BUILDINGS | Building Energy Codes





Using Artificial Intelligence for Energy Code Compliance Verification Tool for faster, more accurate code compliance verification with Generative Al

USING AI FOR BUILDING ENERGY CODE COMPLIANCE VERIFICATION

Principal Investigator (PI)Hanlong WanLead OrganizationPNNLPI Emailhanlong.wan@pnnl.gov

BACKGROUND AND IMPACT

Objective

This project uses Generative AI (Gen-AI) to automate code compliance verification making it faster and more accurate

Background

- Manual verification of building energy code compliance is complex, resource intensive and can result in lost opportunity to save energy.
- Advanced Gen-AI tools like ChatGPT are becoming popular and have big potential in building research and the industry.

METHODS

The tool development methods process steps are outlined in the figure below.

Input (User Queries and Building Data)	 Users input building plan descriptions and numerical metrics. Queries related to specific building energy codes will be entered through a chatbot interface.
Data Conversion & < Preprocessing	 Building plans and metrics will be converted into searchable formats. LLM will process inputs for indexing and retrieval.
	 Input data will be used to retrieve relevant sections of

Input data will be used to retrieve relevant sections of building energy code and architecture design files.
Automated code compliance checks will be initiated based on retrieved data.

Users can ask questions about specific code requirements.
Responses will be provided, retrieving relevant code sections.

response times.

contextually relevant answers.

• Frequently accessed information will be stored in cache.

Various prompts will be tested to ensure accurate and

The system will retrieve cached information to speed up

KEY PRODUCTS

 The project will develop a Building Energy Compliance Checking Assistant Tool with an easy-to-use interface, along with possible features for reporting and visualizing results. This tool helps simplify the process of checking building energy codes by automating it and making the results easy to understand.

CONCLUSION

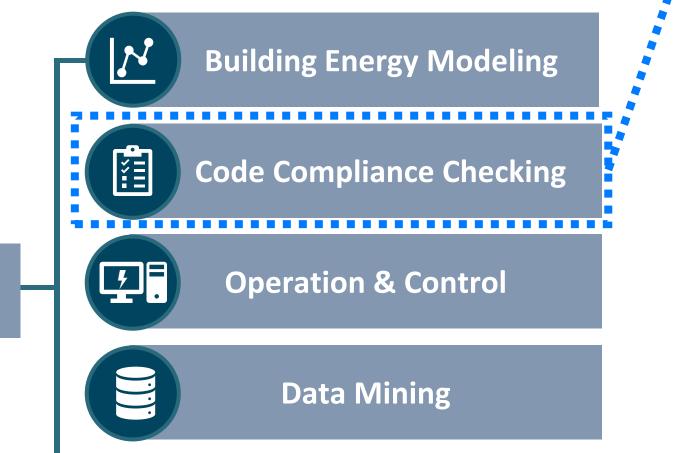
Addressing the Key Challenge

- It will explore the potential of using customized pre-trained models, like GPT-40 or Llama 3, and focuses on improving accuracy and efficiency through prompt engineering, RAG, and fine-tuning.
- It will explore the challenge of accurately extracting important data from tables and figures within building energy codes, ensuring the right information is applied during checks as a long-term goal.

Impact

- This project supports the DOE's goal of cutting energy use in buildings. Better code compliance saves energy and reduces emissions.
- It helps local governments, building owners, and contractors by making it easier to follow energy codes, speeding up approvals, and lowering costs.
- While code compliance is just the start, these tools could also be used for workforce training, control support, and building energy model support in the future.

Application of Generative AI in Building Industry



Building Industry Assistant

Assistant. How can I assist you today?

Custom RAG^{*}

Process

Chatbot

Caching

System for

Improved

Efficiency

Prompt

Testing and

Optimization

Interface

You: What is the R-value requirement for exterior walls in commercial buildings in Washington according to ASHRAE 90.1-2019?

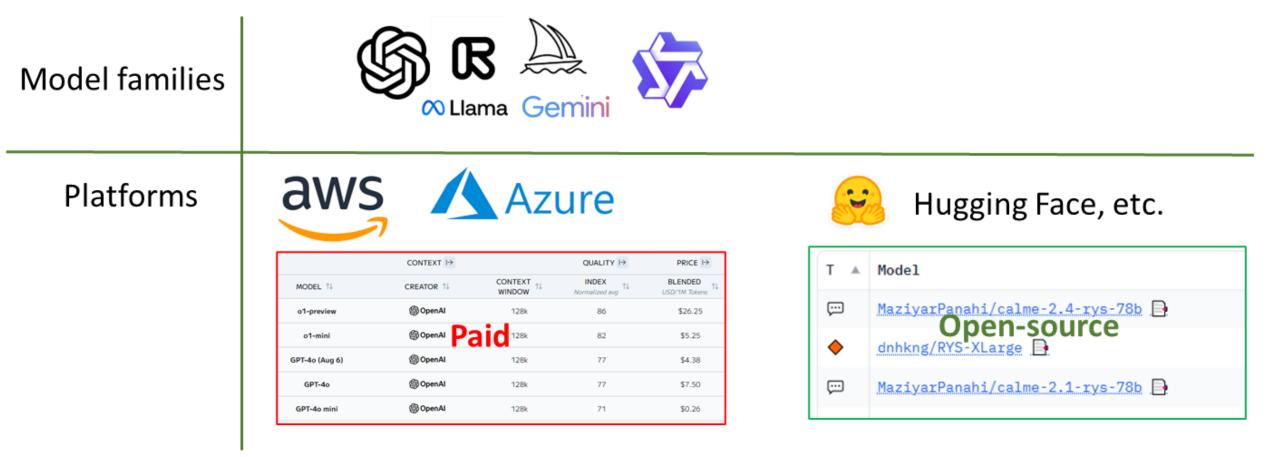
Assistant: According to ASHRAE 90.1-2019, the R-value requirement for exterior walls (mass walls) in commercial buildings in Washington depends on which Climate Zone the building is located in. Washington has multiple climate zones. For example, in Climate Zone 4C, the required R-value for mass walls is R-11.4, and in Climate Zone 5B, it is R-15.2. Please refer to the appropriate climate zone for the specific area of Washington where the building is located to determine the exact required R-value for exterior walls. Impact of the Project

 If successful, the project will save time and resources, helping more buildings meet energy efficiency standards.

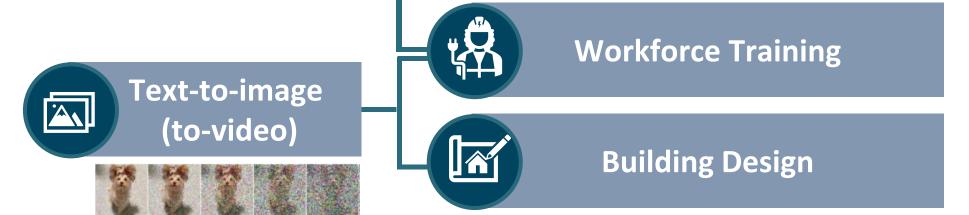
Advancing the BTO's Mission

• The tool supports DOE's mission by automating compliance checking, making it easier to follow energy codes. Ultimately, easier access to energy code information will contribute to sustainability efforts.

Some Available Pre-Trained Models



A variety of pre-trained models are available, which can be accessed through platforms like Microsoft Azure OpenAI API as paid options, or through open-source models from communities like Hugging Face.



The application of generative AI tools includes text-to-text and textto-image (or video), across various building-related tasks. This work of building energy code compliance checking is a start point.



Fext-to-text

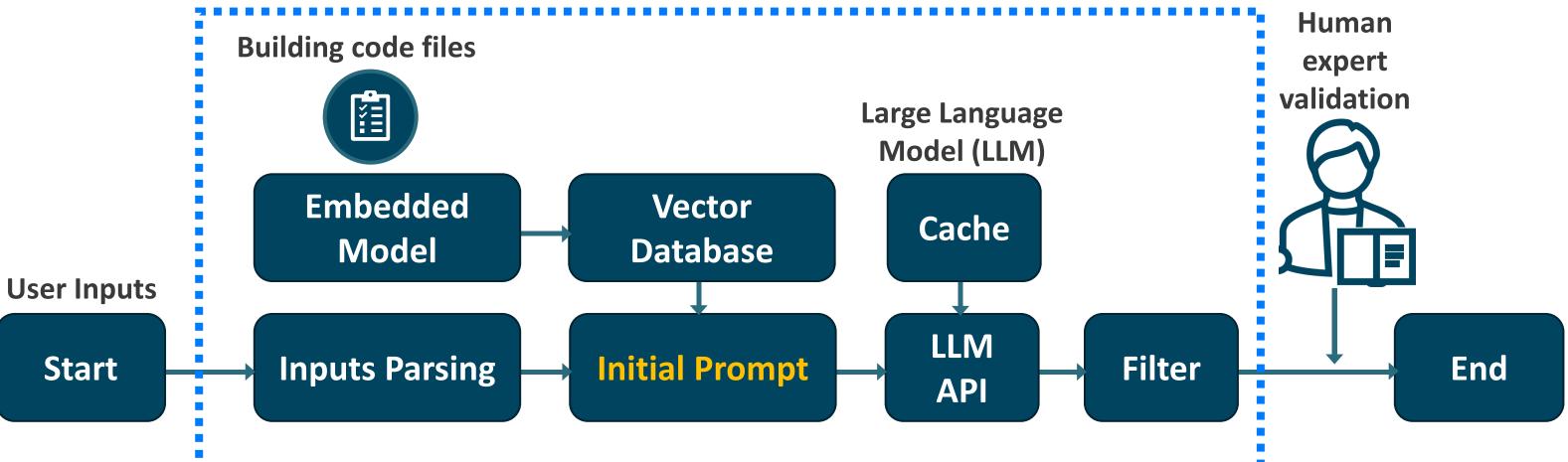
ients between ASHRAE 90.1-2019 and ASHRAE-90.1-2022?	
Load PDF Data	
pdf	
Send	

A demo developed and tested to locate the Rvalue requirements for Washington State from the ASHRAE 90.1-2019 version, streamlining the process of retrieving specific building code information.

PROGRAM OFFICE LEAD | Ian Blanding Supported by Building Energy Codes Program

PROJECT TEAM | Hanlong Wan (PNNL), Fan Feng (PNNL)

Application User Interface (APP UI) Process



*This customized Retrieval-Augmented Generation process is designed for efficient building energy code compliance checking. It starts by parsing input documents such as building plans and energy codes, then transforms them into vector representations using an embedded model. The system retrieves relevant code sections from a vector database, generates an initial prompt, and leverages large language model (LLM) via an application user interface (API) to produce detailed compliance checks.

Preprint Paper: PNNL-SA-203362