led to growing regional disparities. Cities with advanced smart infrastructure enjoyed improved mobility and reduced congestion, while rural and less developed areas continued to struggle with inadequate infrastructure. This exacerbated economic disparities and led to increased migration from rural to urban areas, further widening the urban-rural divide.

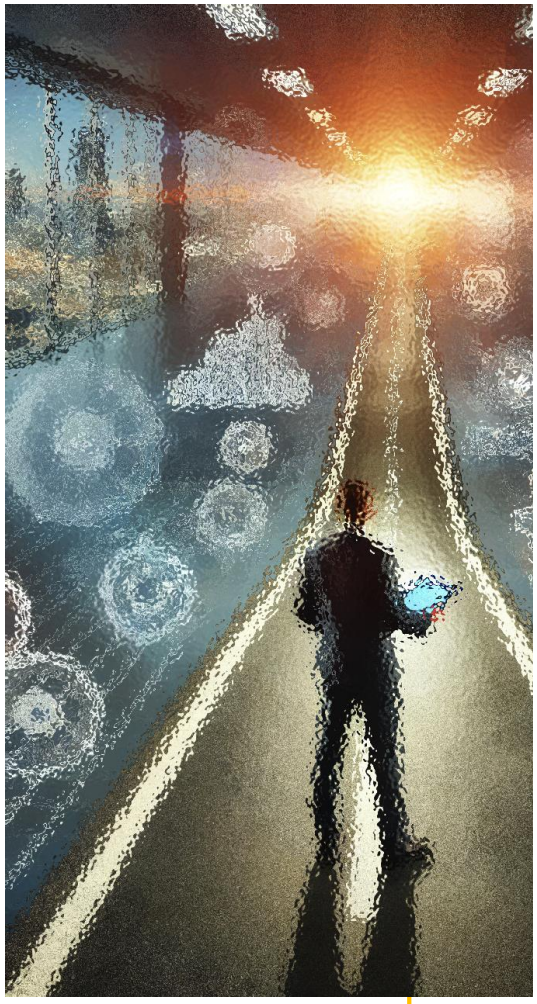
Public investments in smart infrastructure saw a strong increase, driven by private sector initiatives. However, investments in sustainable infrastructure lagged, leading to a reliance on traditional energy sources and slower progress towards carbon neutrality. For instance, while the number of smart traffic management systems in cities like Munich increased significantly, the adoption of renewable energy sources in these systems was limited, causing sustainability concerns.

By 2030, Europe's infrastructure development had achieved significant technological advancements but was marred by regulatory fragmentation and regional disparities. The dominance of large tech companies and the lack of harmonized regulations created a "Tech Wild West" scenario, where innovation

thrived in pockets but failed to deliver cohesive, continent-wide benefits.

Despite these challenges, the push for technological innovation continued to drive economic growth in more developed regions. The reliance on foreign software and technology solutions remained high, making the industry vulnerable to external market fluctuations and cybersecurity threats. Public concern over safety and ethical standards also grew, calling for a more coordinated and regulated approach to infrastructure development in the future.

- Fragmented regulatory framework leads to inconsistencies
- Regional disparities in technological adoption
- Dominance of large tech companies
- Slow progress in carbon neutrality
- Data sovereignty issues
- Increased migration from rural to urban areas

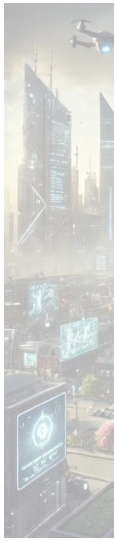


Strategic Recommendations

Digital tools have become indispensable in the development process of future scenarios and today's rapidly evolving business environment, facilitating operational activities and strategic decision-making. Industries are continually reshaped by globalization, technological advancements, and changing customer needs (Hauschildt & Salomo, 2011; Juric et al., 2020). Organizations must adapt and set up promising tools to remain competitive in the long run, as it promises efficiency and productivity, such tools as BIM and AI (Durach & Gutierrez, 2024; EFCA, 2021; Harwardt, 2022). In addition to digitalization, sustainability stands as a crucial global pillar, making a profound impact on businesses by not only attracting investments but also creating new opportunities (EU, 2024; UN, 2024). The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, presents a shared framework for prosperity for both people and the planet, both now and in the future. At its core are the 17 Sustainable Development Goals (SDGs), which serve as a pressing call to action not only for countries but also for consulting engineers with goals including infrastructure, sustainable cities and communities, climate action, and partnerships (UN, 2024). These goals can serve as a guide and opportunity for enterprises of all sizes, especially given their alignment with the European Union's core principles (EU, 2024).

Scenario A - Digital Renaissance

Rapid advancements in digital technologies and a strong emphasis on sustainability are reshaping the future of the mobility and transportation infrastructure sector. *Digital Renaissance*, the best-case scenario, is characterized by high technological adoption within a supportive regulatory environment and presents significant opportunities for consulting engineers to remain competitive and successful.



Small businesses should align their capabilities and resources as simple engineering processes could be fully automated within six years. Hence, the strategy strongly focuses on specializing in a niche market to achieve a competitive advantage. This may entail redeveloping outdated buildings or establishing expertise in eco-friendly design practices and materials for off-site construction, benefiting from private and public green investments for financial support. Medium-sized enterprises should prioritize smart interfaces and simple

automated infrastructure. Compliance frameworks for integrated public and private mobility solutions should be created, focusing on shared mobility and automation. These frameworks can include intelligent traffic management systems and automated freight handling solutions, which can broaden the service offerings such as predictive maintenance. For large enterprises, the primary focus should be on adopting radical digital tools. Implementing advanced digital tools such as Building Information Modeling (BIM), Artificial Intelligence (AI), and data analytics will enable the automation of complex processes. Firms can shift towards a more customer-centric approach by utilizing in-house training programs and data analytics platforms. Creating real-time monitoring and project coordination platforms, such as Digital Twins and Lifecycle Analysis, will be essential. Leveraging EU-wide green funds and investments, consulting engineers can develop infrastructure that supports climate resilience and long-term maintenance services. Embracing advanced technology and interconnected interfaces creates opportunities to collaborate and pursue new, larger (cross-border) projects, which should be emphasized across all enterprise sizes.

Scenario B - Measured Development

Measured Development focuses on the incremental but steady adoption of sustainable practices and digital tools underpinned by a supportive regulatory framework. This scenario emphasizes the gradual shift towards sustainability, with consulting engineers essential in driving this transformation.



Specializing in sustainable niche markets is particularly advantageous for small and medium enterprises. Niche expertise allows firms to differentiate themselves and attract clients seeking specialized sustainable solutions, focusing on refurbishing and circularizing existing and aging infrastructure aligned with sustainable goals such as green material installations and circular management. Upskilling and reskilling employees can be costly and time-consuming, especially for small engineering teams. Medium-sized businesses can begin by implementing e-learning platforms and in-house training programs to reduce the skills gap. They can also consider automating basic engineering processes to maximize available resources. Investing in employee development may ensure that the workforce remains adaptable and capable of meeting the industry's evolving demands. Large enterprises should primarily focus on adopting incremental digital tools and scaling up sustainable change. Data analytics will be essential to identify high-impact sustainable projects and address customer needs. This approach allows leveraging available data for continuous lifecycle monitoring and may achieve higher customer satisfaction. Developing frameworks for sustainable practices is vital for both medium and large enterprises. Establishing long-term standardized practices for green materials and modularized designs will set the standard for the future. This will enable a broader portfolio of services and products, contributing to climate resilience. Companies can lead sustainable development and ensure consistent project quality by setting these standards.

Scenario C - Frozen in Time

Frozen in Time involves an industry that remains highly traditional (´business as usual´), with sluggish technological adoption and a focus on maintaining and upgrading existing infrastructure. Despite limited regulatory pressure, there is a pressing need for consulting engineers to modernize processes and leverage emerging technologies to stay competitive.

Concentrating on specific markets and exploiting traditional engineering can benefit small and medium-sized businesses. Focusing on (sustainable) modernization and standardized practices may increase the market share. Medium-size enterprises should implement strong customer feedback mechanisms. By establishing and utilizing systems to actively gather and carefully analyze customer feedback, companies may enhance their services and substantially increase customer satisfaction. Leveraging data and using affordable digital tools for efficiency should be the top priority for large enterprises. By exploiting data from IoT sensors, companies may enhance critical maintenance, such as energy management and overall operational efficiency. Huge opportunities lie in implementing real-time monitoring systems that may reduce infrastructure downtime. Large corporations should enhance public-private collaborations to finance and potentially undertake larger projects, such as upgrading transportation infrastructure such as railway systems and highways. Furthermore, larger enterprises could streamline and improve existing processes using tools like BIM and IoT, which may lead to lower operational costs in the long run.

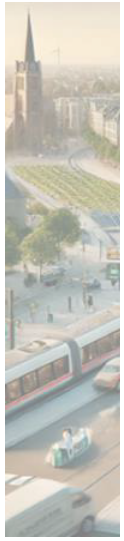


By adopting these strategic recommendations, consulting engineers can effectively navigate the infrastructure modernization scenario. Emphasizing data-driven efficiency, collaboration, automation, niche specialization, and customer-centric approaches will ensure long-term success and resilience in the mobility and transportation infrastructure.

Scenario D - Tech Wild West

The *Tech Wild West* envisions significant technological advancements in mobility and transportation, driven primarily by private companies. However, the fragmented regulatory environment and regional disparities pose challenges.

Small enterprises must invest in digital technologies to survive in the long run. This will help them benefit from interconnected smart interfaces, potentially leading to partnerships and collaborations and enabling them to offer new services such as project planning. It is important for small enterprises to establish strong partnerships at both regional and local levels and to develop a competitive edge in their industry knowledge within their territory. Medium-sized enterprises should prioritize bridging gaps between regions by constructing mobility and transportation infrastructure in less-developed areas. Rural areas connect to modern infrastructure through new bridges, rail systems, and highways, and the overall regional implementation of IoT sensors, leading to broader maintenance services in the long run. Large enterprises should invest in and focus on advanced cross-border transportation and mobility solutions and implementing automated supply chains, such as freight stations and smart traffic systems, which may reduce congestion and improve traffic flow efficiency. This strategy harnesses cutting-edge technology. A similar approach is also recommended for mobility interfaces to connect the public through smart interfaces, presenting opportunities for consulting engineers to gather data for various services, including safety and predictive lifecycle management. Another promising application is in the emerging field of planning and construction (see Fig. 4), enabling involvement from the early stages and the potential for real-time project and price tracking. Continuous learning is indispensable for enterprises of every size. By forming alliances with dominant tech firms, companies can tap into digital solutions expertise, keep up with the latest industry trends, and retain their competitiveness.



Next Normal AEC Value Chain

Basic Requirements:
- Commitment to continuous learning
- ‘Thinking outside of the Box’ mentality
- Positive ‘Corporate Culture’ toward change
- Partnership with a tech (software) company

AEC Value Chain	New roles and activities for consulting engineers (CE)
Planning	▪ Strategy, initial concept, ideas, and project planning ▪ Ageing infrastructure demolition risk assessment ▪ Materials recovery planning and maximization ▪ End-to-end business platform custom-tailored consulting
Design **Architecture** **Engineering**	▪ Renovation, modernization ▪ Development of an in-house digital platform interface ▪ Use of Generative visualization software: VR/AR/3D/BIM ▪ AI-based space optimation for buildings and mobility ▪ Creating frameworks for sustainable practices
Preconstruction	▪ Intern: Scheduling, project budgeting, and cost planning ▪ Extern: Project and customer-tailored approach ▪ E-platforms: for purchasing supplies, learning, contracts ▪ Connectivity & advanced smart communication
Construction	▪ Real-time tracking of projects, safety, prices ▪ Project progress monitoring and reporting ▪ Computer vision and machine learning (AI) ▪ Construction project digital documentation ▪ BIM Construction ▪ Off-site construction, Digital platform end-to-end
Maintenance	▪ Lifecycle / Waste / Energy management ▪ Guidance with sustainable frameworks ▪ Consulting services on consumer behavior (big data) ▪ Quality management of projects and building cost

Consulting engineers break through traditional boundaries, need of multitask in various parts of the value chain, and invest in technological, sustainable, and human resources. Large and medium enterprises will aim to build scale in promising key technologies such as AI and BIM, creating a broader portfolio of products and services they can offer. Due to digital advancement, Cybersecurity will remain a critical concern.

Current Playground of Consulting Engineers

Large Enterprises Medium Enterprises Small Enterprises

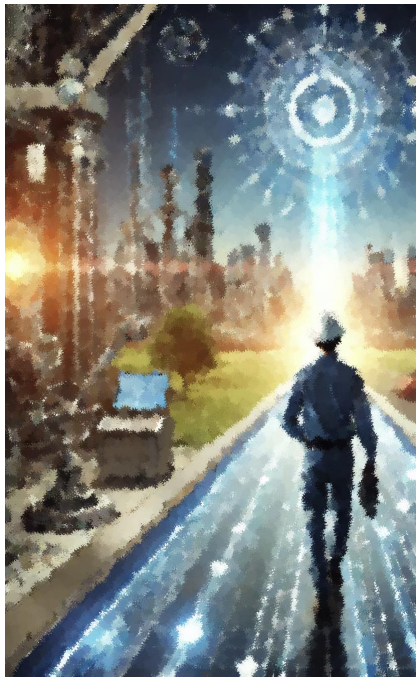
Figure 4: Next Normal AEC Value Chain

Reflection

During our discussions with the EFCA experts, we often noticed that large language models (LLMs), due to their global focus, frequently overlook changes and dependencies in the mobility and transport market influenced by the political and economic situation. While this limitation of LLMs is acknowledged, it's essential to highlight that these models often cannot be tailored to specific regional areas or fail to account for variations in local circumstances that could lead to different outcomes. For instance, the nationalization or non-nationalization of highways or public transport can significantly impact the maneuverability of actors within political or economic constraints. Additionally, LLMs like ChatGPT tend to neglect the struggles associated with bureaucratic decision-making processes, potentially leading to a more outcome-oriented focus that overlooks internal processes, which may appear as a lack of in-depth knowledge compared to expert opinions.

EFCA Acknowledgement

We would like to extend our heartfelt appreciation to the EFCA experts for their invaluable assistance in our scenario analysis utilizing AI. Their generous time commitment and consistently insightful and thoughtful input were instrumental in guiding us forward. Their openness to our solutions and the fascinating perspectives they shared greatly enriched our understanding. Their support was crucial in advancing our research, and we are profoundly grateful for their contributions.



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FUTURE FORESIGHT

CLIMATE ADAPTATION IN THE CONSULTING ENGINEERING INDUSTRY

Authors: *Yeamelake Aklilu, Vanessa Rosenau, Sophia Sauer and Luisa Schulze Marquarding*

This scenario report was authored by master's students from the Philipps-University Marburg, and is presented in its original form to reflect the unique contributions and stylistic choices of the individual authors.

WHICH FUTURE ARE YOU PLANNING FOR?

THE GREEN ENGINEER

AUGUST 2ND 2030

Europe's engineering giants propel green revolution

Europe's top engineering firms are set to lead another year of groundbreaking advancements, successfully outpacing global competitors in the race for climate resilience.

Following a wave of unprecedented climate events, Europe's construction sector has rapidly adapted, fueled by a €900 billion green transformation fund established two years ago. This fund, targeted at sustainable infrastructure and renewable energy projects, has sparked significant growth across the continent.

Productivity in the engineering sector has surged by 10% in 2025, driven largely by accelerated digitalization and the widespread adoption of advanced technologies. Building Information Modeling (BIM) remains at the core, enhancing collaboration, innovation, and efficiency among Europe's leading firms.

New technologies are also becoming mainstream, with the integration of AI for predictive maintenance, drones for environmental monitoring, and IoT systems for smart city developments. The streamlined regulatory environment has further facilitated growth, reducing bureaucratic hurdles and harmonizing standards across member states.

As Europe's market for green technologies continues to expand, the focus remains on scaling up operations. Large firms are leveraging economies of scale, acquiring smaller innovators to enhance their capabilities.

However, competition from Asian firms looms large. While they struggle to match Europe's innovation, their lower labor costs and expansion into Eastern Europe present a persistent challenge. Nonetheless, Europe's engineering giants remain poised to drive the global green revolution.

ENGINEERING TODAY

AUGUST 2ND 2030

Europe's Climate Battle Stumbles on the Tech Tightrope

Despite Europe's strong commitment to addressing climate change, the continent is facing significant challenges as outdated technologies and resource shortages slow down progress. Public demand for immediate and effective climate action has surged, but the tools to deliver on these expectations are in short supply, leading to growing discontent across the region.

Engineering firms, central to Europe's climate adaptation strategy, are struggling to keep up. While there has been a 25% increase in climate adaptation projects aimed at protecting communities from the escalating effects of climate change, these efforts are often constrained by the use of older, less efficient technologies. This has led to a gap between public expectations and what can realistically be delivered, causing frustration among citizens who are eager to see more robust climate solutions.

Governments have introduced ambitious policies, targeting a 40% reduction in carbon emissions by 2035. However, these plans are often hindered by the lack of advanced technologies, which limits the effectiveness of adaptation measures. As a result, many projects fall short of their potential, further fueling public dissatisfaction.

The situation is further complicated by Europe's increasing reliance on foreign technology transfers, up by 15% over the past year. This dependency raises concerns about the continent's economic stability and sovereignty, as Europe's ability to independently tackle climate challenges is called into question.

Ella Eco, CEO of a small German consulting engineering firm, highlighted the urgency of the situation, stating, "Our industry is caught between the public's demand for immediate action and the harsh reality of technological limitations. We must innovate within these constraints to keep moving forward."

Engineering firms are now advocating for a phased approach to climate adaptation, allowing for the integration of more advanced technologies as they become available. However, the road ahead remains challenging, with Europe needing to balance ambitious climate goals with the realities of current technological limitations.

Adaption Insights

AUGUST 2ND 2030

Resource Crisis Leaves Europe Vulnerable to Climate Shocks

Europe is facing a perfect storm of challenges as the climate crisis collides with economic instability and a lack of public awareness. In a continent once known for its innovation, the reality is stark: investment in climate adaptation projects has plummeted by 30%, leaving nations dangerously unprepared for the increasing frequency of extreme weather events.

Public awareness of the climate crisis is shockingly low, with only 20% of the population recognizing the severity of the situation. This apathy has led to minimal demand for climate action, slowing the adoption of sustainable practices and hindering technological progress. Governments, struggling with depleted resources, have been unable to enforce even the most basic regulatory frameworks, and incentives for green initiatives are nearly nonexistent.

"How much longer can we afford to ignore the mounting risks?" asks Greg Green, CEO of a small consulting engineering firm in the Netherlands. "We are trying to do more with less every day, but without stronger public support and investment, the future looks bleak."

Consulting engineering firms find themselves on the frontlines of this crisis, tasked with developing low-cost, resource-efficient solutions in an environment where every euro counts. The focus has shifted to retrofitting existing infrastructure with simpler, more resilient technologies that can withstand climatic events without extensive upgrades. Engineers are pioneering the use of alternative materials, stretching limited resources to maintain functionality in the face of growing challenges.

With international cooperation at a low point, Europe's ability to handle the escalating impacts of climate change is in serious doubt. The engineering sector is calling for immediate investment and stronger regulations to avoid a future where Europe's resilience is dangerously compromised.

EcoEngineered

AUGUST 2ND 2030

Innovation Goes Unused as Europe Fails to Wake Up



In a surprising twist, Europe - home to some of the world's most advanced climate technologies - finds itself lagging in climate action due to widespread public complacency. Despite a 40% increase in investment in cutting-edge technologies over the past three years, the continent's climate adaptation efforts are moving at a snail's pace.

Economic stability has enabled European nations to pour billions into innovations like smart grids, AI-driven energy systems, and resilient infrastructure. Yet, without strong public demand, these technologies remain largely untapped. The lack of public pressure has allowed governments to ease off the enforcement of environmental policies, resulting in only a 15% implementation rate of these advanced solutions in climate projects.

This underutilization is stark when considering the potential: Europe's technological capabilities could significantly reduce climate impacts, but with public engagement at an all-time low, these advancements sit idle. The gap between what can be achieved and what is being done grows wider by the day, threatening to turn Europe from a potential leader in climate adaptation into a mere bystander.

Consulting engineering firms, armed with the tools for transformative climate action, are now forced to pivot their strategies. With public indifference acting as a significant barrier, these firms are investing heavily in public education and outreach, showcasing successful projects that demonstrate the tangible benefits of climate technologies. They are also lobbying for stronger, more enforced policies to ensure that the continent's vast technological resources are not wasted.

As Europe faces increasingly unpredictable climate events, the need to harness its technological potential has never been more urgent. The question remains: will the public wake up in time to drive the change that's desperately needed?

Agenda 2030 - Massive Downfall or Soaring Success?

The 2020s have posed significant challenges to civilization, with the COVID-19 pandemic, economic and social crises, geopolitical conflicts, and climate change all exerting immense pressure on the world. But what does the future hold? Can we adapt to these disruptive times? If so, how? While no one can predict the future with absolute certainty, there are tools that can shed some light on these questions.

For consultant engineers the stakes have never been higher. As climate change accelerates, the need for innovative and resilient infrastructure becomes paramount. How can engineers anticipate and the impacts of extreme weather events, rising sea levels, and shifting climate patterns? The answers lie in forward-thinking strategies and scenario planning.

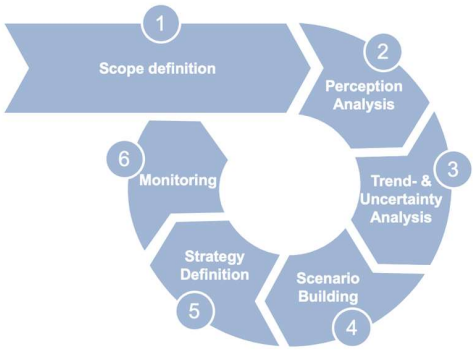
The HHL Roland Berger process of scenario-based strategy, develops various scenarios based on key uncertainties. Through AI and expert consultations, key uncertainties are identified and ultimately consolidated into different scenarios. This method equips consultant engineers with the insights and frameworks necessary to navigate the complexities of climate adaptation, ensuring that infrastructure development is not only sustainable but also resilient to the unpredictable challenges of the future.

The goal of this scenario project was to characterize potential trajectories and future scenarios of the European landscape and develop strategic recommendations for consulting engineers with regard to climate adaptation projects. The urgency of climate adaptation cannot be overstated, as the consulting engineering sector faces unprecedented demands to create resilient infrastructure capable of withstanding extreme weather events and shifting environmental conditions. How will consulting engineers pivot to meet these challenges? The answer is to develop robust, adaptive solutions.

Master's students at the University of Marburg have applied prompt engineering using large language models (LLMs) for the consulting engineering industry. To validate the results, industry experts were consulted, ensuring the accuracy and reliability of the findings. This innovative approach combines the power of AI with human expertise, offering a glimpse into the future of the consulting engineering sector as we approach 2030. This collaboration aims to provide actionable insights and prepare the industry for the challenges and opportunities that lie ahead.



The HHL Roland Berger Process



1. Scope Definition: This approach set out to develop scenarios for the engineering consulting industry in Europe over a six-year period (until 2030)

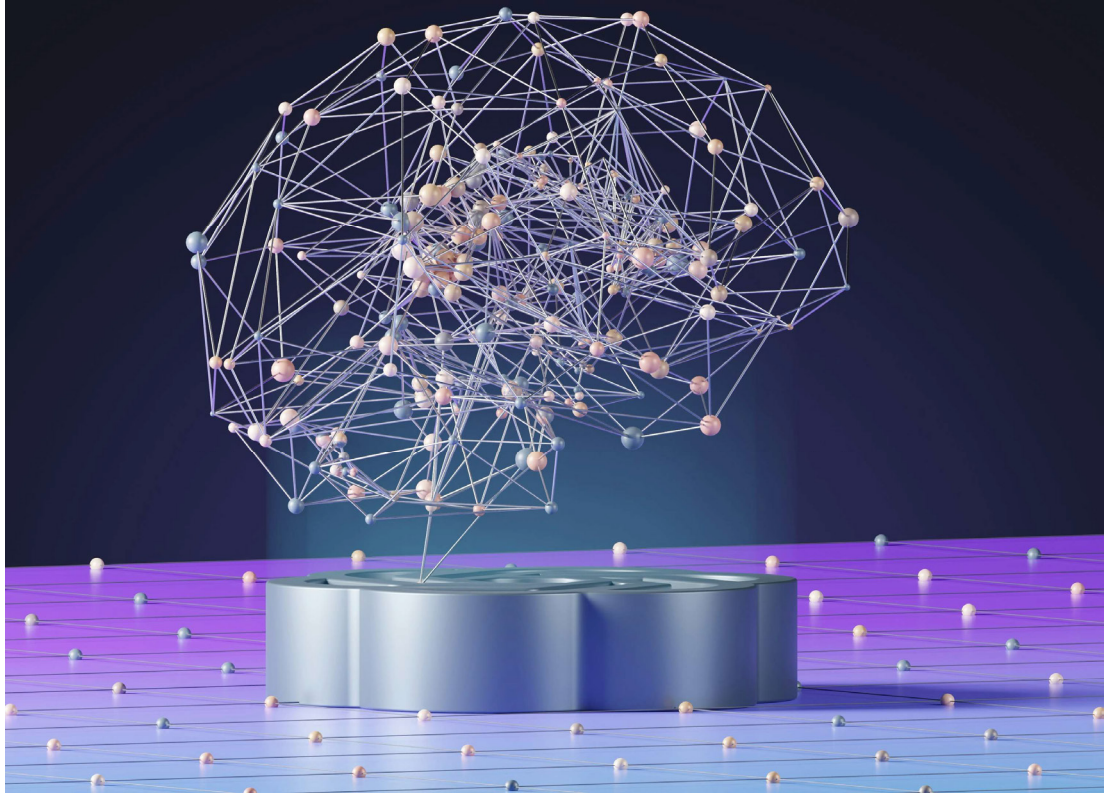
2. Perception Analysis: Normally, stakeholders are consulted, but for this approach, we used ChatGPT and industry experts for gathering perception

3. Trend- & Uncertainty Analysis: We used ChatGPT, which independently developed key drivers with impact and uncertainty scores to identify the key uncertainties. To verify these results, we consulted industry experts

4. Scenario Building: The Key Uncertainties serve as a foundation for the scenario matrix designed to identify four extreme future scenarios.

5. Strategy Definition: The insights gathered, especially the most unpredictable influencing factors, can now be leveraged to craft a core strategy tailored for the Engineering Consultant Industry, outlining options for each of the four identified scenarios (Agenda 2030)

6. Monitoring: By aligning the scenarios with actual developments, strategic options can be chosen to complement the core strategy.



What is certain and what is not …

In the formulation of scenarios, key uncertainties serve as foundational elements, representing the principal drivers of these scenarios. The process relies on the identification of influencing factors, which vary in their degree of certainty. The objective of this approach is to specify the various impacts on the environment, particularly within the context of the engineering consultancy industry, by differentiating between various future scenarios related to climate adaptation. Through this methodology, the following key uncertainties have been identified:

(1) Climate Change Intensity

(2) Economic Conditions

(3) Technological Advancements

(4) Regulatory Frameworks

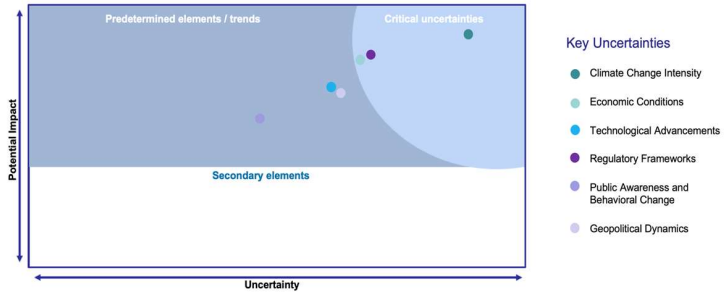
(5) Public Awareness & Behavioral Change

(6) Geopolitical Dynamics

The trends identified in the **upper right** quadrant of the Uncertainty Grid, referred to as "Critical Uncertainties," indicate developments with high uncertainty. These trends are essential in shaping the future scenarios as they represent pivotal factors that could significantly impact the engineering consultancy industry. By recognizing these critical uncertainties, organizations can better prepare for and adapt to potential changes, ensuring strategic resilience and informed decision-making.

(1) The uncertainty around climate change intensity involves the variability and unpredictability of climate changes, including temperature increases, shifts in precipitation patterns, and extreme weather events. This unpredictability complicates adaptive strategies as changes can significantly alter ecosystems, water availability, agriculture, and urban planning

(2) Economic conditions focus on the resilience of European economies to finance substantial climate adaptation projects amidst potential economic fluctuations.



Economic stability affects funding availability for these initiatives, with downturns reducing and growth expanding the resources for adaptation.

(3) Innovations in climate adaptation, such as advanced flood defenses, drought-resistant crops, and efficient renewable energy solutions, are crucial for enhancing adaptation capabilities. However, the pace of technological development and adoption remains uncertain, impacting the overall effectiveness and cost-efficiency

(4) Changes in EU and national climate adaptation policies, including new regulations, subsidies, and penalties related to carbon emissions, shape the operational landscape for adaptation projects. These policies influence implementation methods and costs, and are subject to shifts based on political changes.

(5) The evolution of public perception and behavior toward climate change adaptation is a critical uncertainty. Increased awareness and behavioral changes can drive policy and market demand for sustainable solutions, significantly impacting the success of adaption strategies

(6) Geopolitical Dynamics: International cooperation or conflicts affect resource availability, such as water and energy, which are crucial for adaptation strategies. These geopolitical dynamics can either facilitate or hinder collaborative efforts across borders, impacting the effectiveness of adaptation initiatives

Each of the developed uncertainties has been analyzed for its potential impact on the industry. This analysis includes evaluating how these factors interact and influence each other. For instance, regulatory frameworks might be heavily influenced by public awareness and geopolitical dynamics, while technological advancements could mitigate or exacerbate the impacts of climate change in terms of climate adaptation. Based on this analysis, two primary dimensions have been selected to form the basis for scenario development. These dimensions represent the most significant and uncertain factors that will drive future scenarios



Formulation of Scenario Dimensions

Based on this analysis, two primary dimensions have been selected to form the basis for scenario development. These dimensions represent the most significant and uncertain factors that will drive future scenarios:

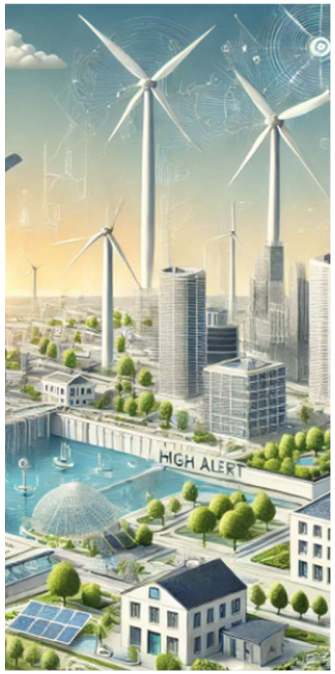
(1) Awareness about Climate Change: This dimension encompasses the level of public and political awareness and engagement regarding climate change. High awareness can lead to increased actions and investments in sustainable technologies, while low awareness may hinder progress.

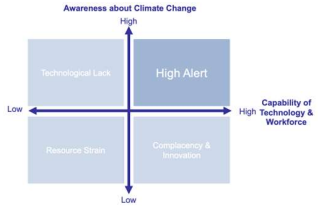
(2) Capability of Technology & Workforce: This dimension refers to the ability and readiness of technology and the workforce to adapt to new challenges and develop innovative solutions. High capability can promote the implementation of sustainable practices and adaptation to climate change.

Scenario 1: High Alert

In the **"High Alert"** scenario, Europe experiences heightened public awareness and understanding of the severe implications of climate change. This awareness leads to strong demand for robust climate action, propelling both governments and the private sector to invest significantly in advanced technologies. Consequently, substantial investments in state-of-the-art flood defenses, drought-resistant crops, and innovative renewable energy solutions become the norm. The workforce is equipped with skilled professionals who drive technological advancements efficiently, supported by stringent regulatory frameworks that offer incentives for sustainable practices and penalize carbon-heavy activities.

International collaboration flourishes as countries share best practices and breakthrough technologies, resulting in a cohesive and aggressive response to climate challenges. This scenario optimizes the intersection of high public awareness and technological sophistication, reducing the vulnerability of European nations to climate impacts and setting a global standard for climate resilience.





How to handle this scenario?

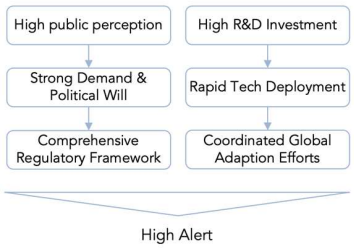
Consulting engineering firms find themselves at the forefront of climate adaptation, driven by strong market demand and substantial investments in infrastructure resilience. Engineering solutions are increasingly sophisticated, incorporating AI, IoT, and smart grid technologies that optimize energy use and enhance urban sustainability. The industry's role expands beyond traditional design and construction towards an integrated approach that includes long-term sustainability consulting and management services. To meet the surge in demand, firms must rapidly scale their capabilities, invest in continuous professional development, and adopt cutting-edge tools to stay competitive. Partnerships between public entities and private firms thrive, fueled by supportive regulatory frameworks that offer incentives for green projects and penalize unsustainable practices.

This heightened public perception leads to strong demand and political will, resulting in comprehensive regulatory frameworks, high R&D investment, rapid technology deployment, and coordinated and effective global adaptation efforts. Several critical influence factors shape this scenario. The intensity of climate change, marked by severe increases in climate-related events, heightens public perception of the urgency of climate adaptation. Public awareness and behavioral changes lead to a surge in demand for immediate action, influencing behaviors such as increased use of renewable energy and support for green policies.

This demand accelerates investment and innovation in advanced technologies, including smart infrastructure and energy-efficient systems, as firms compete to provide effective solutions. Economic growth is spurred by investments in green technology, creating jobs and new market opportunities, which in turn provide more funding for further research and development. Governments respond with strong regulatory support, implementing strict environmental standards and incentives for sustainable practices, reinforcing the cycle of innovation and adaptation.

The effective response and technological leadership position Europe as a model, fostering international partnerships and setting standards in global climate policies. Finally, the robustness and resilience of supply chains support the rapid deployment of advanced technologies, especially in renewable energy and smart infrastructure sectors, ensuring the successful implementation of climate adaptation strategies.

Scenario Chain of Actions:



Which implications are recommended in this scenario?

For consulting engineers, the "High Alert" scenario implies a major shift in their role and responsibilities. They will need to rapidly scale their operations and expertise to meet the rising demand for climate adaptation solutions. Their work will increasingly integrate advanced technologies such as AI, IoT, and smart grids. Furthermore, the focus will expand from traditional design and construction to offering long-term sustainability consulting and management services, requiring continuous innovation and professional development to stay competitive.

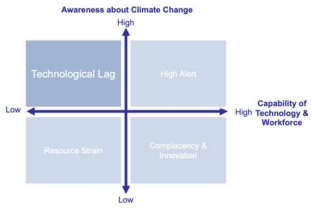
Scenario 2: Technological Lag

In this scenario, European populations are acutely aware of the dangers posed by climate change but face significant limitations due to technological shortfalls and insufficient human resource capabilities. The high level of concern translates into vocal demands for action; however, economic constraints and a lack of advanced technological solutions hamper effective response efforts. Governments find themselves in a precarious position, attempting to implement stringent climate policies without the necessary tools, leading to suboptimal and sometimes ineffective adaptation measures. Public unrest grows as citizens demand improvements that cannot be readily supplied. International relations are strained as Europe seeks aid and technology transfers from abroad, highlighting a dependency that could affect its sovereignty and economic stability. This scenario is fraught with challenges, where high awareness is paradoxically coupled with frustration and potential social discord due to the inability to act effectively against climate threats.

What major challenges can we expect?

Consulting engineering firms face the challenge of managing public expectations while working within the constraints of existing technologies. This demands a focus on optimizing and adapting available technologies to maximize their impact. For instance, firms might prioritize retrofitting buildings to improve energy efficiency using current materials and techniques that are immediately available but less advanced than desired. Economic constraints necessitate cautious investments, which must be directed wisely. Consulting engineers play a crucial advisory role, helping clients navigate the complexities of implementing effective climate adaptation strategies with limited technological options. They advocate for realistic project timelines and phased implementations that can accommodate future technological advancements as they become available. The industry also pushes for policies that support gradual and improvements in infrastructure, ensuring readiness for integration of new technologies when they emerge. In this environment, the ability to innovate within limitations becomes a key competitive advantage.

Reports of escalating climate impacts raise public awareness and concern, yet despite this high awareness, technological limitations frustrate public expectations and increase pressure on political and business leaders.

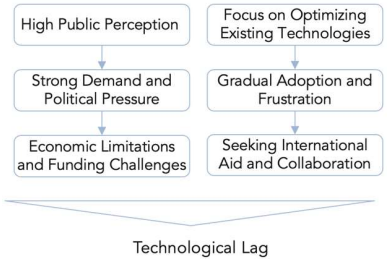


Which implications are recommended in this scenario?

The implications for the engineering consultancy industry are profound. Consulting engineers face significant challenges due to limited resources and outdated technologies, highlighting a pressing need for innovative, low-cost solutions. The vulnerability of existing infrastructure necessitates frequent repairs and retrofits, demanding a high level of ingenuity and adaptability from engineering firms. Furthermore, engineers must take on a proactive role in policy and advocacy, pushing for greater investment in research and development and fostering stronger international cooperation to address these formidable challenges effectively.



Scenario Chain of Actions:



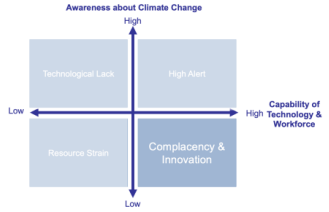
Scenario 3: Complacency and Innovation

Complacency and Innovation, Europe, despite possessing advanced technological solutions and a wealth of skilled human resources, suffers from a lack of public interest and awareness regarding climate change. This complacency results in a paradox where technological capabilities are underutilized. Economic stability facilitates investments in cutting-edge technologies, yet public disengagement means there is little pressure on governments to enforce existing climate regulations vigorously. As a result, much of the technological potential is left untapped, and the implementation of effective adaptation strategies is sluggish. International cooperation remains routine without any significant drive for enhancement. The gap between what could be achieved with available technologies and what is being done due to public indifference poses a significant risk, potentially leading to a reactive rather than proactive approach to climate adaptation.

Consulting engineering firms possess the tools needed for substantial advancements in climate adaptation but must overcome public indifference to implement these technologies effectively. The industry finds itself in a critical position of needing to drive not just technological adoption but also engagement and education about the urgency of climate issues. Firms invest in outreach and public education campaigns, showcasing successful projects and the tangible benefits of advanced technologies in community settings. They also lobby for stronger policies that require the implementation of sustainable technologies, ensuring that advancements in engineering do not sit idle. Internally, firms focus on creating adaptable designs that can be easily updated as public opinion and regulatory environments evolve. This scenario presents a unique challenge: the necessity for consulting engineers to lead not only in technical matters but also in shaping public opinion and policy to fully leverage their advanced capabilities.

Despite increasing climate variability and impacts, public awareness remains low, limiting the sense of urgency among the populace. Low public engagement results in minimal demand for utilizing available advanced technologies, slowing the adoption of innovative solutions. The presence of advanced technologies contrasts sharply with their underutilization, creating a gap between potential capabilities and actual implementation. Economic stability supports investments in technology, but without strong public or political will, these investments do not fully translate into climate adaptation actions. Policymakers implement regulations incentivizing technological adoption, but without public pressure, the enforcement and ambition of these policies may be limited. Europe maintains steady but uninspired international cooperation, sharing technology passively rather than proactively pushing for global climate resilience initiatives. The role of media in shaping public perception and awareness of climate change and the necessity for adaptation measures is crucial.

Corporate Social Responsibility (CSR) initiatives also play a role, as the extent to which large corporations adopt and promote sustainable practices can potentially lead the way in technology usage despite public complacency.

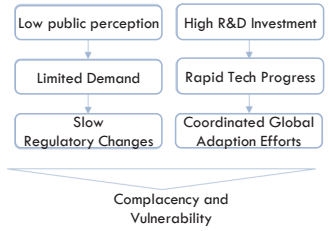


Which implications are recommended in this scenario?

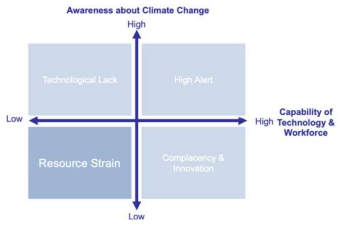
Consulting engineers must demand expertise to optimize and maintain resilient systems, driving policy and technological adoption. Existing infrastructure requires updates to incorporate underutilized advanced technologies. There is a need for strong advocacy to ensure robust regulations and policies that support technology adoption. The industry focuses on enhancing sustainability and efficiency, playing a crucial role in leading public opinion and policy changes. Moreover, engineers must innovate within limitations, fostering increased competition and collaboration to tackle large-scale issues effectively.



Scenario Chain of Actions:



Scenario 4: Resource Strain



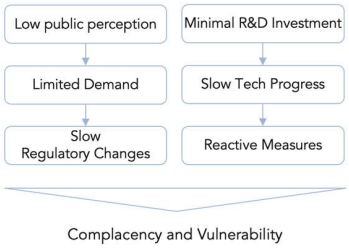
The "Resource Strain" scenario depicts a Europe grappling with both low public awareness of climate change and a lack of technological and human resources. Economic instability exacerbates the situation, leading to decreased investments in necessary climate adaptation projects. Governments struggle to enforce even minimal regulatory frameworks, and public incentives for adopting sustainable practices are scarce. The general populace remains largely uninformed about the climate crisis, resulting in no significant change in behavior or demand for innovation. This lack of awareness and resources results in minimal international cooperation, as countries focus inwardly, trying to manage their limited resources. Severe consequences include increased vulnerability to extreme weather events, significant economic downturns, and social instability, as Europe finds itself ill-equipped to handle the escalating impacts of climate change.

Consulting engineering firms operate in a highly constrained environment where the need for affordable, effective climate adaptation solutions is urgent but difficult to address due to technological and resource limitations. The industry focuses on developing and deploying low-cost, resource-efficient technologies that can be implemented quickly and without extensive infrastructure overhaul. Consulting engineers become vital in crisis management, developing strategies to ensure that the most critical infrastructure can withstand climatic events with minimal resources. They pioneer the use of alternative materials and simpler technologies that maintain functionality while being accessible and manageable within economic constraints. The firms advocate for increased funding and international aid to bolster technological capabilities, emphasizing the necessity of immediate and practical solutions in a resource-strained setting. This scenario demands a high level of innovation and flexibility from the industry, prioritizing resilience and adaptability in the face of severe challenges.

Public perception remains low, resulting in limited demand for climate action, slow regulatory changes, minimal investment in research and development, and slow technological progress, leading to reactive rather than proactive adaptation measures. The increased frequency and severity of climate events go largely unnoticed or underestimated by the public, exacerbating the risk. Lack of awareness leads to inadequate behavioral changes, leaving populations more vulnerable to climate impacts.. Significant technological and resource limitations restrict the development and deployment of effective adaptation strategies.

Economic hardships further reduce available funding for climate adaptation, leading to the prioritization of immediate, short-term survival needs over long-term resilience strategies. Weak or poorly enforced regulatory frameworks fail to drive significant improvements in sustainability or adaptation, compounding the challenges. Strained resources limit the ability and incentive for international cooperation, as countries focus inwardly on their immediate issues, reducing collaborative efforts and shared solutions. The level and effectiveness of international aid play a crucial role in providing the necessary resources for climate adaptation in the face of technological and awareness shortfalls

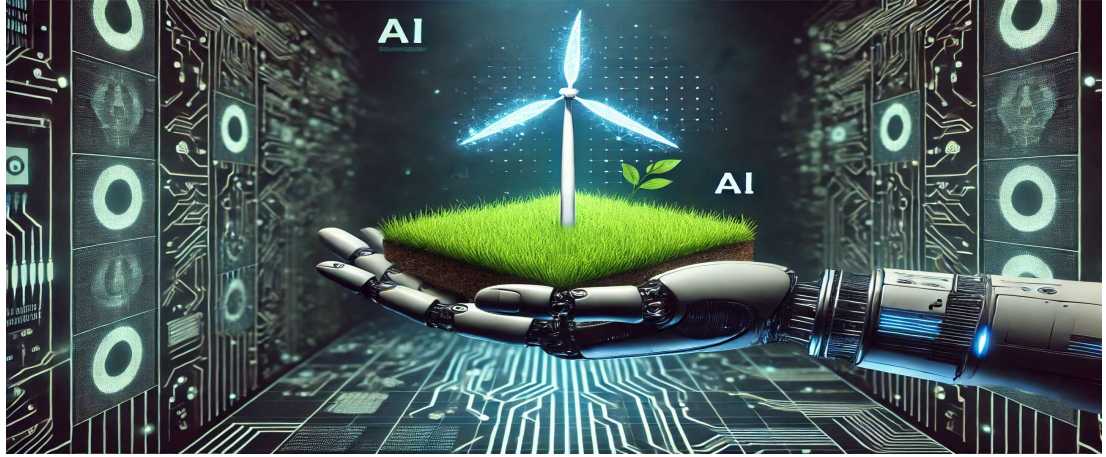
Scenario Chain of Actions:





Which implications are recommended in this scenario?

Consulting engineers face significant challenges due to low demand and limited resources, taking on a critical advisory role in crisis management. Existing infrastructure is vulnerable, requiring low-cost retrofits and frequent repairs to maintain functionality. Policy and advocacy efforts are essential, as engineers push for the implementation of crucial regulations and greater investment in research and development. The industry must manage public expectations by utilizing low-cost, resource-efficient technologies and focusing on retrofitting existing systems for resilience. Despite limited projects, competition drives innovation within these constraints, leading to increased collaboration among firms.



Strategic Measures for High Climate Change Awareness and High Technological and Human Resource Availability
-Scenario High Alert-

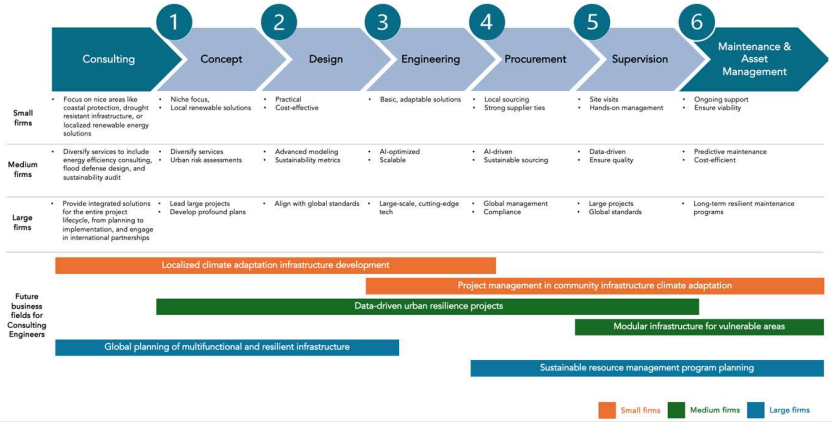
In this scenario, Europe experiences a strong demand for climate action, driven by increased public awareness. This leads to significant investments in new technologies. Consulting engineers are vital in helping Europe adapt to the challenges of climate change by providing practical, lasting solutions.

Small consulting engineering firms should focus on niche areas like coastal protection, drought-resistant infrastructure, or localized renewable energy solutions. These firms excel in specialized fields, offering deep expertise that sets them apart in the market. By concentrating on targeted areas of climate adaptation, they can provide critical, tailored services. Additionally, forming alliances with larger firms or other specialists can enable them to expand their offerings without losing their focus.

Medium-sized firms, with broader capabilities, should diversify their services. This might include energy efficiency consulting, flood defense design, and sustainability audits. Such diversification allows these firms to serve a wide range of clients, from local governments to mid-sized companies, all of whom need robust climate adaptation strategies. Investing in technologies like AI and infrastructure monitoring can further enhance their competitiveness, providing advanced solutions that address the complex challenges of climate change.

Large consulting engineering firms should provide integrated solutions that cover the entire project lifecycle, from planning to implementation. These firms can manage large, complex projects that require significant resources and expertise. Engaging in international partnerships allows them to share best practices and lead in global climate adaptation efforts. This not only strengthens their position but also ensures their projects benefit from the latest innovations and global insights.

Across all firm sizes, developing AI-driven climate risk management tools is crucial. Small firms can create tailored AI solutions to assess local risks and recommend specific adaptation measures, offering clients valuable, actionable insights. Medium-sized firms should integrate AI into their broader services, helping clients prioritize investments by modeling the impact of different climate scenarios. Large firms should focus on comprehensive AI platforms that provide real-time risk assessments and adaptive planning for large-scale projects, ensuring they remain at the cutting edge of technology.





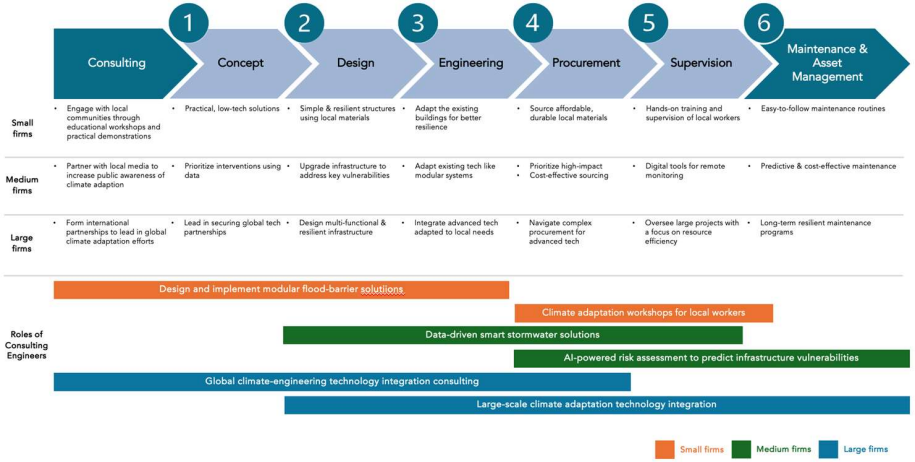
Strategic Measures for High Climate Change Awareness and Low Technological and Human Resource Availability
-Scenario Technological Lag-

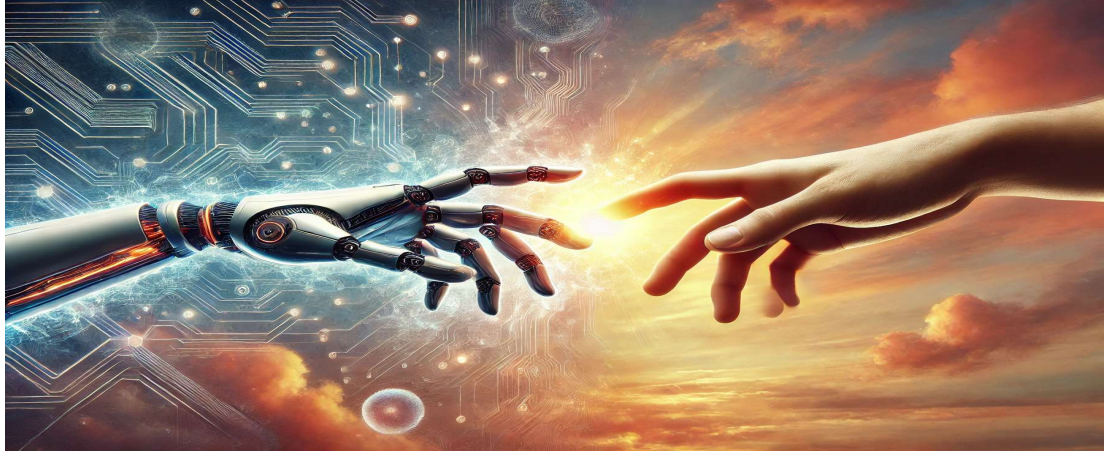
In this scenario, Europe faces serious climate risks, but old technology and not enough skilled workers make it hard to respond effectively. Even though people strongly demand action, economic limits and few resources result in weak adaptation efforts and growing frustration.

For small consulting engineering firms, the focus should be on providing simple and low-cost solutions that can be implemented quickly. These firms can design local flood barriers or improve drainage systems by using readily available materials. Additionally the small firms should work on training local workers in climate adaptation techniques. They also have to help building the skills needed to maintain and manage these measures over time.

Medium-sized firms, on the other hand, should leverage data and technology to make the best use of the resources available. By analyzing local climate risks, these firms can design infrastructure that is specifically tailored to handle threats like flooding or drought. They can also assist governments in creating practical policies that prioritize the most critical and affordable adaptation measures. Moreover, medium firms can use AI tools to predict which parts of the infrastructure are most at risk, ensuring that resources are directed where they are needed most.

Large consulting engineering firms are in a position to lead efforts to bring in advanced climate adaptation technologies from other countries. They can work closely with governments to secure the necessary technology for large-scale adaptation projects. These firms should also focus on developing comprehensive plans that combine engineering with economic and social strategies to build resilience. Additionally, large firms should prioritize retrofitting existing infrastructure, such as energy systems and flood defenses, to make them more resilient to the impacts of climate change.





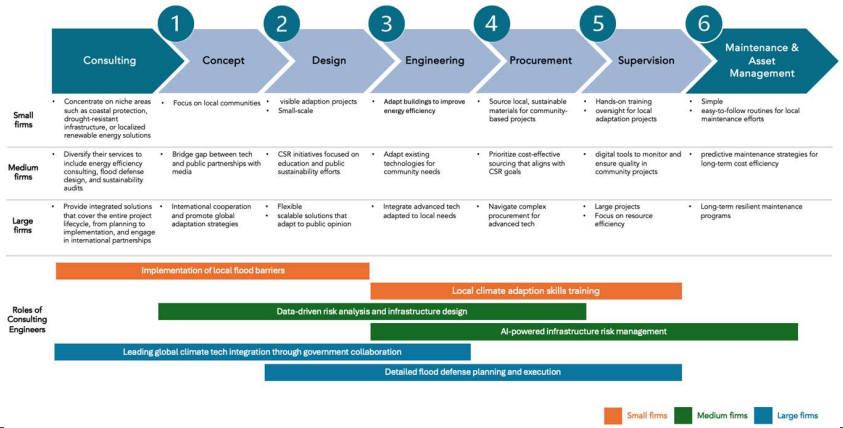
Strategic Measures for Low Climate Change Awareness and High Technological and Human Resource Availability
- Scenario Complacency and Innovation-

In this scenario, where there is low climate change awareness but high technological and human resource availability, consulting engineers are essential.

Small consulting engineering firms should focus on engaging with local communities through education and practical demonstration projects. They can hold workshops and community events to show how climate adaptation solutions can be implemented. They can install rainwater harvesting systems or upgrade buildings for better energy efficiency. These visible and practical steps directly benefit the community and help illustrate the importance of climate adaptation. Medium-sized firms should work to bridge the gap between advanced technology and public understanding. The strategy is to partner with local media to create content that raises awareness about climate adaptation. By simplifying complex technologies into easy-to-understand messages, medium firms can help the public see how these innovations can improve their lives and communities. Additionally, medium firms should develop Corporate Social Responsibility initiatives that educate the public on the benefits of sustainable practices. For example, they could sponsor community based adaptation projects or participate in local sustainability events. They should also advocate for stronger enforcement of climate regulations, working with policymakers to highlight the economic and social benefits of taking action now.

Large consulting engineering firms are in a position to lead global and regional climate adaptation initiatives. They should focus on promoting international cooperation by forming partnerships with other global companies to share best practices and technologies.

These partnerships can help ensure that advanced technologies are applied where they are most needed, even in regions with less public or political support for climate adaptation. Large firms should also design flexible engineering solutions that can evolve as public opinion and regulatory environments change. This might involve creating modular infrastructure projects that can be scaled up or down depending on future needs. Large firms should invest in public awareness campaigns that emphasize the importance of climate adaptation. By using successful projects as case studies, these campaigns can demonstrate the tangible benefits of advanced technologies and help shift public opinion towards greater support for climate action.





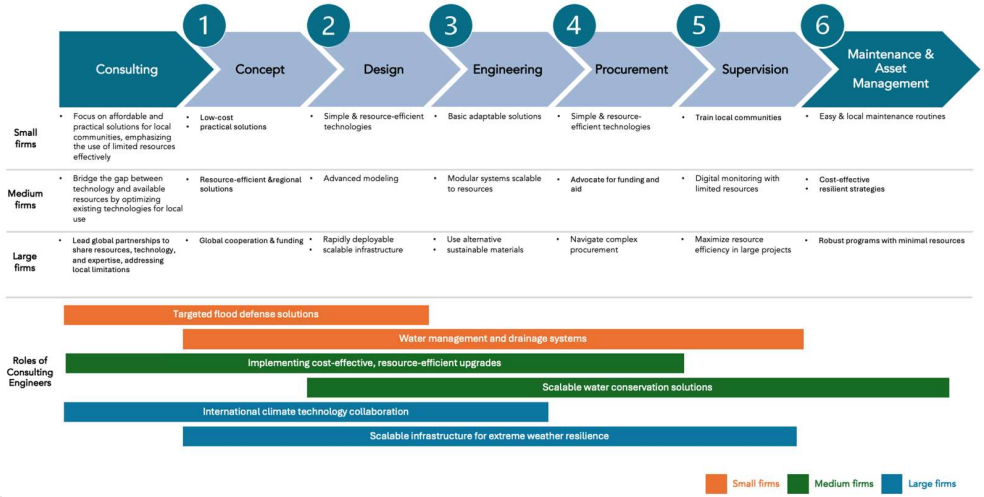
Strategic Measures for Low Climate Change Awareness and Low Technological and Human Resource Availability -Scenario Resource Strain-

In this scenario, Europe faces low public awareness of climate change, combined with a shortage of technology and resources, making consulting engineers crucial for developing effective climate adaptation strategies.

Small consulting engineering firms should focus on affordable and practical solutions. They can develop simple technologies that are easy to use with limited resources. Examples include basic flood defenses, better water management systems, or energy-efficient upgrades to buildings. They should also promote the use of local, low-cost materials to reduce reliance on global supply chains. Offering services that help communities prepare for and respond to immediate climate threats is crucial in this scenario.

Medium sized firms should aim to bridge the gap between technology and available resources. They can help communities make the most of existing technologies to stretch limited resources. This might involve improving energy efficiency or water conservation in ways that are tailored to local needs. They can also adapt current technologies to work better in resource-limited environments, such as creating modular systems that can expand as resources grow. Additionally, they should advocate for more funding and international aid to support critical climate adaptation projects.

Large firms need to lead efforts to build global partnerships. By sharing resources, technologies, and expertise, they can help overcome local resource limitations. Large firms should focus on designing scalable solutions that are resource-efficient and can be implemented quickly. These solutions should be adaptable to different levels of resource availability. Investing in infrastructure that can withstand extreme weather with minimal maintenance is also essential. This ensures long-term resilience even in a strained environment.





Reflection on the Differences between ChatGPT Input and Expert Input

When comparing the advice from ChatGPT to that of experts, several clear differences emerge, particularly in how the information is applied and how effective it is in practice.

First, ChatGPT provides a broad range of suggestions, often covering multiple possibilities. This can be helpful because it gives a wide array of options to consider. However, this broad approach can sometimes be a drawback. GPT often lacks the specific details needed to implement these ideas effectively. For example, it might suggest using several different technologies or strategies but might not specify which ones are the most practical or feasible for your particular situation. This can make it challenging to decide which path to follow.

In contrast, experts bring years of practical experience to their advice. They can provide options and give specific guidance. An expert might recommend a particular energy-saving technology that has been tried and tested in similar situations. That means, their advice is based on what has worked before, making it more likely to be successful. Experts can also prioritize actions based on what resources are available, ensuring that the advice is not only relevant but also practical.

Based on that planning might be handled very differently by ChatGPT and experts. While ChatGPT can generate a variety of plans, it doesn't always know which steps are the most important. This can lead to plans that are less focused and might miss the mark in terms of what's most needed. ChatGPT's recommendations are based on patterns in the data it has been trained on, so it might suggest advanced technologies without considering whether they are available or affordable in your area. Experts, on the other hand, understand these local challenges. They can offer advice that considers factors like local regulations, available resources, and potential partnerships, making their guidance more tailored and realistic.

So it is clear to see that ChatGPT's main limitation is its difficulty in prioritizing information. While it can suggest a wide range of options, it doesn't always have the ability to determine which ones are the best fit for a specific situation. This can result in a lot of ideas, but no clear direction on which to pursue. Experts, by contrast, are skilled at quickly identifying the key steps that need to be taken. This is especially important when resources are limited and every decision carries weight. Their ability to prioritize can make the difference between a successful project and one that falters.

Lastly, while ChatGPT might not have the same level of specialization as an expert, it does have its advantages. ChatGPT can access a vast amount of information quickly and provide a broad perspective on a problem. It's also significantly cheaper to use than hiring a human expert, and it offers more flexibility in terms of when and where it can be used. This makes it a valuable tool, especially for situations where cost and access are major concerns.

In summary, ChatGPT is excellent at generating a lot of ideas and offering a wide range of options. However, it often struggles with making those ideas practical for specific situations. Experts, on the other hand, provide more focused advice that is better suited to the unique challenges and opportunities of each situation. While ChatGPT can be a useful tool, the targeted, experience-based guidance of experts remains crucial for effective decision-making.



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