

# **How Can Generative AI Lead the Building, Construction and Real Estate Industry Toward a More Sustainable Future?**

An Investigation with ChatGPT

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**Can generative artificial intelligence (GenAI) help overcome the building industry's hurdles to digitization and sustainability? We have conducted some hands-on experiments and share the practical learnings we have gained from using AI technology, and our insights into how it can help achieve sustainability goals. With our explorations and insights, we aim to motivate others to embark on a GenAI journey and leverage their contributions to the industry and possibly to a more sustainable future.**

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# Introduction

One of the biggest challenges of our time is sustainable development: promoting economic and social development without depleting the planet's resources and endangering the quality of life. The building, construction and real estate industry, with its mission to provide comfortable and sustainable housing and infrastructure for all, is shaping this sustainable future. In addition, it has a significant share in carbon emissions, the production of waste, the use of natural resources and other impacts on the environment.

The industry's journey toward sustainability is underpinned by three key objectives: decarbonization, the creation of a circular economy, and energy efficiency. While the industry is making progress on energy efficiency, it has a lot of catching up to do on the other two objectives. The goals are clear, but the actionable strategies are less so.

Recently, generative AI (GenAI) has been making waves as a transformative tool, offering breakthrough solutions that challenge traditional processes. Its integration is gaining momentum in various industries. In the construction industry in particular, its potential to revolutionize the current state of the art seems immense.

Given this emerging prominence, a pertinent question arises: In what capacities, and to what extent, can GenAI be harnessed to navigate the building, construction, and real estate industry toward improved sustainability trajectories? The intersection of advanced artificial intelligence with traditional industry practices offers a compelling avenue for exploration, potentially fostering novel methodologies and reshaping industry standards.

*« In what capacities, and to what extent, can GenAI be harnessed to navigate the building, construction, and real estate industry toward improved sustainability trajectories? »*

# The Challenges of the Industry

The building, construction, and real estate industry is lagging behind in the adoption of emerging digital technologies despite tangible advances in the technological landscape. While progress has been made in recent years, as evidenced by the integration of Building Information Modeling (BIM), Digital Building Twins, and other relevant digital technologies, the industry faces a widening technology adoption gap. This widening gap can be attributed to resistance from various stakeholders and the many challenges associated with evolving design, construction, and operations processes to accommodate new technology paradigms.

While some players have embraced the digital age and set out to take advantage of the new opportunities, many are still hesitant to embark on the digital transformation journey. This challenge is compounded by the complex and fragmented nature of the industry. Composed of a few dominant players and a plethora of small businesses, the industry operates through an interconnected network of disparate processes and systems along the entire value chain, encompassing the production of the building materials, construction, and maintenance of buildings and assets.

To achieve net zero and create a circular economy, we must use fewer natural resources and become more efficient. Digitizing the necessary processes and maximizing the use of technology are key elements in achieving this goal. However, we will only be successful if the data from all systems involved are interoperable. In short, a highly digitalized and interoperable industry is an integral part of our quest for sustainable development. And this is the challenge we are tackling with the help of GenAI.

*« Digitization is critical to achieving net zero. As the complexity and fragmentation of the construction industry are hampering its efforts toward digitalization, generative AI has the potential to overcome these challenges. »*

# Our Setup to Test ChatGPT

In the context of our setup, ChatGPT was used as a representative example of generative artificial intelligence. The release of OpenAI's ChatGPT, a user-accessible interface for the GPT 3.5 Large Language Model (LLM), in November 2022 demonstrated the capabilities of generative AI to a wider audience. This release catalyzed an expanded awareness of the potential of generative AI by demonstrating its ability to generate a wide range of outputs, from textual content and functional code to the synthesis of realistic images, product demonstrations, and videos.

Fueled by the remarkable and rapid advancements in generative AI, we believe it is the time to explore how GenAI can lead the industry to a more sustainable future and share our findings. Coming from diverse backgrounds – AI technology, smart building development, data management, enterprise architecture, and real estate and infrastructure management – we discussed the potential of AI to overcome the industry's hurdles.

## Goals

Our collaboration had the following objectives:

- A. On the **application side**, we aimed to find out the most effective approach to using this AI tool to get quality responses; and
- B. on the **content side**, we wanted GPT-4 to generate valuable suggestions on how to become more sustainable, how to get to net zero, and on how generative AI can further assist our industry get there.

We argue that generative AI has the potential to accelerate the digitization of this industry, helping to address overarching challenges such as sustainable development at strategic, tactical and operational levels.

Strategically, this refers to the alignment of digitization initiatives with overarching organizational goals and industry trends. Tactically, it involves using GenAI to design and implement specific initiatives that bridge strategic goals and operational tasks. Operationally, it involves using GenAI to enhance day-to-day processes and tasks, thereby improving efficiency and effectiveness at the ground level.

## Workshop sessions

To substantiate our view, we began practical explorations with ChatGPT with a series of online workshops that took place between April and July 2023:

- **Session 1 – Getting further with GenAI:** In the first session, we wanted to understand how to phrase the prompts to get the best results. The description of this process can be found in the next chapter. At the same time, we used ChatGPT to make recommendations on how to achieve net zero and to suggest the potential contribution of generative AI.

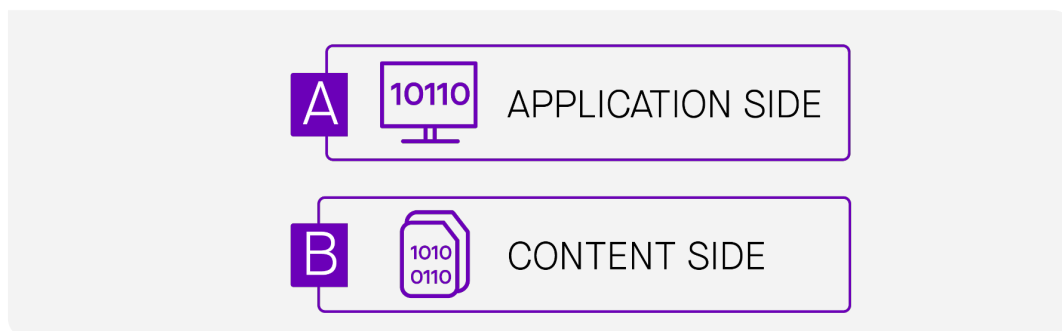
Check out the following link for a glimpse into the prompting process of this iteration to get ChatGPT’s suggestions toward a more sustainable future:

[ChatGPT: Generative AI in Construction](#)

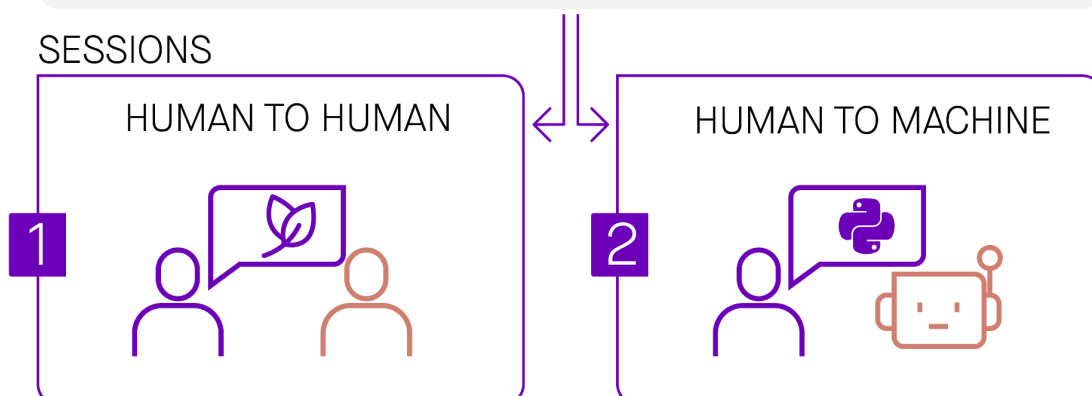
- **Session 2 – Generating machine-readable outcome:** To achieve interoperability, we need results that machines can read. In session 2, we used GPT-4 to explore its ability to produce machine-readable results, facilitating the transition between natural and machine-readable language.

Here is our prompting process using chain-of-thought and tree-of-thought techniques: [ChatGPT: Architectural Data Script - AI](#)

## OBJECTIVES



## SESSIONS



# We Asked ChatGPT How to Achieve Sustainability

We initiated our AI exploration with a series of broad, open-ended questions presented through voice recordings (Figure A). However, it quickly became evident that this approach required refinement. We received an output that provided initial insights on varied topics, approaches, and concrete support suggestions, which were rather general (Figure B).

We then adopted a more structured strategy, proposing chapter outlines, specifying aspects to be included, refining our questions, and providing more contextual detail. (Figure C). This revised approach significantly improved the quality of the responses. We continued this process by asking follow-up questions (Figure D) to elicit more specific, relevant aspects of the topic. We also experimented with rephrasing the prompts to compare the diversity of the responses.

During this process, ChatGPT's responses improved significantly: The value proposition of the total output was fascinating. In our understanding, it would take a professional with at least a few years of experience in the field and decent knowledge transfer skills to come up with such thoughtful suggestions.

Our exploration continued with a more in-depth examination of the role of humans and machines, the interaction between the two, an assessment of the costs and potential financial benefits of GenAI, and the request for a roadmap to achieve the sustainability goal of net zero.

*« It would take a professional with at least a few years of experience in the field and decent knowledge transfer skills to come up with such thoughtful suggestions. »*



## The Outcome of Session 1

# ChatGPT's Suggestions for the Future of Construction

ChatGPT emphasizes the need for the industry to adopt innovative economic models that integrate not only economic considerations but also social and environmental factors. To address the challenge of data complexity, a two-tiered approach is proposed. The first layer contains as a base all necessary information collected or stored by relevant software systems used throughout the design, construction, and operation of a building, while the second layer filters, processes, and presents information from the base layer in a simplified and actionable format tailored to the needs of a specific role, such as building energy optimization.

To ensure the right level of simplicity in the provision of information between the two layers, ChatGPT suggests encouraging open communication and collaboration between the various roles involved and the software system vendors, prioritizing user-centered design principles when creating interfaces and visualizations for layer 2, ensuring that the systems facilitating the transfer of information are adaptive and flexible.

The role of simulation is emphasized as a key tool for design alternatives, optimization, risk mitigation, and overall process improvement, and a comprehensive building lifecycle data model is promoted because of its potential to provide insight for decision-making.

To implement data-driven decisions, deliverables and target monitoring, ChatGPT recommends replacing traditional document-based performance indicators with measurable, and time-bound data-based objectives, establishing open data standards and formats, investing in a comprehensive data management system, and incorporating data-driven deliverables into contracts.

It also emphasizes that GenAI can play a significant role in helping the industry to improve sustainability, efficiency, and overall project success collaborating with stakeholders to implement the above suggestions.

## ChatGPT's proposals for a more sustainable building process

- **Economic Models:** Emphasize innovative economic models that integrate social, environmental, and economic factors.
- **Information Balance:** Adopt a two-layered approach for filtering complex data into actionable insights. Layer 1 is a repository of all necessary information, while Layer 2 focuses on specific use cases like facility services.
- **Human-Machine Interaction:** Create tools that facilitate seamless collaboration between humans and machines.
- **Holistic Approach:** Consider the interplay between people, processes, systems, and Life Cycle Data Management (LCDM).
- **Simulation:** Use simulations for design optimization, risk reduction, and process improvement.
- **Interoperability:** Prioritize system compatibility and continuous optimization in project operations with open data standards.
- **Data Models:** Use comprehensive building lifecycle data models for better decision-making and resource allocation.
- **Adaptability:** Prepare for emerging technologies and trends.

## The Chronology of Session 2

# We asked ChatGPT to Generate Code

If generative AI can lead the real estate and building industry to an interoperable BIM, this journey will take place in stages, each operating at different levels of communication: at the human-to-human level assemble the various industry players, at the human-to-machine level whenever a human interacts with generative AI, and then at the machine-to-machine level, which is our ultimate goal. In the future, as we envision it, data should be able to interact and communicate seamlessly across most processes and systems.

This conviction led us to engage in a subsequent work session in which we used GPT-4 to explore its ability to produce machine-readable results. We aimed to identify a practical scenario in which generative AI could facilitate the transition between natural and machine-readable language.

### **Asking ChatGPT to write a Python script**

Again, we started with a simple natural language prompt, asking ChatGPT to write a code to read data from IFC files with a given data processing system and considering that we would deploy it on a specified data analytics platform (Figure E). Specifically, we wanted a Python script to read data from binary IFC files with external library IfcOpenShell, structure and store it with Spark within Azure Data Lake Storage. For subsequent evaluation according to the Swiss standards SIA416 we wanted to use Azure Databricks Data Lab Service and provide API Endpoint for external analytics like PowerBi dashboards etc. The AI generated code, but the lack of consistency and quality in the output caused us to rethink our approach. We decided to provide more context within the prompt to improve the quality, focusing on factors such as the persona requesting the code, the data sources, the expected output, and required business specifications.

### **Deconstruct complexity with chain-of-thought and tree-of-thought prompting**

One of our IT experts suggested using chain-of-thought and tree-of-thought prompting techniques. These approaches would facilitate breaking down complex problems into manageable steps, which is crucial to achieving effective solutions through AI.

Chain-of-thought prompting breaks down complex problems into simpler, intermediate steps, enhancing the cognitive capabilities of an AI model and increasing the accuracy of the result. It recognizes that inherently complex programming can be broken down into manageable components (Figure F).

Conversely, the tree-of-thought approach acknowledges that thoughts do not follow a strictly linear progression. Instead, they branch out, like a tree, from an original idea or root into various related but distinct concepts. The technique mirrors this cognitive process, including stages of brainstorming, evaluation, expansion, and decision-making stages. Following this model, the AI generates multiple solutions, evaluates them, refines the proposals, and selects the most effective solution (Figure G).

Based on these techniques, we created a new initial prompt. Rather than immediately aiming for the final output, our initial natural language prompt aimed to generate a JavaScript Object Notation (JSON) model output, an easily readable code, to be used as our tree-of-thought prompt, which explores multiple solution paths and guides us to the desired outcome in the Python programming language (Figure H). We also asked ChatGPT to provide steps or suggestions for improvement regarding the flexibility, robustness, and cleanliness of our JSON model. In addition, the iterations were further scrutinized for validation purposes (Figure I).

*« Rather than immediately aiming for the final output, our starting natural language prompt aimed to generate a JavaScript Object Notation (JSON) model output, an easily readable code, to be used as our tree-of-thought prompt, which explores multiple solution paths and guides us to the desired outcome in the Python programming language. »*

## The Outcome of Session 2

# The Process of Result Validation

A current challenge with AI is the diversity of responses generated from identical prompts. To improve the resulting quality, we further refined the context. We provided ChatGPT with an example of the desired JSON model, including any specific standards we needed to adhere to within the prompt.

Through this process over several rounds of iteration, with built-in and ongoing validation and selection of the most appropriate result, we aimed to refine our result to an optimal level. Ultimately, we expected to arrive at a highly valued answer or response. However, to ensure code quality, programming unit testing remains essential. Before deploying a solution, we would need to build a test environment to validate our results, effectively confirming the soundness of our validation process.

Looking back at the beginning of this session, we started with a simple natural language prompt to create this Python code. A few hours later, we find ourselves with a sophisticated chain-of-thought and tree-of-thought model that utilizes this reasoning process to generate a clear and robust response. By handing over the responsibility of output reflection to the machine, we can make the process more accessible and efficient. This is an achievement we find truly remarkable.

### **Necessary steps from the business request to the final script**

1. Identification of Human Request / Business Need
2. Transformation of the identified human request or business need into an initial data model
3. Refinement of the data model by examination and potential integration of prebuilt models or code snippets
4. Implementation of reasoning methodologies
5. Generation of the final script
6. Rigorous testing of the script to confirm its functionality and accuracy, ensuring it's ready for deployment

## Practical Recommendations

# How to Work with ChatGPT

Precise and correct prompting and comprehensive contextualization are fundamental to the effective use of language based GenAI. The time spent refining these aspects can significantly improve the quality of the GenAI's output.

To derive high quality answers, a thorough, in-depth investigation is essential. Digging deeper will lead to better results and allow for a transition from a strategic perspective to an operational level and, if necessary, down to hard numbers. A superficial or unsophisticated investigation is doomed to fail and won't produce a concrete list of actions, which could compromise team leadership. If this inhibits execution, nothing will happen.

Our machine-oriented work session made an important discovery: the machine could generate code autonomously, complete with reasoning and validation processes. However, human intervention remains critical at various stages, including setup, operation, and validation. The presence of responsible humans is still a necessity.

In summary, while effective use requires a learning curve, our exploration of generative AI tools has demonstrated their potential for scalability and high quality output.

*« While effective use of ChatGPT requires a learning curve, our exploration of generative AI tools has revealed their potential for scalability and delivering high-quality outputs. »*

## Our key learnings when working with ChatGPT

- **Active Engagement:** Maximizing the potential of AI tools requires active involvement and practice. Follow our example and share your insights and learnings within your Community!
- **Structuring:** Organizing prompts and requesting specific response structures improve the comprehensibility of AI-generated outputs.
- **Contextualisation:** Providing clear context significantly improves the quality of an AI output. Comprehensive information regarding writing perspective, target audience, and desired outcomes leads to better results. Employing templates from the target environment can effectively guide the creation of prompts for machine-readable outputs and the outcome of all kinds of requests.
- **Clarity and Specificity:** Being explicit and precise in prompts enhances the AI's response quality. Clear and specific instructions yield more accurate and relevant outputs.
- **Follow-up and Validation:** Reprompting and evaluating the AI's answers contribute to its learning process. Validating at each step, including the initial prompt, ensures output quality.
- **Prompting Techniques:** Employing approaches like the chain-of-thought and tree-of-thought methods can help solve complex problems. By comparing different versions of answers, the best one can be selected and used as a starting point for subsequent prompts.
- **Establishing a Validation Benchmark:** When posing machine-to-machine questions, it is essential to have a validation benchmark and an iterative process for optimisation.

## Discussion on the Quality of the Answers

# How Can AI Take Us Further?

Our exploratory sessions working with ChatGPT have exceeded our expectations. The machine provided strategic considerations and suggestions. It generated insights into the future of economic models, the opportunities for the industry to address its biggest challenges, and the value added in innovation.

On a tactical level, ChatGPT provided valuable suggestions for improving digital capabilities, automation, development and implementation, and achieving interoperability. In follow-up prompts, it provided practical step-by-step roadmaps, such as optimizing the interaction of people, processes, systems and lifecycle data management to achieve efficient and sustainable building projects.

It also explained how AI could support each step, quantified the added value and used examples to illustrate its points. However, it also identified limitations in tasks typically performed by project managers. For example, translating a step-by-step plan into a realistic timeline proved too challenging.

### **A tool to make data-driven decisions**

Given the complexity and difficulty of overseeing the entire building industry, the vision is that AI can help the industry because it spans all areas and disciplines and has access to vast knowledge that it can connect.

One strategic challenge, for example, is the value proposition of investing in digitization. Through our work with ChatGPT, we have seen its potential to articulate and quantify this value proposition. Managers are faced with the critical question: What is the justification for this technology investment? Consider the example of Building Information Modeling; while its abstract value proposition is widely acknowledged, quantifying that value in tangible, measurable terms is a formidable challenge. The benefits of digitization, which include aspects such as improved efficiency, increased accuracy, and financial savings, are often difficult to correlate, concretize, and integrate into a comprehensive value narrative.

From our perspective, generative AI has the ability to connect these elements. It can analyze the individual benefits of a digital investment and integrate those. AI even quantifies the immediate and future value of digitization, while justifying the investment.



## **A tool to facilitate interoperability beyond standards**

Interoperability is at the heart of building projects. Integrating disparate systems and disciplines is a must to increase efficiency and sustainability.

Talking about interoperability inevitably leads to a discussion of standards. The industry is full of standards. As important as they are, due to the dynamic nature of the processes, practices and technologies they encapsulate, standardization often results in rules that need to be updated once finalized.

The strength of GenAI lies in its access to multiple standards and its ability to differentiate and transition between them. With generative AI technologies, humans no longer need to master every standard. Instead, users can query AI for optimal processes. This doesn't diminish the importance of standards, but it does require a re-evaluation of the role and methodology of standardization, and calls for more dynamic and open standards.

Perhaps at some point, we can envision a phase-out of traditional standards as AI's understanding of construction deepens. But for now, without standardization, AI would lack a fundamental basis for understanding and application. Documented standards, full with illustrative examples, are integral to AI's learning and interpretation. The focus should therefore be on evolving standardization to capitalize on AI's strengths and facilitate its learning and application.

## **The crucial role of openBIM**

In this context, the role of openBIM becomes critical. It promotes transparent standards and seamless interoperability. With AI's ability to analyze multi-faceted BIM data, we see opportunities for enhanced data integrity and predictive analytics. Hence, we shall thoroughly investigate and research to maximize GenAI's potential in openBIM.

Python offered a flexible coding environment to craft customized solutions and facilitate smooth integration with pre-existing systems. This confluence of AI, openBIM, and modern programming languages is not accidental. It plays a pivotal role in the contemporary shift toward adopting DevOps methodologies – software engineering that aims to integrate development and operations by fostering a collaborative and shared responsibility culture – within the real estate and construction industry.

Moreover, the open standards of BIM provide a transparent and universally interpretable canvas for deploying AI models, ensuring the pivotal machine-to-machine interactions required for automated decision-making and workflow optimization.

## Conclusion & Outlook

# A Call to the Industry: Go for it!

In an era of increasing complexity and the need for multi-disciplinary systems, it is essential to manage the constant addition of tools, regulations, materials, processes, and data. The industry must find ways to present data that is both simple and contextualized so that all stakeholders can easily understand it.

The industry ecosystem needs to prepare in not just working with data but also delivering structured or unstructured data to maximize the potential of AI. This will require significant evolution and transformation of current procurement and compensation practices. Ownership of data and ethical use of data with transparency are pivotal to the success in adoption of integration of AI in our industry. The upcoming EU AI Act, the first regulation on artificial intelligence, should be carefully evaluated and integrated in further discussions and deliberations.

### **AI displaces jobs**

For those concerned about AI displacing jobs, this is a tangible issue. As one of our technology experts confirmed, the increasing prevalence of AI has already begun to affect certain professions, such as programming contractors. However, keeping a human in the loop is still crucial. Learning to work with AI could increase efficiency and better align professionals with future business needs.

### **The energy investment of AI is worthwhile**

Regarding sustainability, the considerable energy consumed by AI cannot be ignored. However, two factors mitigate these concerns. First, technological developments have consistently shown that increases in computing power are accompanied by reductions in energy consumption. Second, AI has significant potential to drive the overall shift toward sustainability, making the additional energy investment worthwhile.

### **Generative AI will disrupt the industry**

Technological developments cannot be dismissed or ignored. Industry players should consider the potential benefits of the changes they bring. We are currently witnessing the dawn of the era of generative AI. As models, tools, and questioning methods evolve, the capabilities of generative AI will improve. This transformation may be comparable to, or even superior to, the shift from pen-and-paper drawings to computer-aided design.

Therefore, it's plausible to expect this technology to have a non-integrative, but somewhat disruptive impact on our industry.

### **Engage with AI and explore the new technology**

For this reason our key recommendation is active exploration: engage with the technology and evaluate its practical implications for your business. Enhance the team's skills through education to ensure they can take advantage of the change ahead. The most effective way to gain this understanding is through experiential learning.

### **Let's discuss and interact**

This is just the beginning. We are still in the early days of the development of generative AI. We must continue to learn and evolve in our knowledge, application, and best practices for using it. Every small step can lead to significant improvements.

We present our white paper as a foundation and springboard for ongoing discussion, feedback, and recalibration of our collective knowledge and strategies. Your experiences and insights matter:

- What are your concrete experiences?
- What insights, thoughts and learnings can you share with our community and the building and real estate industry?

We will continue to share our experiences and bring ideas and potential challenges to events to discuss with you.

Let's move forward together! Let's contribute to net zero!

*« This is a pivotal juncture: The ability to adapt can lead to significant progress. »*

*« What are your tangible experiences?  
What insights, thoughts, and learnings can you share with our  
Community? »*

# Figures

Figure A.: Session 1, First prompt via voice recording. (copy from Miro-Board)

FIRST  
PROMPT

15:30

**Imagine you are a journalist and an expert in the building industry.**

Please write a white paper of around seven pages for people and experts interest in the building industry, **especially the owners of buildings**. Please elaborate on how to tackle the biggest challenges and opportunities in the building industry in the next 10 years, how generative artificial intelligence can contribute and what solutions and can it enable.

Specifically talk about solving the problems of complexity, and how to make sense of the upcoming changes in the new developments in the world. Please answer the question whether generative AI will provide incremental solutions or disrupt the industry. Please specifically explain the topic of inter-operability, and how different disciplines in the building industries and different rules in the industry and different systems can communicate, navigate and understand each other better. Please answer the question what contribution Generative AI will have.

Please include a section on what some of the biggest challenges are in moving forward and how to solve some of these challenges in the industry.

Please include a section and elaborate on the future of economic models, specifically the balance between the internal costs of building projects, and their incomes versus the external costs and incomes, which are generated around a building project.

Also reflect on the balance between the complex information and situation versus simple specific pieces of information that are relevant the humans involved and their challenges and context. As well as the tools and technology and specifically about the data and interactions between humans and the machine.

Please elaborate on people, processes and systems in the building industry and how they relate and benefit from data in the context of LCDM. What will be the impact on sustainability and how will we tackle the sustainability challenge in the building industry.

What is the role and opportunity in simulation?

How can we connect complex systems and ensure interoperability and look at all the different aspects when we think about buildings.

How can we create continuous optimizations in buildings and building projects.

During the building lifecycle, how can we create a data model which is complete consistent and how do we work with a data model in the future.

Please start the white paper with a provocative statement and end the white paper with a joke about humans and machines.

Figure B: Session 1, ChatGPT output after first voice prompt. (copy from Miro-Board)

FIRST  
RESULT

First Learning  
Qualität

**Title: Harnessing Generative AI to Revolutionize the Building Industry: A New Era of Interoperability, Sustainability, and Optimization**

**Introduction: The Dawn of the AI-Driven Building Revolution**

The building industry is on the precipice of a paradigm shift. As we stand at the edge of this new frontier, we must ask ourselves: Are we ready to embrace the promise of artificial intelligence (AI), or will we be left behind in the dust of incremental improvements?

Generative AI is poised to not just disrupt the industry, but to redefine it entirely – creating unprecedented opportunities for inter-operability, streamlined processes, and sustainable practices. This white paper will explore the revolutionary potential of generative AI in the building industry and propose strategies to harness its power for maximum impact.

**Section 1: Generative AI and the Building Industry – A Match Made in Heaven**

Generative AI holds the key to solving the building industry's most pressing challenges. By tackling complexity head-on and enabling seamless communication between different disciplines, systems, and regulations, AI can create a new era of inter-operability. This will empower stakeholders to navigate and understand the ever-evolving landscape of the industry, leading to more efficient, effective, and sustainable building projects.

Generative AI has the potential to provide both incremental solutions and industry-wide disruption. By automating mundane tasks, optimizing processes, and facilitating collaboration across disciplines, AI can revolutionize every aspect of the building lifecycle – from design and construction to operation and maintenance.

**Section 2: Overcoming Challenges – A Roadmap for AI-Driven Progress**

Some of the biggest challenges in embracing generative AI include:

1. Data management and integration: Developing standardized data models and ensuring data consistency throughout the building lifecycle.
2. Talent and skills development: Cultivating a workforce with the necessary skills to leverage AI and emerging technologies.
3. Regulatory adaptation: Updating building codes and regulations to accommodate AI-driven innovations.
4. Security and privacy: Ensuring the protection of sensitive data and intellectual property.
5. Ethics and fairness: Implementing AI systems that prioritize human values and avoid perpetuating biases.

To tackle these challenges, the industry must invest in education, research, and public-private partnerships, fostering a culture of innovation and collaboration.

**Section 3: The Future of Economic Models – Balancing Internal and External Costs and Incomes**

Generative AI will reshape economic models by enabling a more comprehensive understanding of internal and external costs and incomes. This will drive more informed decision-making, optimizing the balance between project-specific expenses and revenues, and the broader economic implications of building projects.

To achieve this balance, industry stakeholders must adopt a holistic approach to value creation, considering both tangible and intangible benefits, such as social and environmental impacts.

**Section 4: Striking the Right Balance – Complex Information vs. Simplicity**

Generative AI offers the ability to synthesize vast amounts of complex information into simple, actionable insights for humans. This empowers decision-makers to focus on the most relevant aspects of a project while still benefiting from the comprehensive analysis that AI can provide.

Collaboration between humans and AI requires seamless interaction, leveraging intuitive tools and technology that promote efficiency and foster a symbiotic relationship.

**Section 5: Leveraging LCDM – People, Processes, Systems, and Data**

In the context of Lifecycle Data Management (LCDM), generative AI can optimize people, processes, and systems by harnessing data to drive better decision-making. This will result in improved sustainability, as stakeholders can make data-driven choices that minimize resource use, reduce waste, and promote energy efficiency.

**Section 6: Simulation – A Powerful Tool for AI-Driven Optimization**

Simulation offers a unique opportunity to test and optimize building designs, systems, and processes before implementation. By incorporating generative AI into simulation,

**Figure C:** Session 1, Third prompt with refined context, questions, and structure. (copy from Miro-Board)

THIRD PROMPT

11:53

**Generative AI in Construction.**  
A conversational AI system that listens, learns, and challenges

---

Imagine you are a project management professional representing the building owner and with a deep understanding of the building industry and artificial intelligence.

Please write a thorough white paper in three chapters with one leading question for each chapter. Each Chapter will consist of a succession of more detailed aspects. Please write one page per each aspect.

The three questions for the three chapters are:

- Chapter one: Please elaborate on how to tackle the biggest challenges and opportunities in the building industry? The detailed aspects to be addressed are:
  - the future of economic models, specifically the balance between the internal and external costs in the context of building projects in the context of SDG Goals
  - the balance between the complex information versus simple specific pieces of information that are relevant for the humans involved and their challenges?
  - the tools and technology and specifically about the data and interactions between humans and the machine and how to solve the gap between human readability and machine readability of information?
  - the four perspectives of people, processes, systems and LCDM in the building industry and the interaction between those four?
  - the role and opportunity in simulation?
  - complex systems and interoperability and the continuous optimization in building projects and building operation?
  - the potential from a building lifecycle data model which is complete consistent and pays into the overarching question from chapter one?
  - and anything else that you see relevant?
- Chapter two: Please elaborate on what contribution is generative AI to the solutions of the described challenges in chapter one? Please focus on the contribution of AI as a technology, not on the contribution in the aspect as such. Please elaborate on specific examples per each Question in chapter one, giving an insight on **the actual added value by generative AI**. Further please address the following aspects:
  - solving the problems of complexity, and how to make sense of the upcoming changes in the new developments in the world?
  - whether generative AI will provide incremental solutions or disrupt the industry?
  - explain the topic of inter-operability, and how different disciplines in the building industries and different rules in the industry and different systems can communicate, navigate and understand each other better?
  - answer the question what contribution Generative AI will have?
- Chapter three: Owners of Buildings or built infrastructure generally focus on two types of added value when investing in innovation. Please elaborate on the two following options:
  - Added value for owners through increased efficiency in building and operations?
  - Added value by increase of the transactional value?

Please start the white paper with a provocative statement and end the white paper with a joke about humans and machines.

C: Details corrected

C:Open Question added

Learning: Matrix Zerlegung nicht mehr relevant / wird über Nachfragen abgebildet

**Figure D:** Session 1, example for a Follow-up prompt. Answer on the left, follow-up prompt on the right.

generative AI can facilitate interoperability by enabling different disciplines and systems to communicate, navigate, and understand each other more effectively.

**Chapter Three: Added Value for Building Owners through Innovation**

*3.1 Increased Efficiency in Building and Operations*

Investing in generative AI can lead to significant improvements in efficiency throughout the building lifecycle, reducing costs, and optimizing resource utilization.

*3.2 Enhanced Transactional Value*

Generative AI can increase the transactional value of built infrastructure by optimizing design, improving building performance, and reducing environmental impact.

**Conclusion:** As we embrace the power of generative AI in the construction industry, we must remember that the ultimate goal is to create a harmonious and efficient partnership between humans and machines. After all, the perfect collaboration would be a human with a machine-like memory and a machine with a human-like sense of humor.

thank you for your answers in Chapter Three: Added Value for Building Owners through Innovation.

Please take the following concept into your consideration and elaborate your answers under point 3.1. and 3.2. further.

→ imagine you are a building owner contract manager who wants to change the way deliverables and results are procured and targets measured.

you wants to step away from the traditional document and file based deliverables (like reports, plans etc.) to data driven contractual deliverables and target monitoring.

**Figure E:** Session 2, first simple prompt to generate a python script

< 2 / 2 > A write python script to read binary data with spark and please take into account that i will deploy on ms data bricks

---

< 6 / 6 > To read binary data with PySpark on Databricks, you can use the BinaryFiles API provided by PySpark. Here's a simple script that demonstrates how to read binary files using PySpark and perform some basic operations. Before you execute the code, make sure you have uploaded your binary files to a location accessible by Databricks, such as Azure Blob Storage or Databricks File System (DBFS).

python Copy code

```

from pyspark.sql import SparkSession
from pyspark.sql.functions import udf
from pyspark.sql.types import StringType

# Initialize the Spark session
spark = SparkSession.builder \
    .appName("Read Binary Data with PySpark on Databricks") \
    .getOrCreate()

# Define the path to your binary files (e.g., Azure Blob Storage or DBFS)
binary_files_path = "path/to/your/binary/files"

# Read the binary files using the BinaryFiles API
binary_files_df = spark.read.binaryFiles(binary_files_path)

# Define a UDF to process the binary files

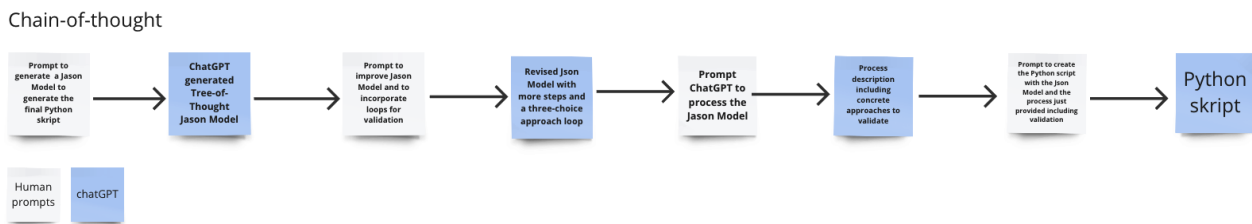
```

↻ Regenerate response

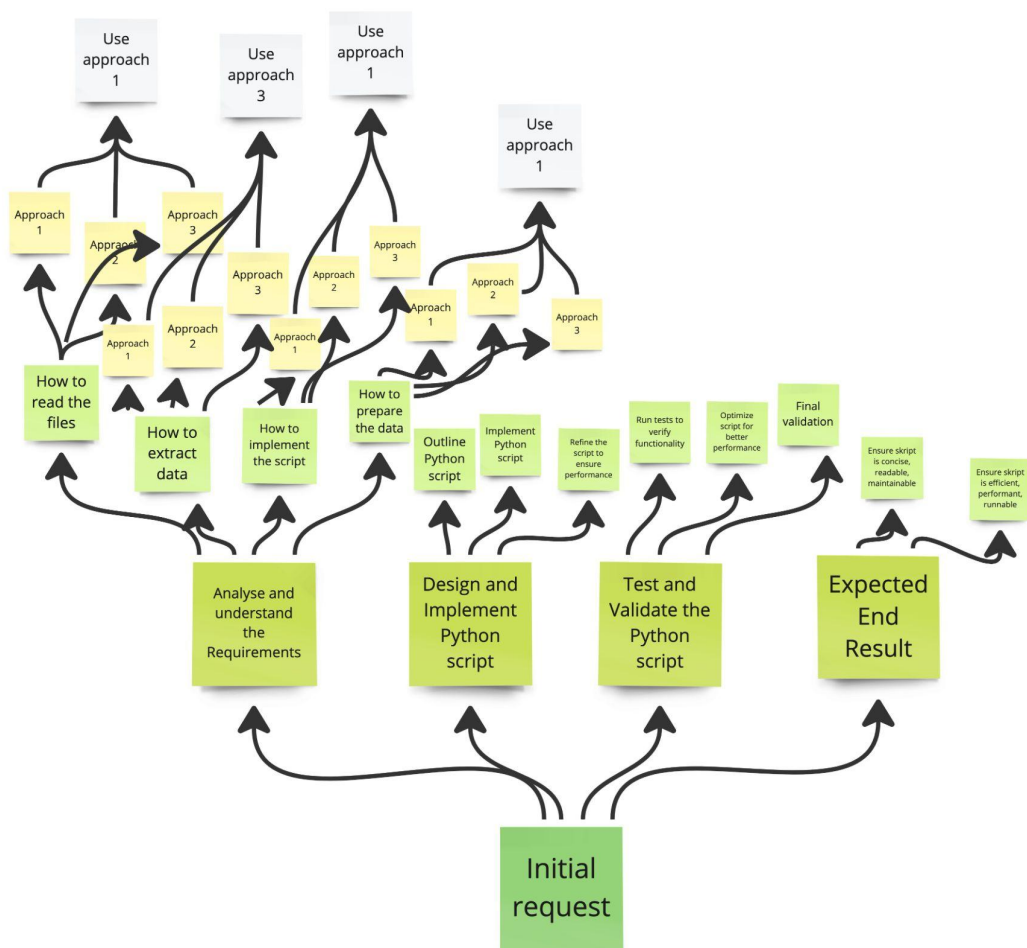
➤

ChatGPT may produce inaccurate information about people, places, or facts. [ChatGPT Mar 23 Version](#)

**Figure F:** Session 2, chain-of-thought prompting from our session



**Figure G:** Session 2, tree-of-thought prompting process from our session





**Figure H:** Session 2, first prompting for a JSON Model as an intermediate step to get the final python script



can you create a prompt that references the json model below to take an initial statement, request or prompt and create the tree of thought json model so that I can copy the new prompt and pass it as a prompt to an AI model to have it process the entire prompt as a tree of thought prompt and provide me the best result for the initial prompt.

For example the starting prompt could be something like

Initial\_Instruction: You are an amazing problem solver for all types of problems including technical, psychological, mathematical, programming, architectural and any topic related to the request provided below after the label "request:". You are provided the following request that may not be in its best format. Your job is to take the request, and the example json model and create the best result possible based on the Expected result description below using the tree of thought structure.

request: I have 4 ifc binary files stored in Azure. I need to read them, use ifc openshell to extract space or room data according to category SIA416 for an architectural project. I need a script that can be run in Azure databricks to prepare the data for use in Power BI.

Expected\_result: a short performant python script runnable in Azure Databricks

```
{
  "initial_prompt": "You are an amazing problem solver for all types of problems including technical, psychological, mathematical, programming and any topic related to the request provided below after the label 'request:'. You are provided the following request that may not be in its best format. Your job is to take the request, and the example JSON model and create the best result possible based on the Expected result description below using the tree of thought structure.",
  "thoughts": [
    {
      "prompt": "request: I have 4 ifc binary files stored in Azure. I need to read them, use ifc openshell to extract data according to category SIA416 for an architectural project. I need a script that can be run in Azure databricks to prepare teh data for use in Power BI. ",
      "thoughts": [
```

Continue this conversation

**Figure I:** Session 2, prompt to improve the JSON Model and implement a validation process

---



can you analyze the prompt response and json model you provided to check for any steps or thoughts that can help improve the flexibility, robustness and cleanliness of the json model to generate the final result? Also incorporate any loops in any areas to ensure that you validate any choices by testing three different approaches to get the best path to the best final result

---

# About the Authors

**Alar Jost** brings over two decades of expertise in transforming data into actionable insights and organizational value, evident in his role as a culturally versatile leader of global, cross-functional digital teams. Intrigued by the possibilities that AI offers for learning and industry innovation, he excels in mobilizing executives, specialists, and users to achieve synergistic advancements. Alar serves as the Co-Founder and CEO of beyondBIM Ltd. and is a Board Member of buildingSMART International. Additionally, he holds positions as Vice Chair and founding member of buildingSMART Switzerland, is a Founding Partner at ETH Zurich's Competence Hub for data integration in the built environment, and is co-initiator and host of ConstructionRide.ch.

**Christian Ehl** is an accomplished tech entrepreneur with a remarkable history of establishing seven start-ups, including one within the building industry. In 2018, he authored a book on Artificial Intelligence, and he has just released a book about chatGPT and Generative AI titled «Generative AI – The Future of Everything». In his experience, bringing the building and real estate industry players together poses an intriguing challenge. It comprises many different perspectives, audiences, and people who struggle to align, leading to difficulties and inefficiencies. In addition, Christian's profound interest in sustainability further fuels his anticipation for innovative solutions, eagerly seeking new avenues for progress in this vital area.

**Jugal Makwana** is the Global Director of BIM/Digital Engineering at Royal HaskoningDHV and a Board Member of buildingSMART International with 25 years of experience and a proven track record in digital transformation, BIM and digital engineering, and standards development across the AEC industry. He is recognised for developing and executing creative strategies that promote organizational transformation, enhance operational efficiency, and provide clients with long-term value. Jugal is passionate about delivering value by digitizing sustainably. He is a people-oriented leader, coach, and influencer with a track record of working with cross-functional teams, stakeholders, and technology partners to establish OpenBIM as the cornerstone for industry collaboration and best practices.

**David Bucher** is a final-year PhD student from ETH Zurich. Throughout his professional development, he has been fascinated by the use of advanced data systems and the processes derived from them to solve social, environmental, and economic challenges, particularly in the construction industry. Drawing on his industrial background, he had the opportunity to research digital innovation in depth as part of his Ph.D., focusing on decentralized data marketplaces to optimize supply chain operations and improve

decision-making based on a common data basis. Alongside this scientific contribution, he gained experience in writing technology strategy reports, establishing and managing innovation centers, and supporting stakeholders toward Web3-based innovations.

**Fabian Cortesi** is an environmental scientist, communications expert, co-creation specialist as well as entrepreneur and partner of IEU Kommunikation AG. He and his team support start-ups and established companies in communicative and collaborative tasks in the fields of energy, environment, construction, architecture, real estate, digitization, mobility and spatial planning.

**Isabelle Pryce**, with her foundation in journalism and philosophy, dedicated a decade to freelance communications before joining Fabian's team at IEU Kommunikation AG. Fascinated by the potential of new technologies and convinced of the importance of sustainability in every industry, she enjoyed immersing herself in the world of AI and engaging in thought-provoking discussions with her fellow authors.

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