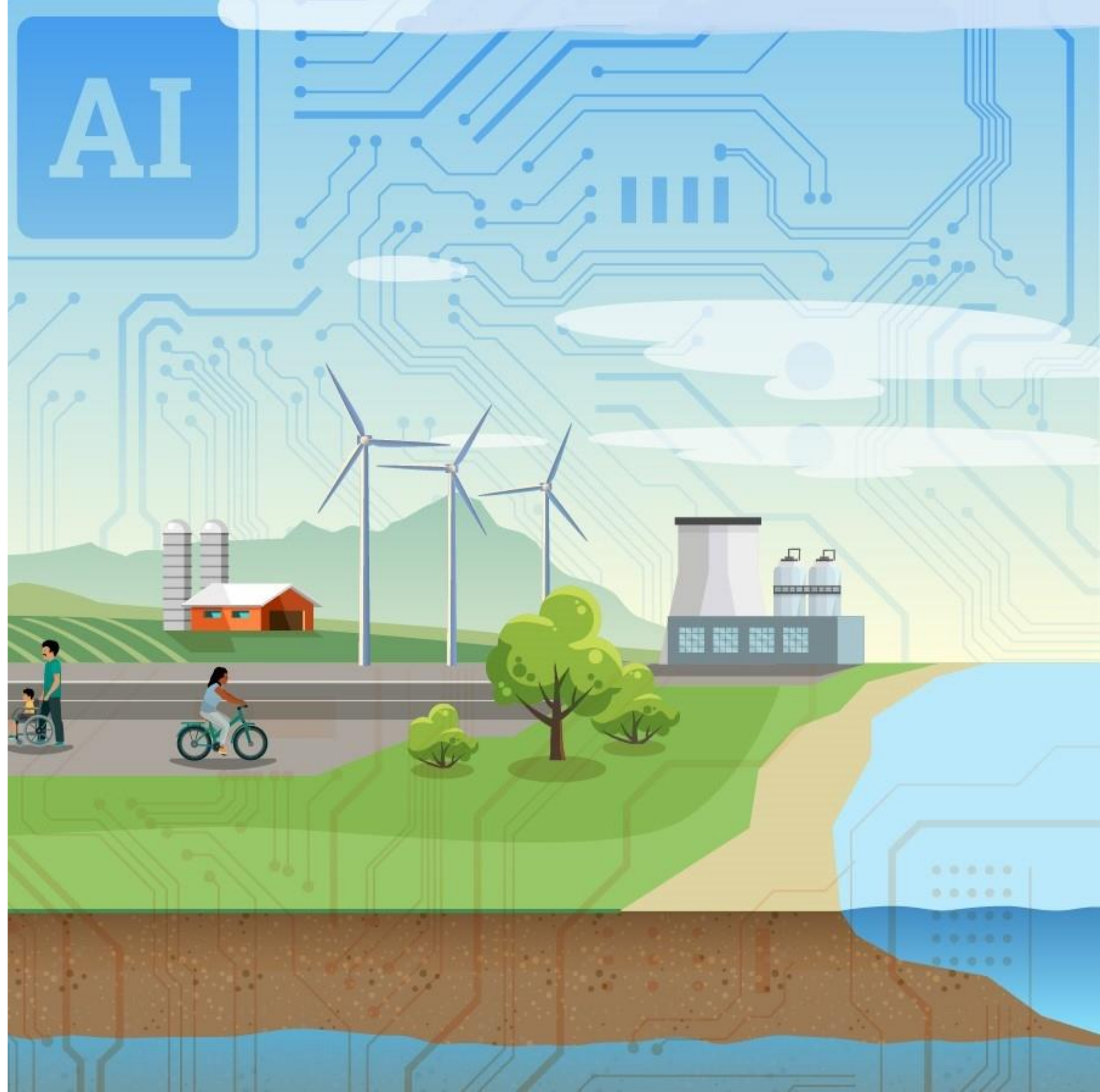


# Accelerating Environmental Reviews with Automated Knowledge Synthesis Agents

**Sameera Horawalavithana, Ph.D.**  
[yasanka.horawalavithana@pnnl.gov](mailto:yasanka.horawalavithana@pnnl.gov)

Data Scientist



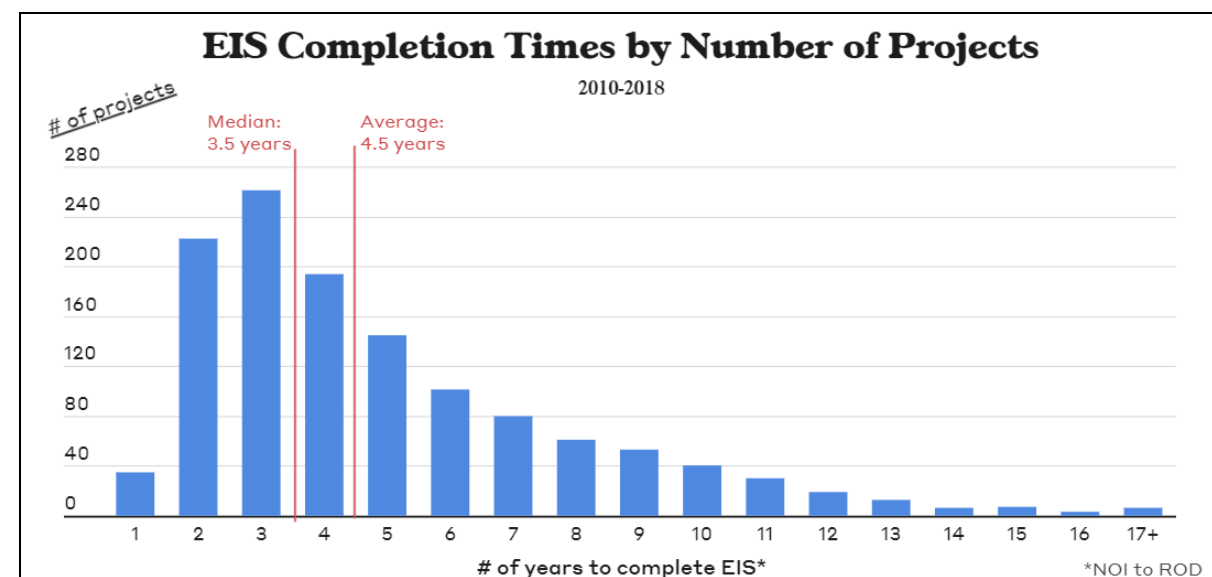
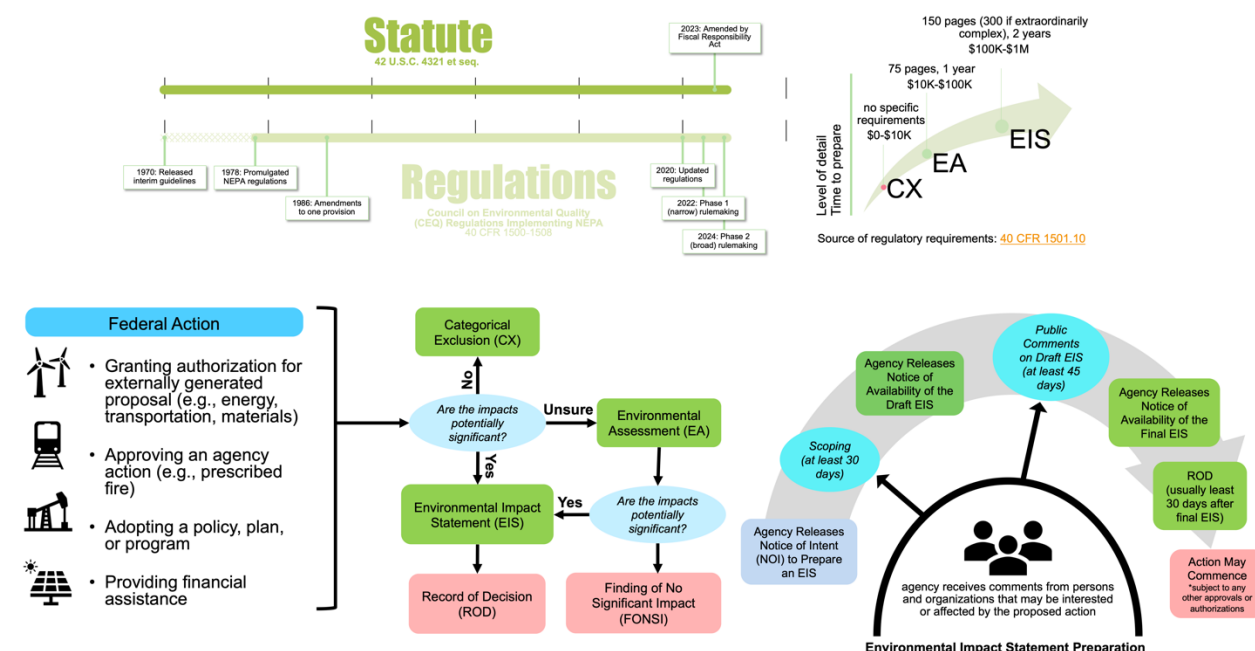
# Outline

- PolicyAI Project Overview and Background
- Environmental Review Workflows
  - NEPA Drafting – Socioeconomic Sections
  - Public Scoping Comment Analysis
  - Coding Ordinances
- Discussion

# Environmental Reviews

- The National Environmental Policy Act (NEPA) requires agencies to examine and disclose the potential significant environmental impacts of major actions
- NEPA does not require a substantive result, it only requires that agencies take a "hard look" at the impacts of their actions
- Three main levels of environmental reviews:
  - Environmental Impact Statement** – for actions likely to have a significant impact
  - Environmental Assessment** – for actions that may have a significant impact (EA results in either a Finding of No Significant Impact or a decision to prepare an EIS)
  - Categorical Exclusion** – for actions that normally do not have a significant impact

Environmental review process is tedious, expensive and time consuming.



Source: [Council on Environmental Quality](#)



# Recent Environmental Reviews



SunZia Southwest Transmission, a 550 mile transmission line project transporting renewable energy to residents in the southwest. The project will support modernizing renewable energy infrastructure, potentially lowering energy costs for consumers in AZ, NM, & CA.



Coastal Virginia Offshore Wind farm is the largest offshore wind project in U.S. history, expected to create 900 direct and indirect jobs and power up to 660,000 homes with renewable energy.

# Origins and Initial Steps

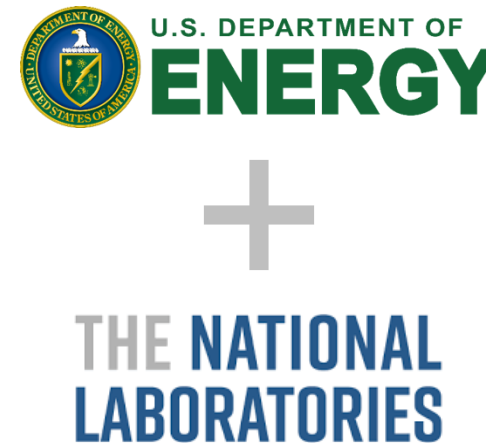
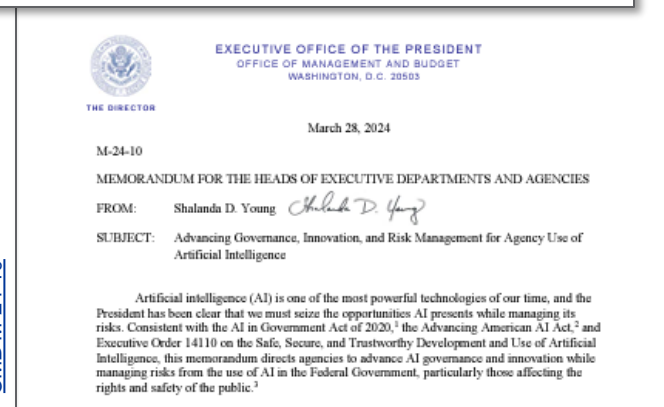
[Executive Order 14110](#)



<https://www.whitehouse.gov...>



[OMB M-24-10](#)

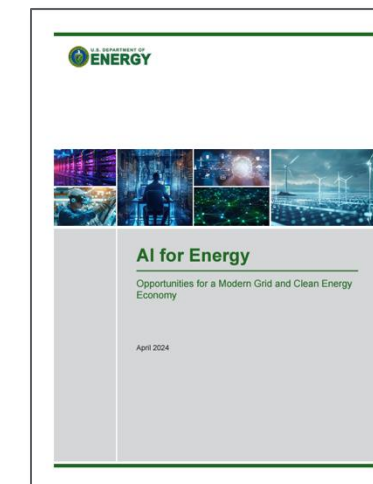


ACTIONS

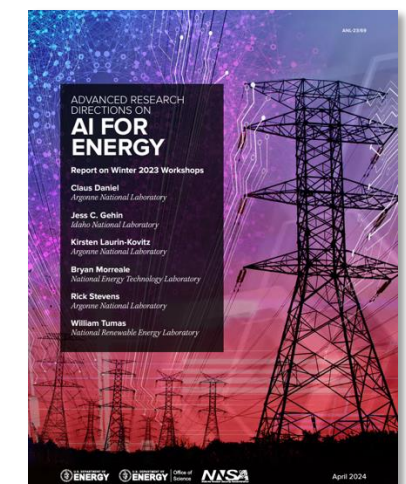
The U.S. Department of Energy (DOE) [has announced many actions](#) to assess opportunities and challenges of AI for purposes of accelerating deployment of clean energy and managing growing energy demand.

These actions include coordination with regulators, researchers, utilities, clean energy developers, data center owners and operators, and other interested parties.

REPORTS

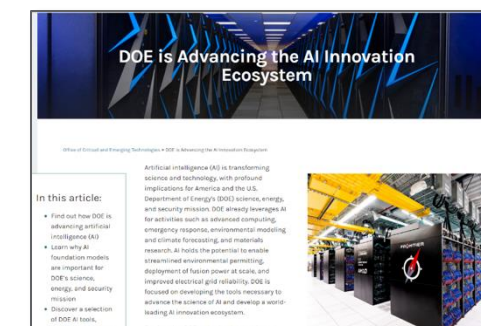


[DOE 2024](#)

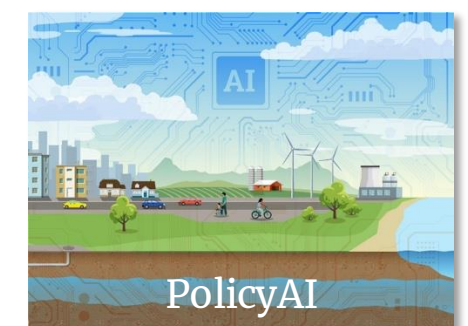


[DOE 2024](#)

TOOLS



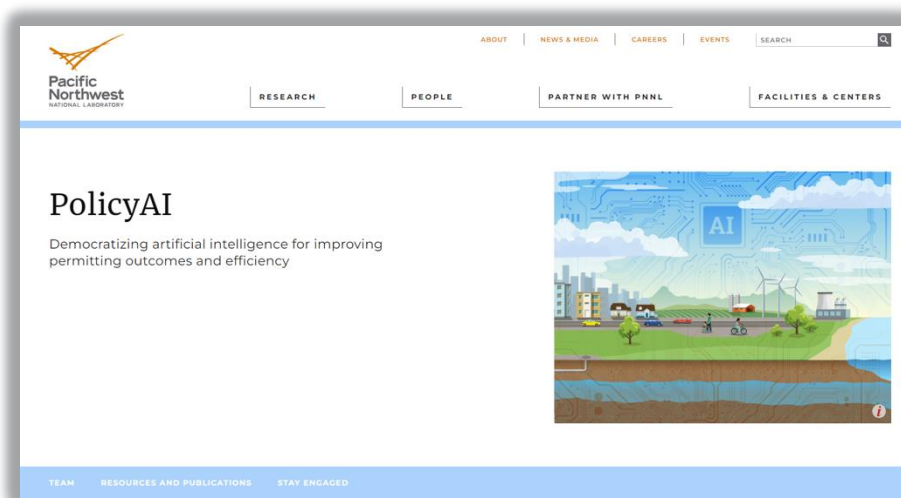
<https://www.energy.gov...>



<https://www.pnnl.gov...>



# PolicyAI Overview



<https://www.pnnl.gov...>

Developing AI tools and applications for improving permitting outcomes and efficiency

- PolicyAI is the anchor project in DOE's \$20 million VoltAIc Initiative that includes support from the Permitting Council
- DOE partnered with the Pacific Northwest National Laboratory (PNNL) to develop PolicyAI
- Includes coordination with the Council on Environmental Quality (CEQ), various federal agencies, and industry
- PolicyAI tools are intended to be adaptable for use by multiple federal agencies

## Timeline

**Current status:** Research and development, pilot and v1 applications, interagency agreements and feedback

1–2 years

AI-enabled pilots improving permitting workflows

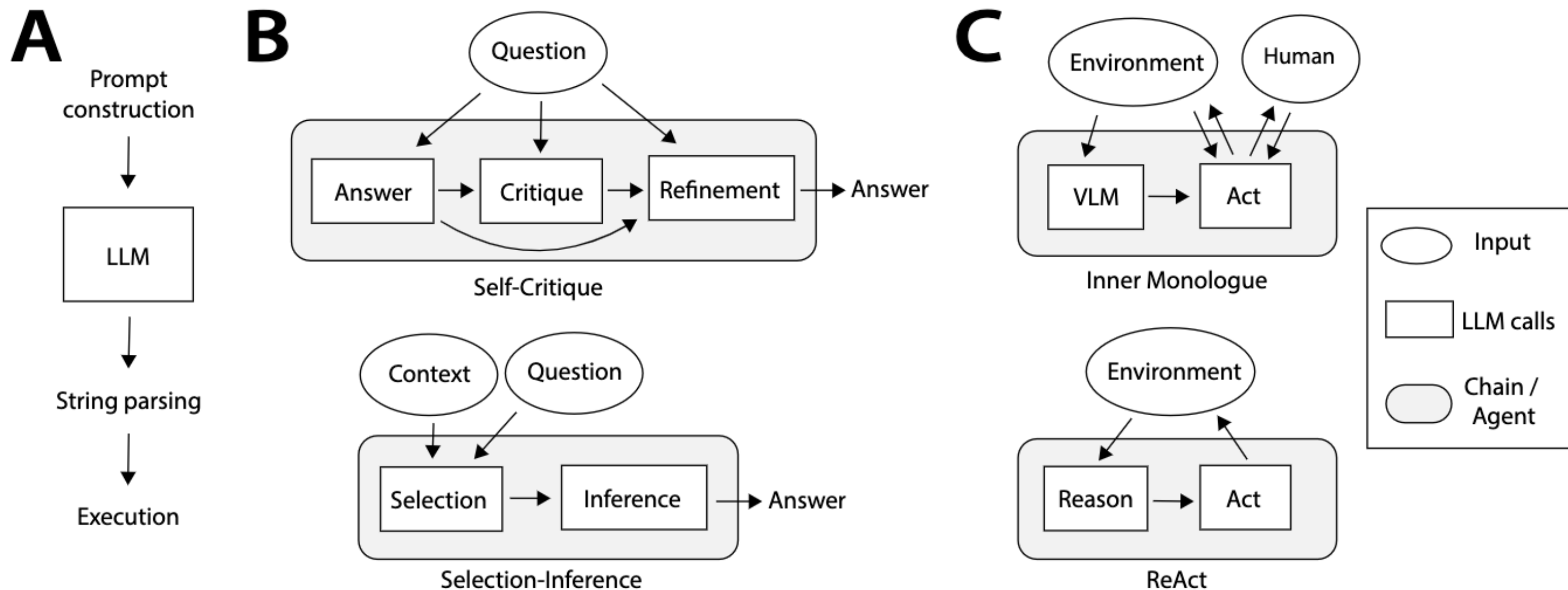
5 years

Operationalized AI models streamlining permitting

# AI-Driven Environmental Review and Permitting



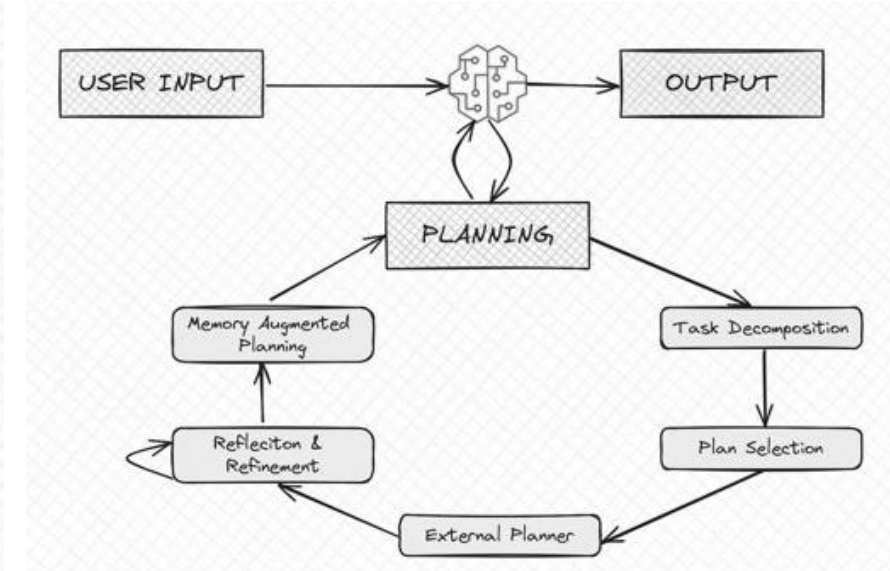
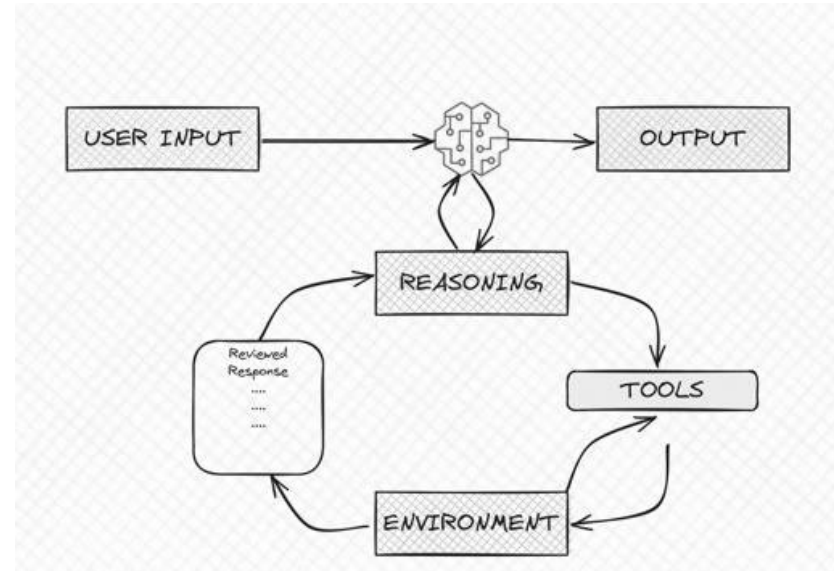
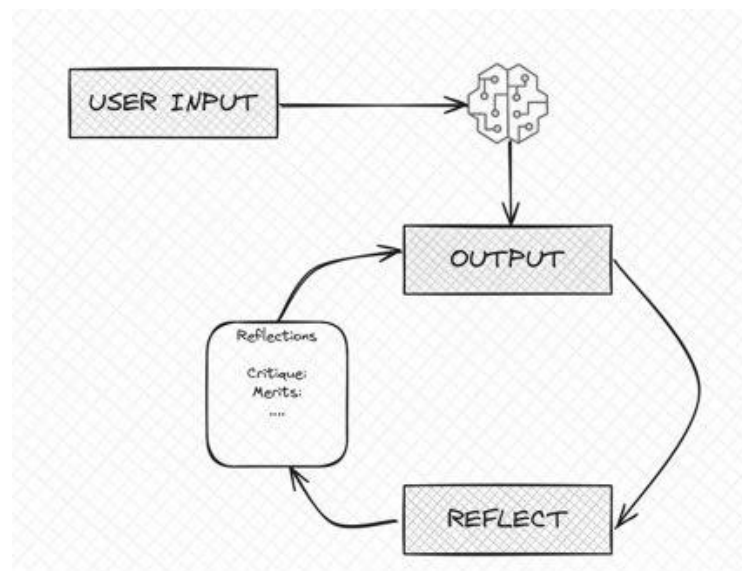
# From Language Models to Language Agents





# Language Agents Design Patterns

## Single Agent



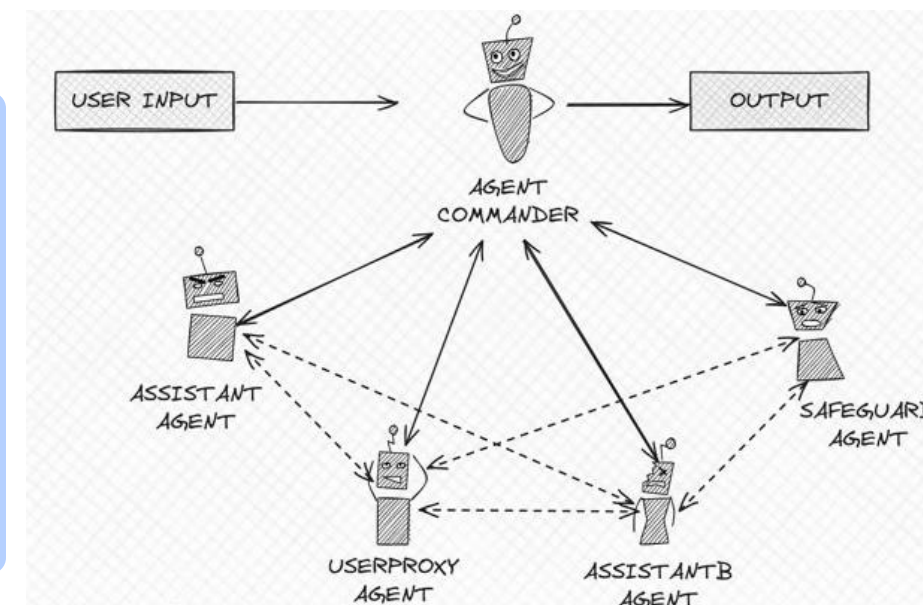
## Language Agents Case Studies

NEPA Drafting – Socioeconomic Sections

Public Scoping Comment Analysis

Coding Ordinances

## Multiple Agents



Ground Truth Evaluation and SME Testing/Feedback

Single Agent

# NEPA Drafting – Socioeconomic Sections



Karen DSouza



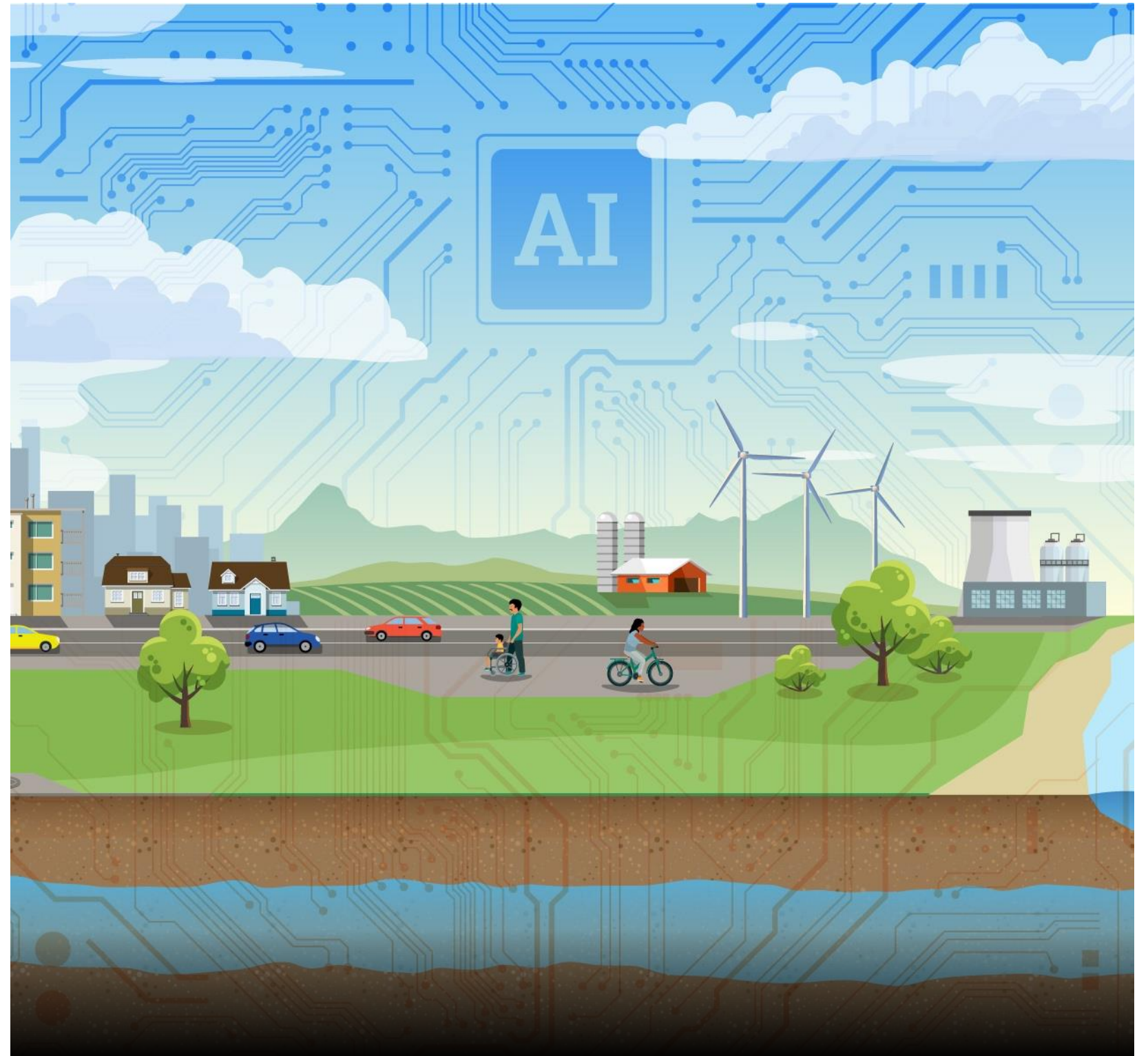
Sai Munikoti



Mike Parker  
(SME)

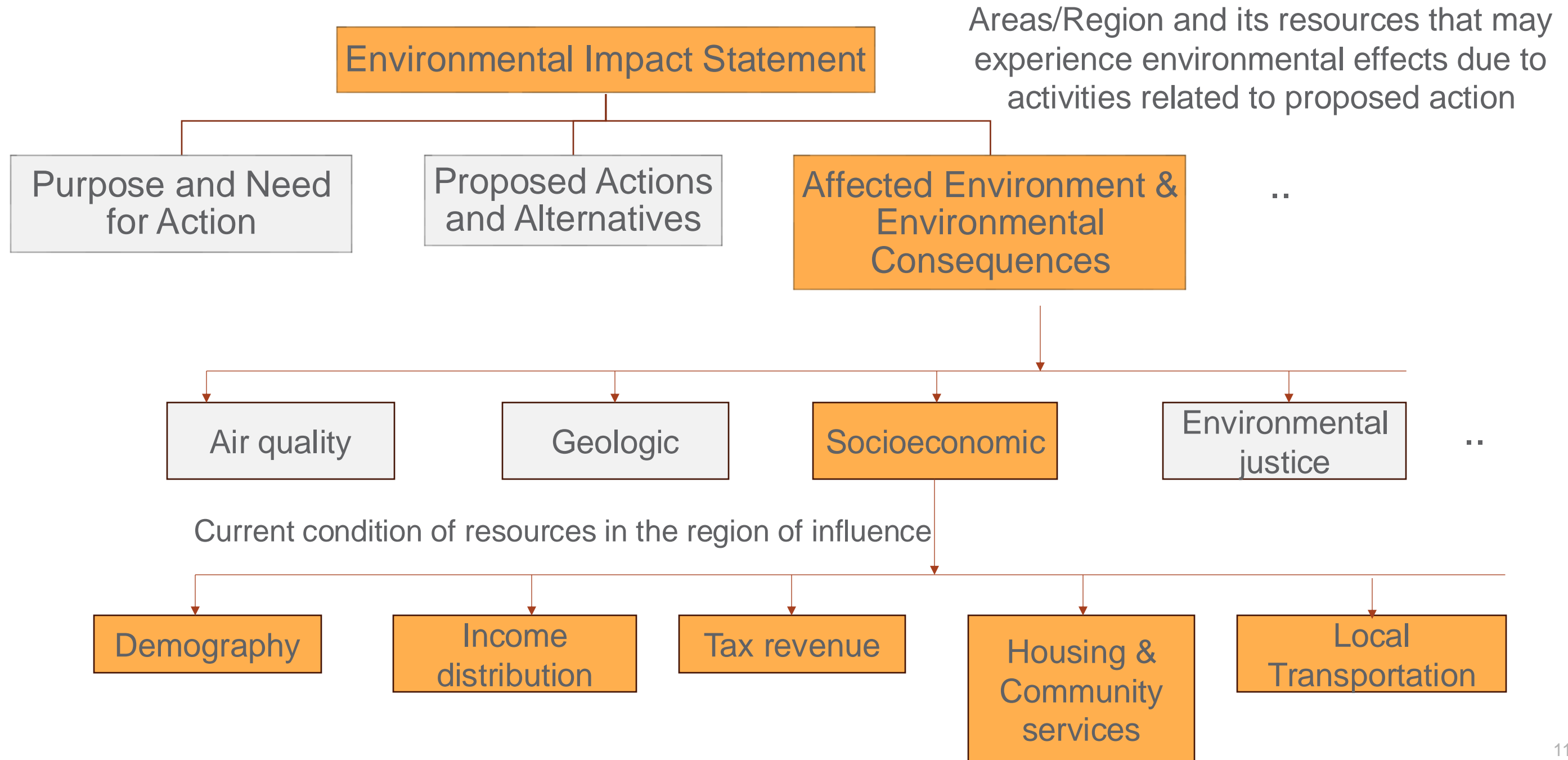


Dan Nally  
(SME)



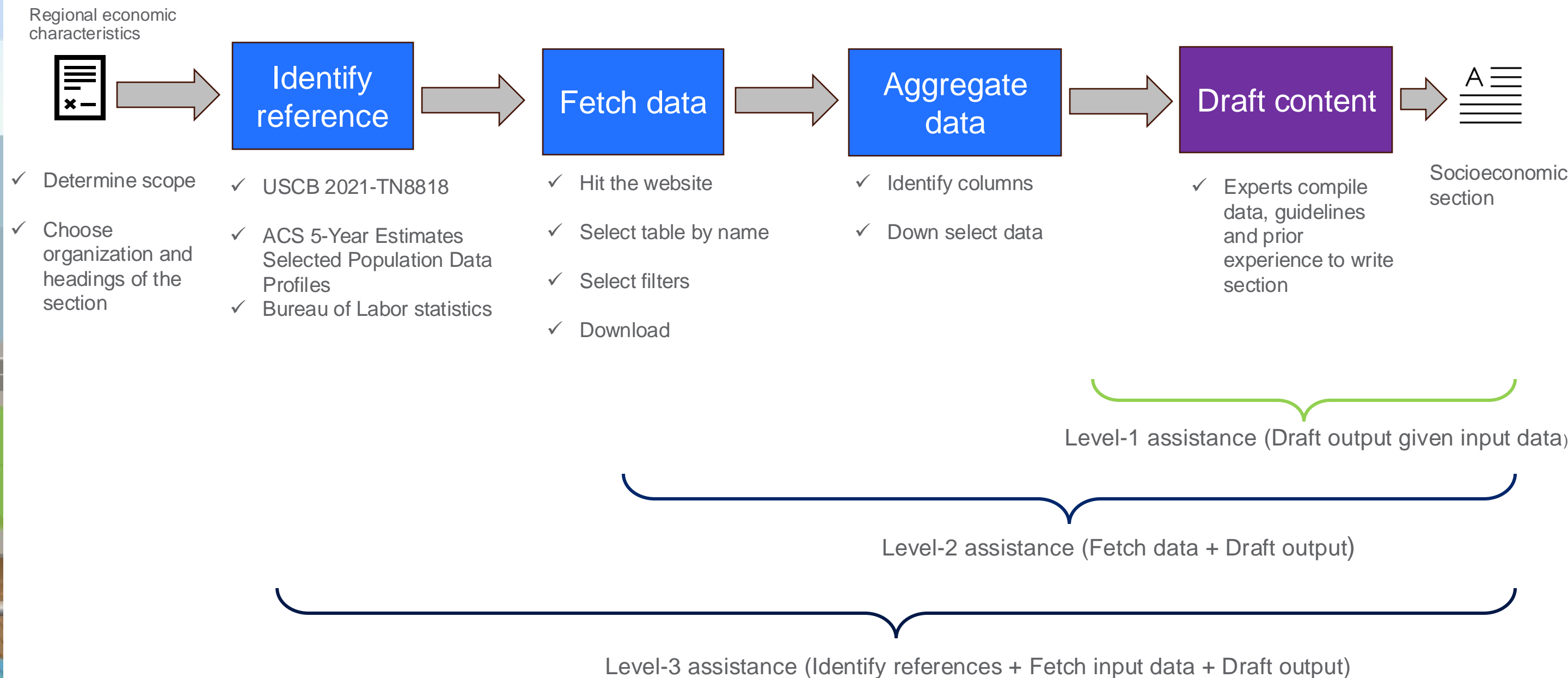


# NEPA Drafting – Socioeconomic Sections





# Human Workflow



# Experimental Setup

- **Task:** Write “3.10.2.1 Regional Employment and Income” subsection from Socioeconomics section in Final Environmental Impact Statement for Combined Licenses (COLs) for Comanche Peak Nuclear Power Plant
- **Data Sources:**
  - Two CSVs from census bureau
  - 1 EIS with gold references: Comanche Peak EIS
- **Implementation:** Llamaindex, Agents, Query as tool, GPT-4o as agent
- **Expected Output:** Table 3-19 Estimated Income Information for the Comanche Peak Socioeconomic Region of Influence (2017–2021, 5-Year Estimates)

**EIS**

Table of Contents

**Affected Environment**

- Land use
- Air quality
- Water resources
- **Socioeconomics**
- Waste management



## EIS Writing assistance task Socioeconomics

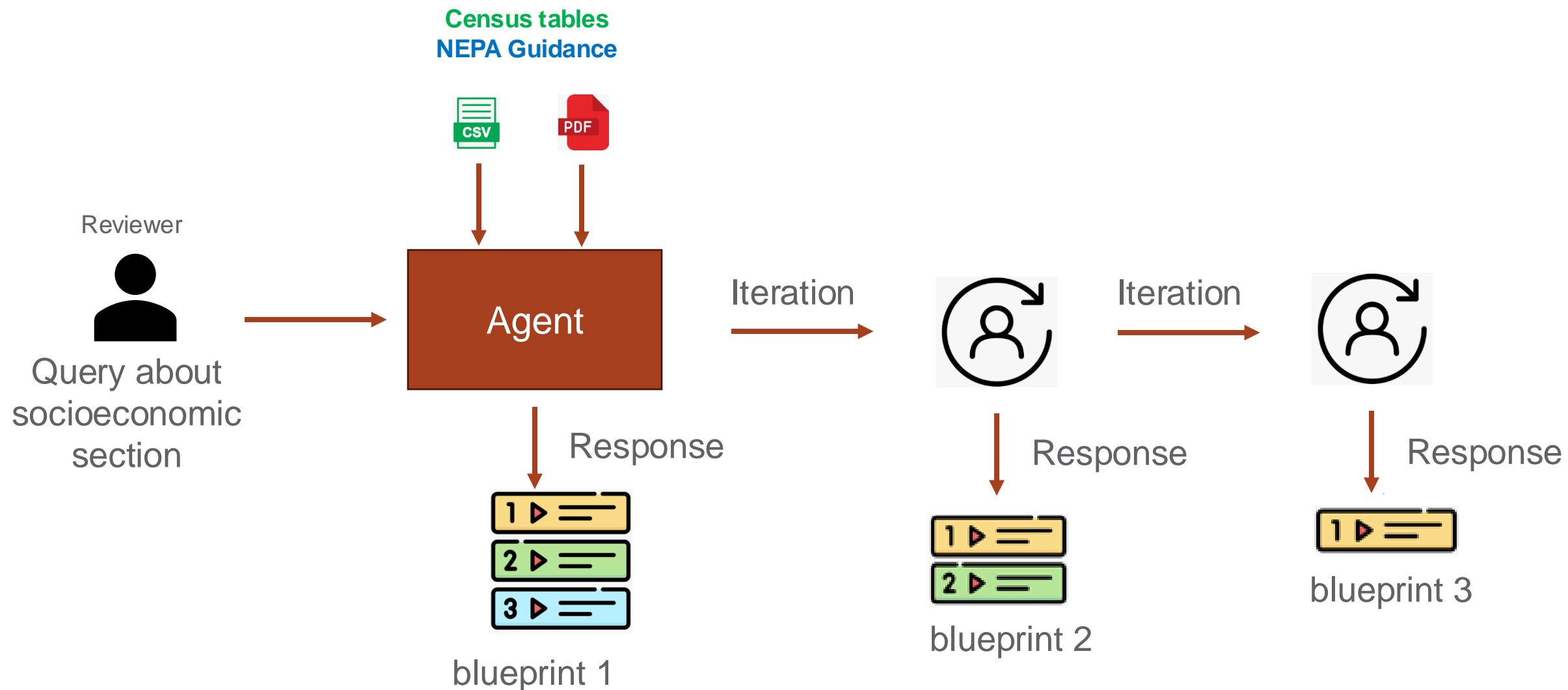
- Regional Economic Characteristics
  - 3.10.2.1 Regional Employment and Income
    - Table 3-19 Estimate Income Information

**Table 3-19 Estimated Income Information for the Comanche Peak Socioeconomic Region of Influence (2017–2021, 5-Year Estimates)**

Metric	Hood County	Somervell County	Tarrant County	Texas
Median household income (dollars) <sup>(a)</sup>	75,851	89,253	73,545	67,321
Per capita income (dollars) <sup>(a)</sup>	39,252	37,395	36,170	34,255
Families living below the poverty level (percent)	6.1	6.4	8.4	10.7
People living below the poverty level (percent)	8.6	10.8	11.3	14
Unemployment rate	3.5	3.2	3.5	3.5

(a) In 2019 inflation-adjusted dollars.  
Source: USCB 2021-TN8818.

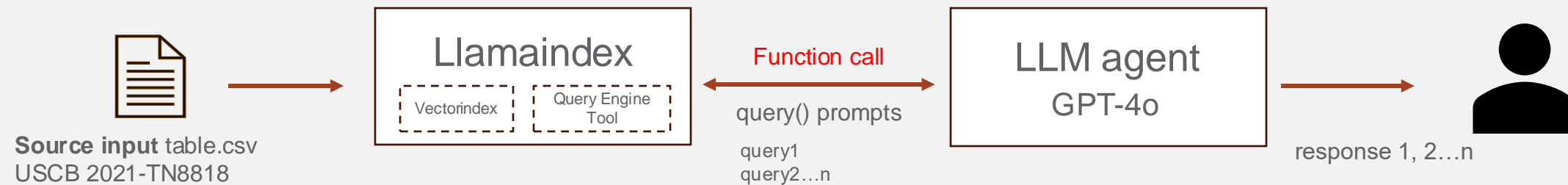
# Language Agents + Human Workflow



- Use NEPA guidance and historical EIS to prompt the LLM agent
- Iteratively improve the generated blueprint response



# Language Agents Workflow: Retrieval



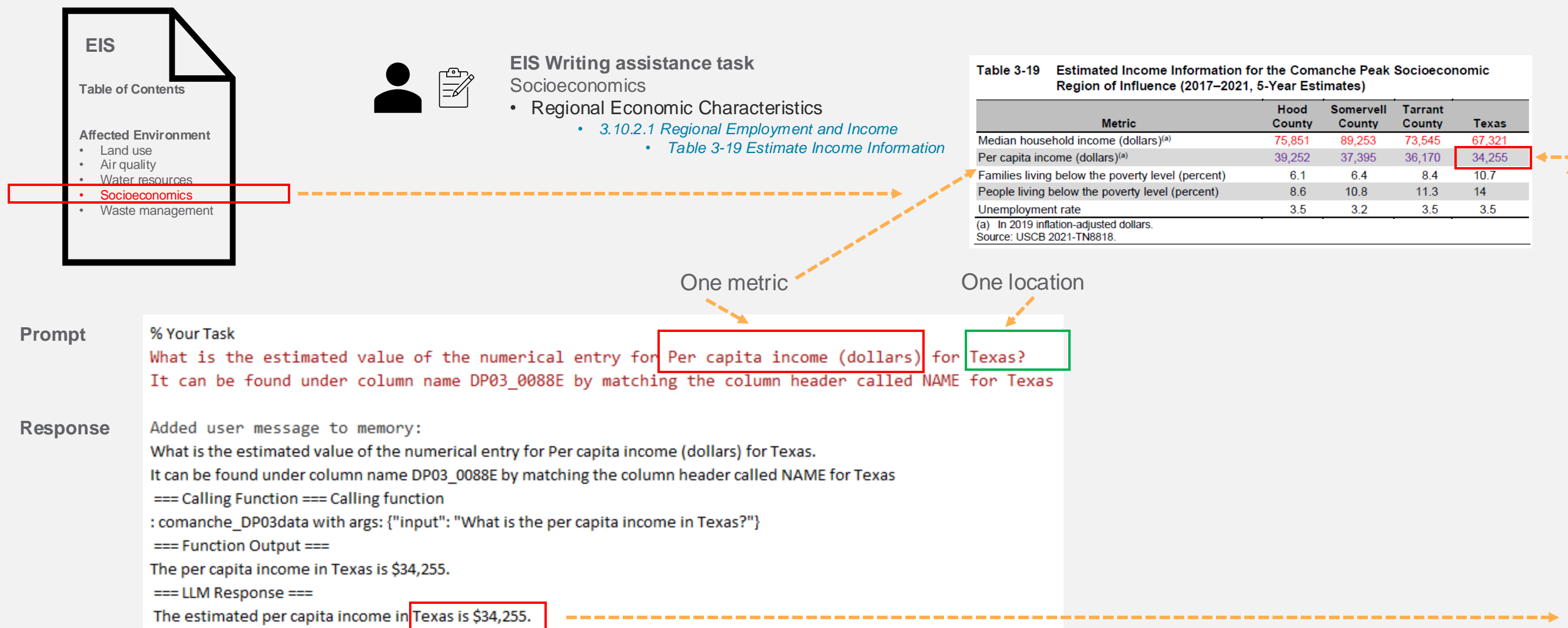
GEO_ID	NAME	DP03_0062E	DP03_0088E	DP03_0119PE	DP03_0128PE	DP03_0005PE
0400000US48	Texas	67321	34255	10.7	14	3.5
0500000US48221	Hood County, Texas	75851	39252	6.1	8.6	3.5
0500000US48425	Somervell County, Texas	89253	37395	6.4	10.8	3.2
0500000US48439	Tarrant County, Texas	73545	36170	8.4	11.3	3.5

## Agent Instructions

```
template="""
% System prompt
You are a specialized agent designed to answer queries about regional employment & income.
You must ALWAYS use at least one of the tools provided when answering a question.
Do NOT rely on prior knowledge.
Answer queries related to estimated income info;
socioeconomic region of influence 2017-2021, 5-year estimates
```

# Language Agents Workflow: Retrieval

1x Metric, 1x Location



Repeat the LLM agent prompt process to retrieve the metric for every region.

# Language Agents Workflow: Retrieval

## 1x Metric, 4x Locations

### Prompt

% Your Task

What is the estimated value of the numerical entry for unemployment rate for Texas, Hood County, Somervell County, and Tarrant County.  
It can be found under column name DP03\_0005PE by matching the column header called NAME for Texas, Hood County, Somervell County, and Tarrant County.

### Response

Added user message to memory:

What is the estimated value of the numerical entry for unemployment rate for Texas, Hood County, Somervell County, and Tarrant County.

It can be found under column name DP03\_0005PE by matching the column header called NAME for Texas, Hood County, Somervell County, and Tarrant County.

=== Calling Function ===

Calling function: comanche\_DP03data with args: {"input": "What is the estimated unemployment rate for Texas?"}

=== Function Output ===

The estimated unemployment rate for Texas is 3.5%.

=== Calling Function ===

Calling function: comanche\_DP03data with args: {"input": "What is the estimated unemployment rate for Hood County?"}

=== Function Output ===

The estimated unemployment rate for Hood County is 3.5%.

=== Calling Function ===

Calling function: comanche\_DP03data with args: {"input": "What is the estimated unemployment rate for Somervell County?"}

=== Function Output ===

The estimated unemployment rate for Somervell County is 3.2%.

=== Calling Function ===

Calling function: comanche\_DP03data with args: {"input": "What is the estimated unemployment rate for Tarrant County?"}

=== Function Output ===

The estimated unemployment rate for Tarrant County is 3.5%.

=== LLM Response ===

The estimated unemployment rates are as follows:

- Texas: 3.5% - Hood County: 3.5% - Somervell County: 3.2% - Tarrant County: 3.5%

Agent  
automatically  
decomposing  
question into  
sub parts

Use one LLM agent prompt to retrieve the metric for all 4 regions.



# Language Agents Workflow: Retrieval

## 5x Metrics, 4x Locations

### Prompt

#### % Your Task

What are the values of the metrics for median household income, per capita income, families living below the poverty line, people living below the poverty line and unemployment rate for Hood, Somervell, Tarrant County and Texas. The numerical values for each metric can be found under column names DP03\_0062E, DP03\_0088E, DP03\_0119PE, DP03\_0128PE, and DP03\_0005PE respectively by matching the column header called NAME for Hood County, Somervell County, Tarrant County and Texas.

### Response

- Unemployment Rate: 3.5%  
Here are the estimated values for the specified metrics for Hood County, Somervell County, Tarrant County, and Texas:

#### \*\*Hood County, Texas:\*\*

- Median Household Income: \$75,851
- Per Capita Income: \$39,252
- Families Living Below the Poverty Line: 6.1%
- People Living Below the Poverty Line: 8.6%
- Unemployment Rate: 3.5%

#### \*\*Somervell County, Texas:\*\*

- Median Household Income: \$89,253
- Per Capita Income: \$37,395
- Families Living Below the Poverty Line: 6.4%
- People Living Below the Poverty Line: 10.8%
- Unemployment Rate: 3.2%

#### \*\*Tarrant County, Texas:\*\*

- Median Household Income: \$73,545
- Per Capita Income: \$36,170
- Families Living Below the Poverty Line: 8.4%
- People Living Below the Poverty Line: 11.3%
- Unemployment Rate: 3.5%

#### \*\*Texas:\*\*

- Median Household Income: \$67,321
- Per Capita Income: \$34,255
- Families Living Below the Poverty Line: 10.7%
- People Living Below the Poverty Line: 14%

**Table 3-19 Estimated Income Information for the Comanche Peak Socioeconomic Region of Influence (2017–2021, 5-Year Estimates)**

Metric	Hood County	Somervell County	Tarrant County	Texas
Median household income (dollars) <sup>(a)</sup>	75,851	89,253	73,545	67,321
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People living below the poverty level (percent)	8.6	10.8	11.3	14
Unemployment rate	3.5	3.2	3.5	3.5

(a) In 2019 inflation-adjusted dollars.  
Source: USCB 2021-TN8818.

Use one LLM agent prompt to retrieve five metrics for all 4 regions.

Single Agent

# Public Scoping Comment Analysis



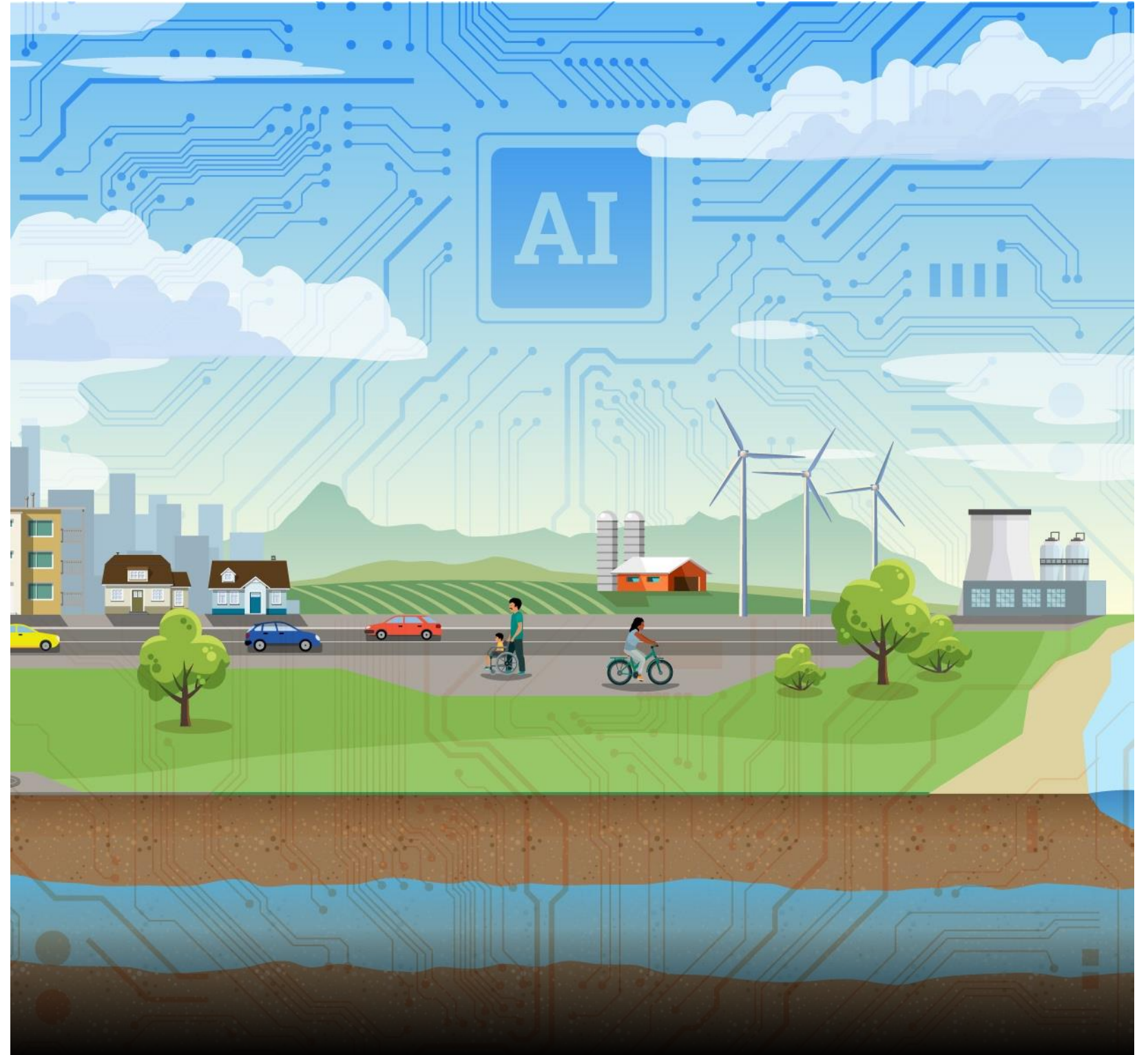
Sai Munikoti



Mike Parker  
(SME)



Dan Nally  
(SME)



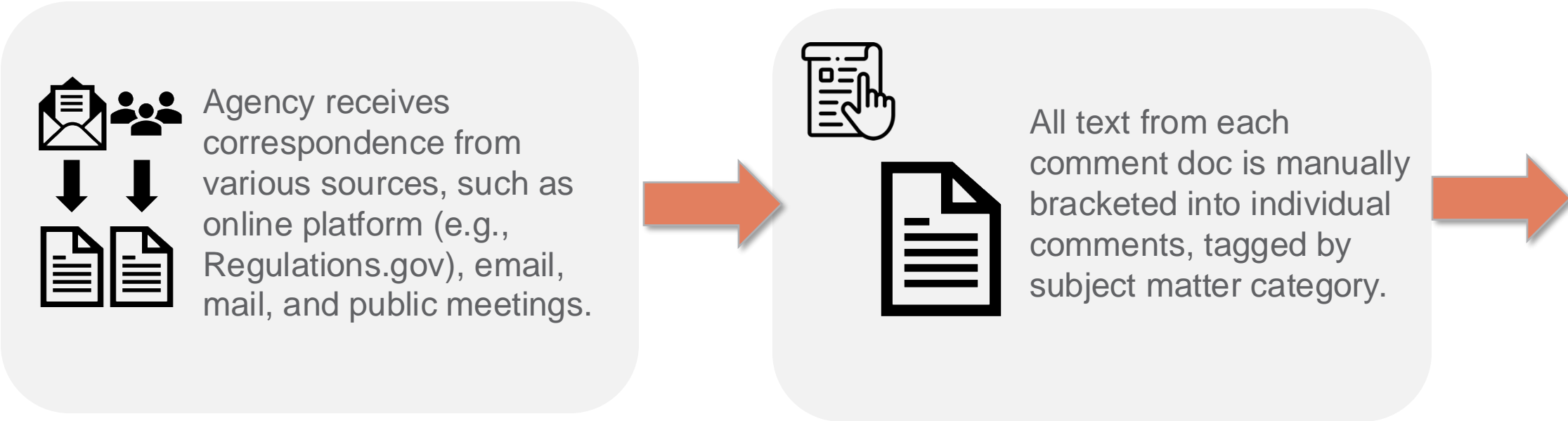
# Public Scoping Comment Analysis

- Public scoping comments are typically collected through public scoping meetings, written submissions (mail, email, website), verbal comments provided to court reporters at meetings, comment forms distributed at public meetings.
  - Identify relevant issues and concerns from the public
  - Determine the scope of issues to be addressed in the EIS
  - Identify significant issues related to the proposed action
  - Help focus the EIS on important environmental issues
- Main challenges in the human processing workflows
  - When multiple agencies are involved as joint leads, coordinating approvals and reconciling different perspectives can be time-consuming
  - Various agencies may have different requirements or approaches to the EIS process
  - The number of comments received during public scoping can be overwhelming to process and analyze effectively



# Human Workflow

Summary report  
Draft EIS report



**M.2 Summary of Comments and Responses**

**M.2.1 Scope of Analysis**

Comments in this category related to the scope of BLM’s analysis, including the appropriateness of programmatic NEPA, the purpose and need for the plan, and the identification of the planning and decision areas for analysis.

**M.2.1.1 Purpose and Need**

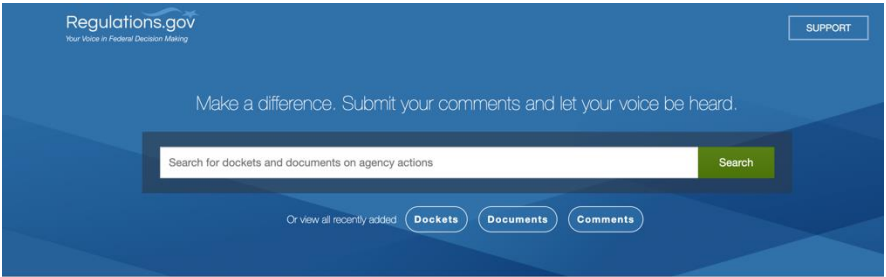
*Summary:*

These comments provided input on the purpose and need for the proposed action, including the appropriateness or legality of conducting programmatic land use planning as opposed to planning at a state- or field-office level. Many commenters thought that the purpose and need was too narrow and that the Programmatic EIS failed to consider a full range of alternatives. Some comments expressed concern that this Programmatic EIS defers analysis to project-specific NEPA, and commenters questioned the value of this Programmatic EIS. Other comments suggested that transmission rights-of-way should be more specifically included within the scope of the plan; that the 11-state planning area is too extensive and does not allow for an appropriate level of analysis; that greater detail is needed as to how resource management plans (RMPs) will be amended; and that this EIS should provide guidance for field offices to apply in separate RMP amendments.

*Response:*

A purpose and need statement shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action. (40 CFR 1502.13.) This planning effort supports the BLM’s administration and management of public lands under the principles of multiple use and sustained yield and responds to direction in the Energy Act of 2020 and relevant Executive Orders on environmental justice and clean energy. The purpose and need statement described in Section 1.1.1 of the Final Programmatic EIS was developed consistent with the BLM’s responsibilities under FLPMA and NEPA. BLM’s land use planning regulations allow planning at any appropriate geographic scale. See 43 CFR 1610.1(b) (“A resource management plan shall be prepared and maintained on a resource or field office area basis, *unless the State Director authorizes a more appropriate area.*”) (emphasis added). See also BLM Land Use Planning Handbook (“State Directors may also establish regional planning areas that encompass several field offices and/or states, as necessary.”). The planning area here, defined in coordination with relevant BLM state directors, includes 11 Western states experiencing increasing interest in solar energy development. This planning area facilitates consistency across states in the West and updates the approach taken in the BLM’s 2012 Western Solar Plan. Further, FLPMA (at 43 USC 1712(a)) directs the *Secretary of the Interior* to develop, maintain, and revise land use plans. While the Secretary has delegated land use planning authority to BLM Field Managers and State Directors through the planning regulations (43 CFR 1601.0-4),

PNNL’s Comment Response Management System  
Regulations.gov

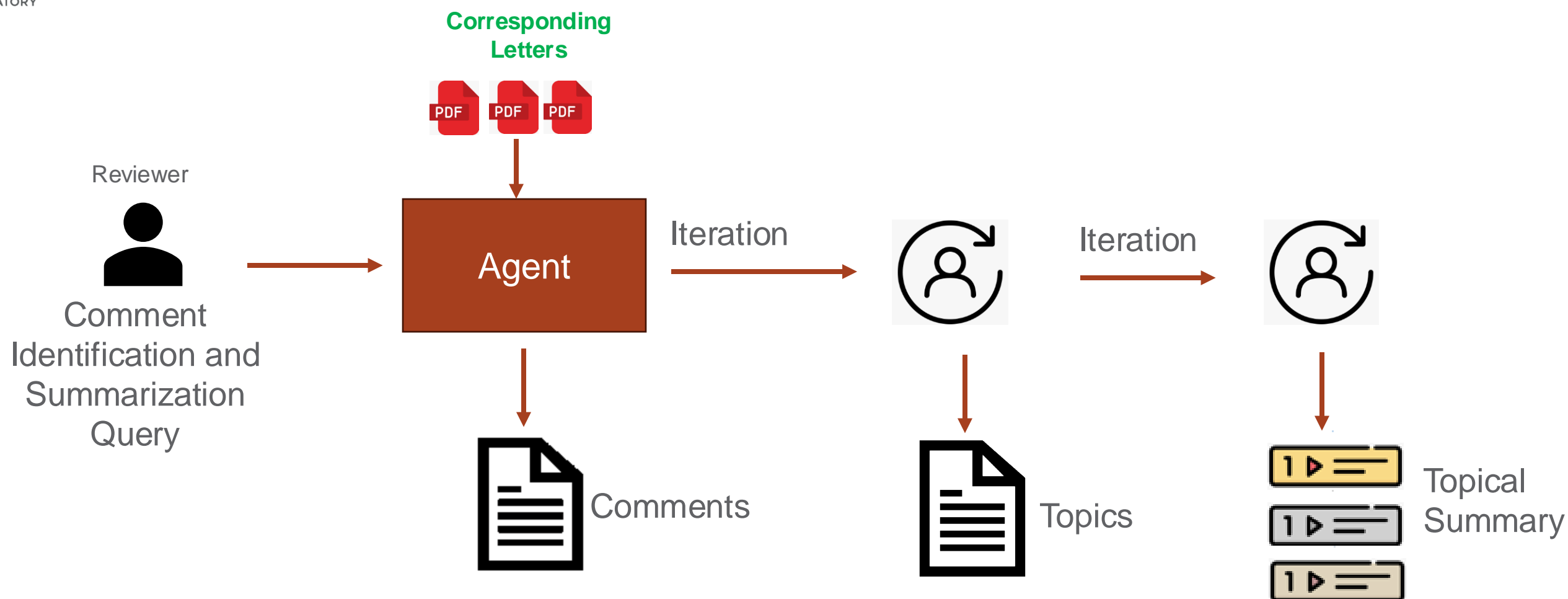


Tedious  
Time/Resource intensive

Table 7-4. Draft Programmatic EIS Comment Categories and Number of Comments in Each Category

Comment Category	Number of Comments (Total = 4,329)	% of Comments	Appendix M Section
Scope of Analysis	458	10.6%	M.2.1
Purpose and Need	88	2.0%	M.2.1.1
Multiple Use	67	1.5%	M.2.1.2
Project-Specific NEPA	132	3.0%	M.2.1.3
Eliminating the Variance Process	19	0.4%	M.2.1.4
Exclusion of DRECP	4	0.1%	M.2.1.5
Expanded Planning/Decision Area	18	0.4%	M.2.1.6
Exclusion of CSP technologies	4	0.1%	M.2.1.7
Removal of Solar Insolation Criteria	7	0.2%	M.2.1.8
Definition of Utility-Scale	8	0.2%	M.2.1.9
Projects under Review	39	0.9%	M.2.1.10
RFDS	67	1.5%	M.2.1.11
Existing Priority Areas including SEZs	5	0.1%	M.2.1.12
Alternatives	720	16.6%	M.2.2
Range and Comparison of Alternatives	115	2.7%	M.2.2.1
Other Suggested Alternatives	196	4.5%	M.2.2.2
Preferred Alternative	409	9.4%	M.2.2.3

# Language Agents + Human Workflow



Prompt: *This set of correspondence contains quotes that will be used to populate a NEPA scoping summary report. That report will be organized by resource areas (e.g., Environmental Justice, NEPA Policy, Air Quality). With that in mind, I need this correspondence to be broken into discrete delineated quotes by NEPA-relevant resource areas. If a quote does not fit any category, list that quote at the beginning under the heading “Not Applicable”. The content should be formatted as a table where column 1 would have a relevant section title and column 2 would contain the quote from the correspondence that fits in that section.*

# Experimental Setup

- **Task:** Group and summarize public comments
- **Data Sources:**
  - Two projects w/ 100+ corresponding letters
  - 16K+ human annotated comments extracted from PNNL's Comments Response Database
  - 20+ annotated topics
- **Implementation:** Llamaindex, GPT-4 as agent
- **Expected Output:** Identified Comments and Topical Summary

# Language Agents + Human Workflow

## Comment Identification and Topics

### Successful Instance

Specific NEPA terms related to hydrology, geology, and aging.

Section	Quote <sup>(a)</sup>
Public Meetings/Hearings	"The Date XX, 20XX in-person meeting was canceled in favor of an online meeting, therefore, we are requesting an in person in Redacted County so residents and other concerned citizens can directly interact with agency staff. There were multiple technical issues with the presentation and many speakers were not able to unmute and speak."
Public Meetings/Hearings	"We request a formal hearing due to the aging nature of the plant for safety reasons."
Comment Period Extension	"We request an extension for comment period for the XX/XX/20XX Federal Register Notice."
Safety – Plant Aging	"There are too many safety issues concerning cracks in the foundation, cracks in pipes, the dome, the spillway, and "loss of material," on the dam."

(a) content has been manually sanitized and redacted.

### Unsuccessful instance

containing metadata or non-relevant sections

Category	Verbatim Quote <sup>(a)</sup>
Contact Information	"Please send our office an electronic copy of the Draft EIS when it is electronically filed with the Office of Federal Activities using the following link: <a href="https://www.agency.gov/nepa/e-nepa-guide-registration-and-preparing-eis-electronic-submission">https://www.agency.gov/nepa/e-nepa-guide-registration-and-preparing-eis-electronic-submission</a> . If you have any questions, please contact....
Signatory	"Digitally signed by ..... Date: 2023.01.23
Email Correspondence	"From: Doe, John John.Doe@xxxx.gov Sent: Tuesday, January 24, 2023 9:14 AM To: XXXXXXXXXX Resource Cc: Jack Doe; Jason Doe Subject: [External_Sender] Agency Scoping Comment Letter for the Power Plant Attachments: Agency Scoping Comments for Power Plant.pdf"



# Language Agents + Human Workflow

## Multi-Document Comment Summarization

### Summary Prompt

The table below categorizes public scoping comments with the scoping summary report section name in column 1, comments in column 2, and the comment number in column 3. For each section, prepare a concise narrative summary of the key concerns, questions, and information conveyed in the comments.

The content should be formatted as a report, with sections listed as headings in the order they appear in the table.

Section Title	Comment	Comment Number
B.1.1 Postulated Accidents	Severe accidents must not be discounted simply because agency assumptions deem them unlikely. Plausible worst case scenarios mandate evaluation and transparent disclosure to the public.	38-17
B.1.2 Alternative – No-Action	We would also ask the agency to consider alternatives including no renewal, renewal and a renewal of less time.	37-7
Etc.	Etc.	Etc.

### Agent Output

Here is the narrative summary of the public scoping comments formatted as a report.

#### B.1 Comments on the Resource Areas

##### B.1.1 Postulated Accidents

Comment Summary (Accidents – SAMAs): Commenters expressed concerns regarding accidents at the energy plant. One commenter requested that the plausible worst-case scenarios be disclosed to the public. Another commenter expressed concern about accidents releasing airborne toxins.

Comments: (38-17) (76-2)

##### B.1.2 Alternative – No – Action

Comment Summary: A commenter requested that the agency consider not renewing the operating license or consider a shorter period for operating license renewal for the energy plant: (37-7) (37-9)

Comment Summary (No - Action – Decommissioning): Commenters expressed concerns about decommissioning including the impacts of decommissioning, particularly the economic impacts, costs for decommissioning, and waste management.

Comments: (29-13-4) (38-25) (51-2) . . .

Multiple Agents

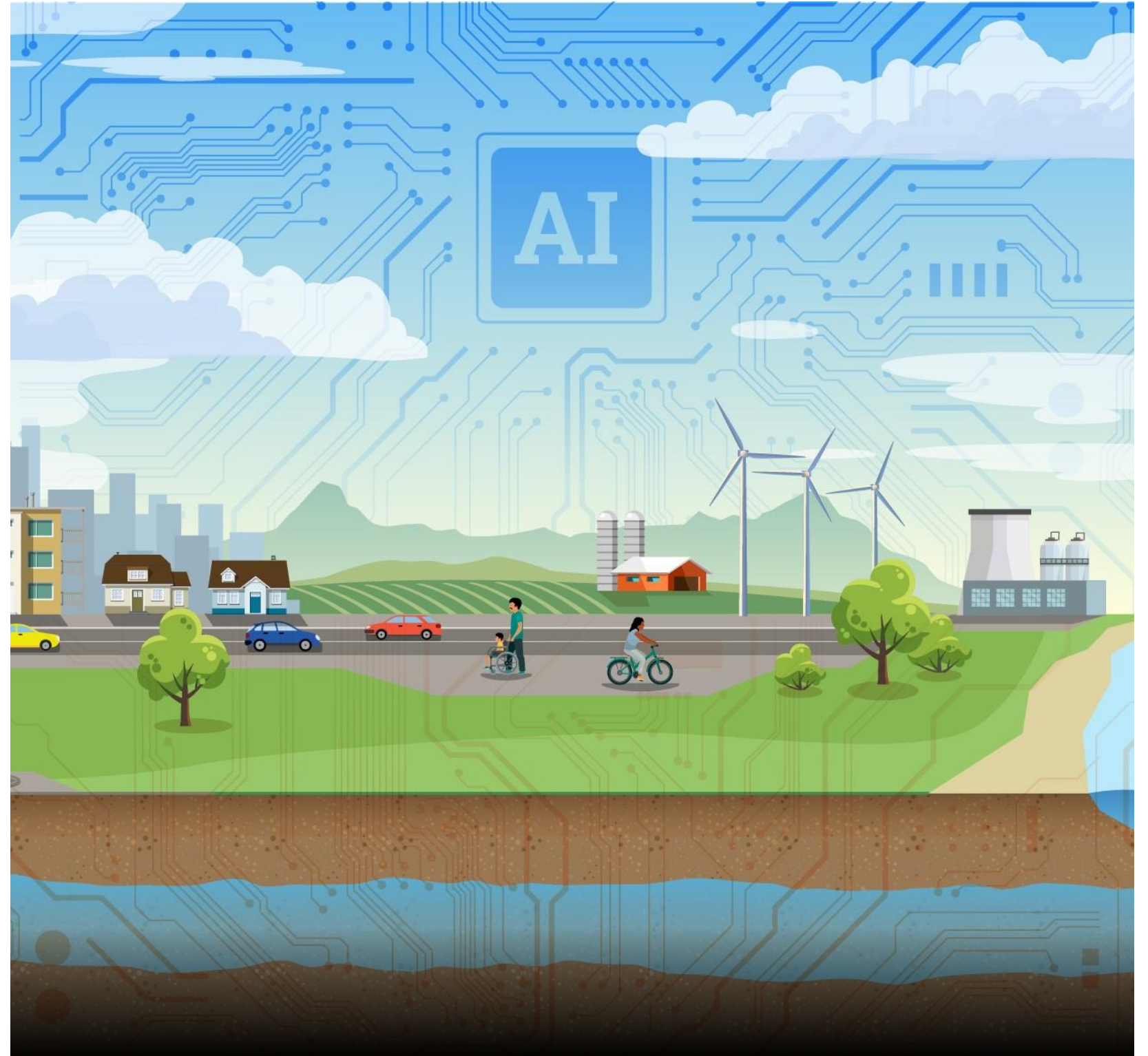
# Coding Ordinances



Sai Koneru

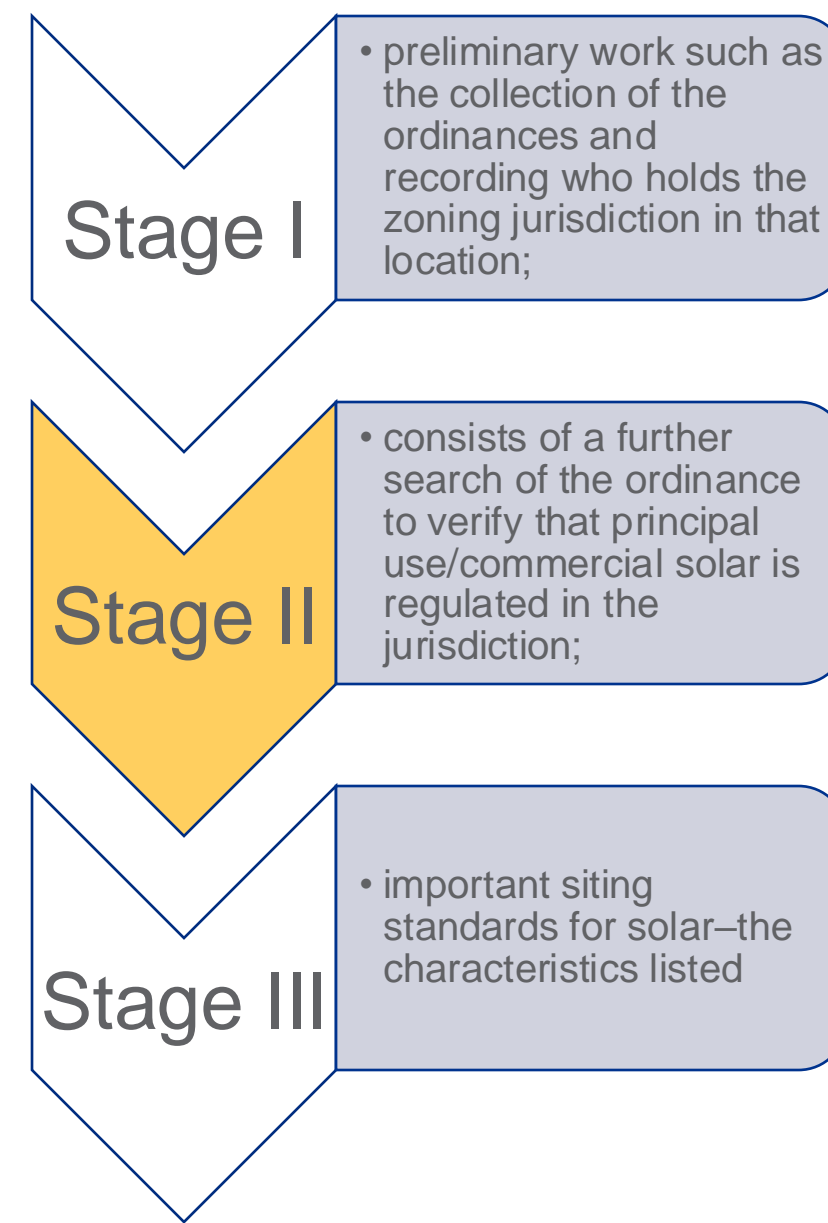


Sai Munikoti



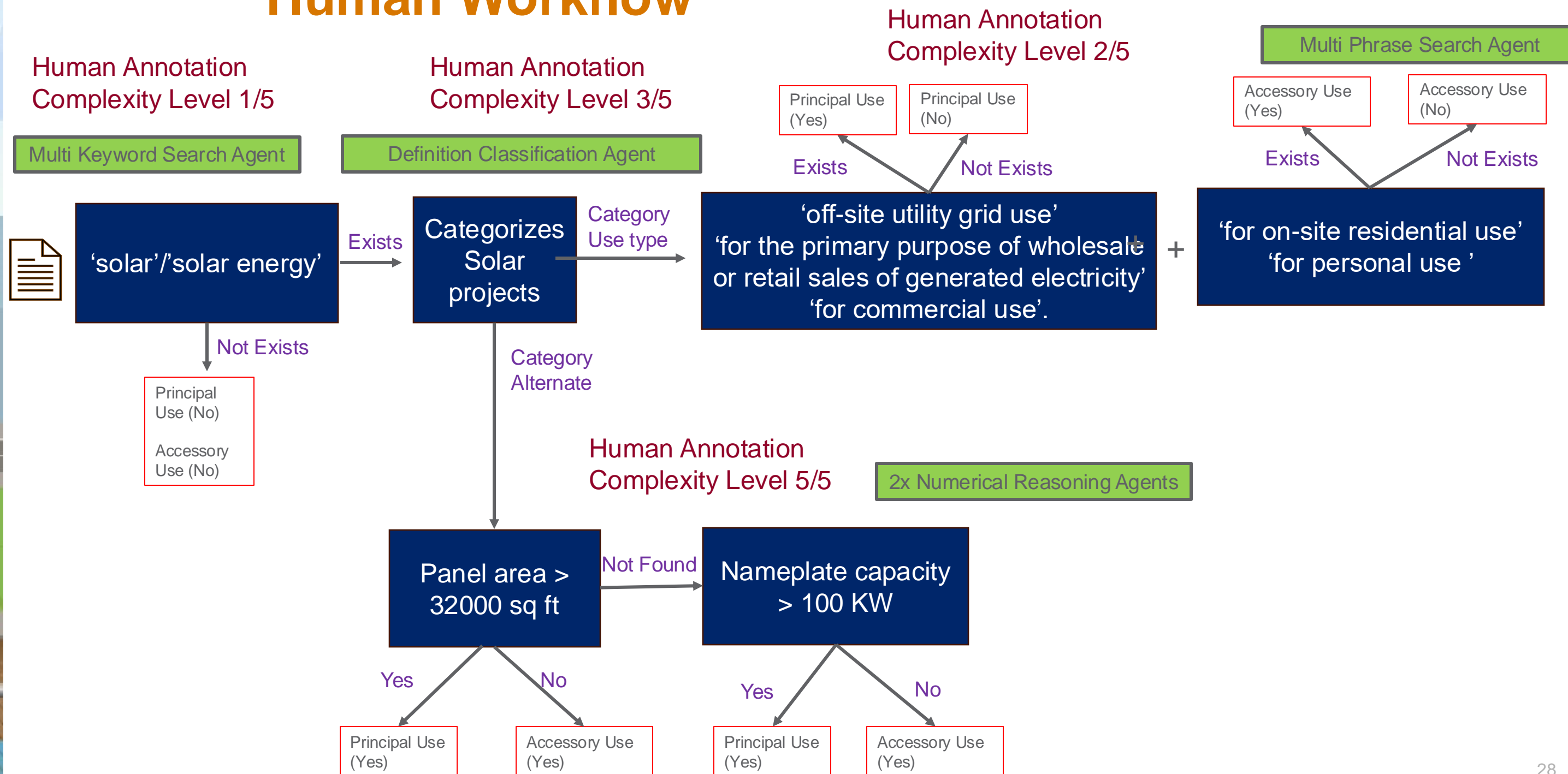
# Coding Ordinances

- Extract and classify complex and context specific information from zoning and ordinance documents to enhance data transparency
- Identify if a jurisdiction regulates solar energy projects for Principal and Accessory Use
  - **Principal Use (PU):** Activities relevant to the dominant/primary intent of use for that parcel. e.g., a solar farm that is used to supply electricity to the grid
  - **Accessory Use (AU):** Secondary and incidental. e.g., a solar panel on a rooftop to provide electricity for onsite consumption





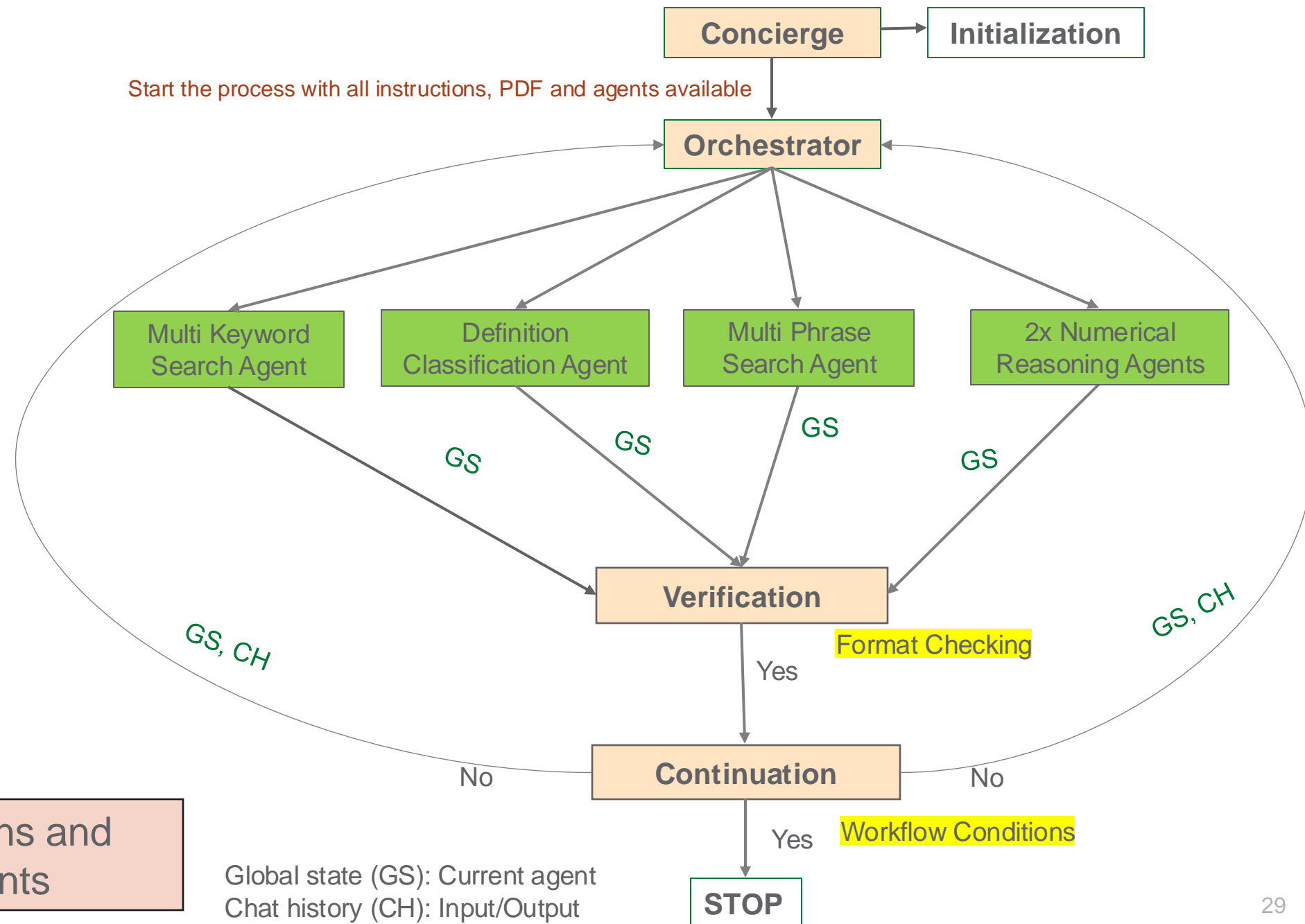
# Human Workflow





# Language Agents Workflow

- 9x Agents
- Assistance: 4 agents
  - Concierge
  - Orchestrator
  - Verifier
  - Continuation checker
- Extraction: 5 agents
  - Keyword search
  - Definition classification
  - Phrase search
  - Panel area extraction
  - Nameplate capacity



Following Exact Human Instructions and Workflows with Language Agents

Global state (GS): Current agent  
Chat history (CH): Input/Output

# Language Agents Workflow

## Agent 1

Multi  
Keyword  
Search Agent

### Prompt:

You are a helpful assistant that is looking up if a given ordinance document contains **key words solar, solar energy**. If the ordinance doesn't mention either solar or solar energy in the context of a renewable energy project, mark it as "no".

Based on your look up, your answer *\*must\** be of the following format: {"solar": <"yes", "no", or "unsure">}

If you are not sure about the answer respond as "unsure".

### Post extraction:

```
if response == "YES"  
    GS.task_status = "unfinished"  
    GS.current_agent = "orchestrator to definition  
classification"  
else if response == "NO":  
    GS.task_status = "finished"  
else:  
    GS.task_status = "unfinished"  
    GS.current_agent = "orchestrator"
```

```
Running step concierge  
Step concierge produced event InitializeEvent  
Running step initialize  
Step initialize produced event ConciergeEvent  
Running step concierge  
Step concierge produced event OrchestratorEvent  
Running step orchestrator  
Orchestrator received a request  
__emitted: search for energy  
orchestrator response is The energy source type for the project has been successfully identified in the document.  
Step orchestrator produced no event  
Running step determine_energy_type  
Received request to identify the energy type: corresponding to search solar/solar energy  
keyword lookup result: {  
  'solar': <yes, no, or unsure>,  
}  
Step determine_energy_type produced event VerificationEvent  
Running step verifier
```

Sample log showing different steps in workflow

# Language Agents Workflow

## Agent 2

Definition  
Classification  
Agent

Prompt:

You are a document reading agent.

Your job is to read an ordinance document carefully and identify how the specific solar regulations categorize a project.

Generally, one can find this under the 'Definitions' section, or often, the specific solar regulations section will include a description of how they categorize a project. Localities often categorize project based on:

**a. Use type: is the electricity generated being used onsite or offsite for utility purposes.**

**b. Alternate criterion: definition includes an alternate criterion with no mention of use type e.g. nameplate capacity, area. These require judgment calls around thresholds, like should a project over 40,000 sq ft be classified as Principal use or a wind turbine height of under 170 ft is considered as an Accessory use.**

c. Note: There will be times where projects might be classified nominally such as small, medium or large based on size, nameplate capacity but use type is outlined for each category. Utilize use type as criteria then.

d. If renewable energy system is listed in 'Definitions' section, but is mentioned nowhere else in the zoning ordinance, reply "no" but write in notes "mentioned in definitions"

Your response must be one of the following format:

```
{"solar_use_type": <"yes" or "no" or "unsure">,"solar_alternate_criterion":  
<"yes" or "no" or "unsure">}
```

If you did not extract any information, return the string "FAILED" without quotes and why you couldn't extract any information.

Post extraction:

```
if response['use_type'] == "YES":  
    GS.task_status = "unfinished"  
    GS.current_agent = "orchestrator to multi  
phrase search (use type)"  
else if response['alternate_criterion'] == "YES":  
    GS.task_status = "unfinished"  
    GS.current_agent = "orchestrator to numerical  
reasoning (panel area / name plate capacity)"  
else:  
    GS.task_status = "unfinished"  
    GS.current_agent = "orchestrator"
```

# Language Agents Workflow

## Agent 3

Multi Phrase Search  
Agent

Prompt:

You are a document reading agent. Your job is to read an ordinance document carefully and identify if the document classifies Principal Use or Alternate Use for a renewable energy project. Generally, one can find this under the 'Definitions' section, or often, the specific solar regulations section will include a description of how they categorize a project. Localities often categorize project based on use type: is the electricity generated being used onsite or offsite for utility purposes. If the definition is based on use type, our job is relatively easy.

- a. **Identify as Principal Use if the definition includes keywords like: 'off-site utility grid use', 'for the primary purpose of wholesale or retail sales of generated electricity', 'for commercial use'.**
- b. **Identify as Accessory Use if the definition includes keywords like: 'for on-site residential use', 'for personal use'**

Your response must be one of the following format: {"Principal Use": <"yes" or "no" or "unsure">,"Accessory Use": <"yes" or "no" or "unsure">}

If you did not extract any information, return the string "FAILED" without quotes and why you couldn't extract any information.

Post extraction:

```
if Principal Use == "YES" or "NO" and Accessory Use == "YES" or "NO":  
    "Principal Use": "Yes/No"  
    "Accessory Use": "Yes/No"  
    GS.task_status = "finished"  
else:  
    GS.task_status = "unfinished"  
    GS.current_agent = "orchestrator"
```



# Language Agents Workflow

## Agent 4

Numerical  
Reasoning  
Agent:  
Panel Area

Prompt:

You are a document reading agent. Your job is to read an ordinance document carefully and **identify the required panel area for the solar energy project in square feet.**

Your response must be one of the following format: {"solar panel area": <panel area in square feet>}

If you did not extract any information, return the string "FAILED" without quotes and why you couldn't extract any information.

Prompt:

You are a document reading agent. Your job is to read an ordinance document carefully and **identify the nameplate capacity for the solar energy project in mega watts.**

If you need to convert the units, call the appropriate function available to you.

Your response must be one of the following format: {"solar name plate capacity": <name plate capacity in kilo watt>},

If you did not extract any information, return the string "FAILED" without quotes and why you couldn't extract any information.

Post extraction:

if Panel Area > 32,000:

“Principal Use”: “yes”

GS.task\_status = "finished"

if Panel Area < 32,000:

“Accessory Use”: “yes”

GS.task\_status = "finished"

else:

GS.task\_status = "unfinished"

GS.current\_agent = "orchestrator to nameplate capacity"

## Agent 5

Numerical  
Reasoning  
Agent:  
Nameplate  
capacity

Prompt:

You are a document reading agent. Your job is to read an ordinance document carefully and **identify the nameplate capacity for the solar energy project in mega watts.**

If you need to convert the units, call the appropriate function available to you.

Your response must be one of the following format: {"solar name plate capacity": <name plate capacity in kilo watt>},

If you did not extract any information, return the string "FAILED" without quotes and why you couldn't extract any information.

Post extraction:

if Nameplate capacity < 100 kW:

“Accessory Use” = "Yes"

GS.task\_status = "finished"

else if Nameplate capacity > 100 kW:

“Principal Use” = "Yes"

GS.task\_status = "finished"

else:

GS.task\_status = "unfinished"

GS.current\_agent = "orchestrator"

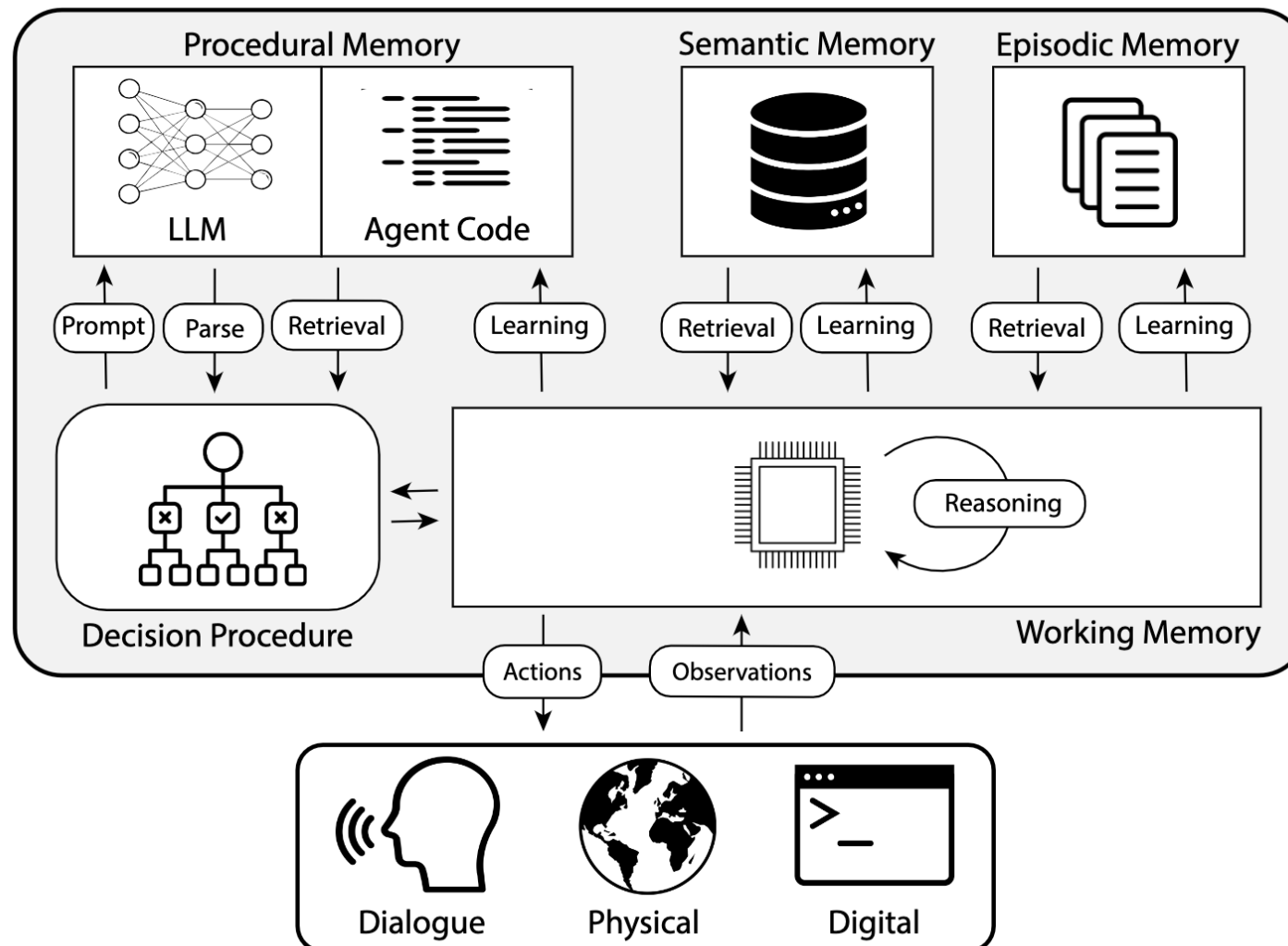
# Experimental Setup

- **Task:** Extract and classify complex and context specific information from zoning and ordinance documents
- **Data Sources:**
  - 1856 ordinance documents from 83 counties as extracted from Energy Zoning Database for 6 Great Lakes states (MI, OH, IN, IL, WI, & MN)
- **Implementation:** LlamaIndex, GPT-4o as agent
- **Expected Output:** Yes/No output to present the solar and principal use in zoning and ordinance documents

Multi Agents Path (Exit Agent)	#Documents	F1 (micro)	
		Principal Use	Accessory Use
Agents #1 (Multi Keyword Search Agent)	627	0.99	0.97
Agents #1 #2 #3 (Multi Phrase Search Agent)	196	0.92	0.85
Agents #1 #2 #4 #5 (Numerical Reasoning Agents)	29	0.52	0.82
Overall	852*	0.96	0.93

# Towards Building Effective Language Agent Systems

## Cognitive Architectures for Language Agents (CoALA)



### Structured and Modular Agents

- Break down complex problems into smaller, manageable subtasks
- Assign specific roles or capabilities to different agents
- Implementing a hierarchy of agents for complex tasks

### Calibration and Alignment

- Provide examples within prompts to guide agent behavior
- Make agents aware of their available tools and knowledge bases
- Design systems for agents to provide and receive feedback



# PolicyAI Team



Sameera  
Horawalavithana  
(PI)



Sai Munikoti  
(Co-PI)



Shivam Sharma  
(Thrust Lead)



Mike Parker  
(Domain Lead)



Dan Nally  
(Domain Lead)



Anurag Acharya  
(Thrust Lead)



Anastasia  
Bernat (Thrust  
Lead)



Sadie  
Montgomery  
(Domain Lead)



Tim Vega  
(Engineering Lead)



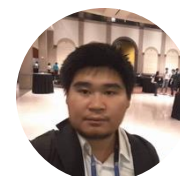
Sridevi Wagle



Derek  
Lilienthal



Sarthak  
Chaturvedi



Phan Hung  
(Past)



Gihan Panapitiya  
(Past)



Rounak Meyur



Sai Koneru



Cameron  
Rutherford



Kathy Nwe



David Hansen



Amanda Reed



Heng (Alfred)  
Wan



Alex Buchko



Karen Dsouza  
(Past)



Srinath Kannan



Reilly Raab

NEPA  
SMEs

Lin Zeng	Cleve Davis
Kim Leigh	Cyler Conrad
Jim Jackson	Caitlin Wessel
Tracy Fuentes	Dave Goodman



Bethel  
Tarekegne (PM)



Mahantesh  
Halappanavar (Advisor)



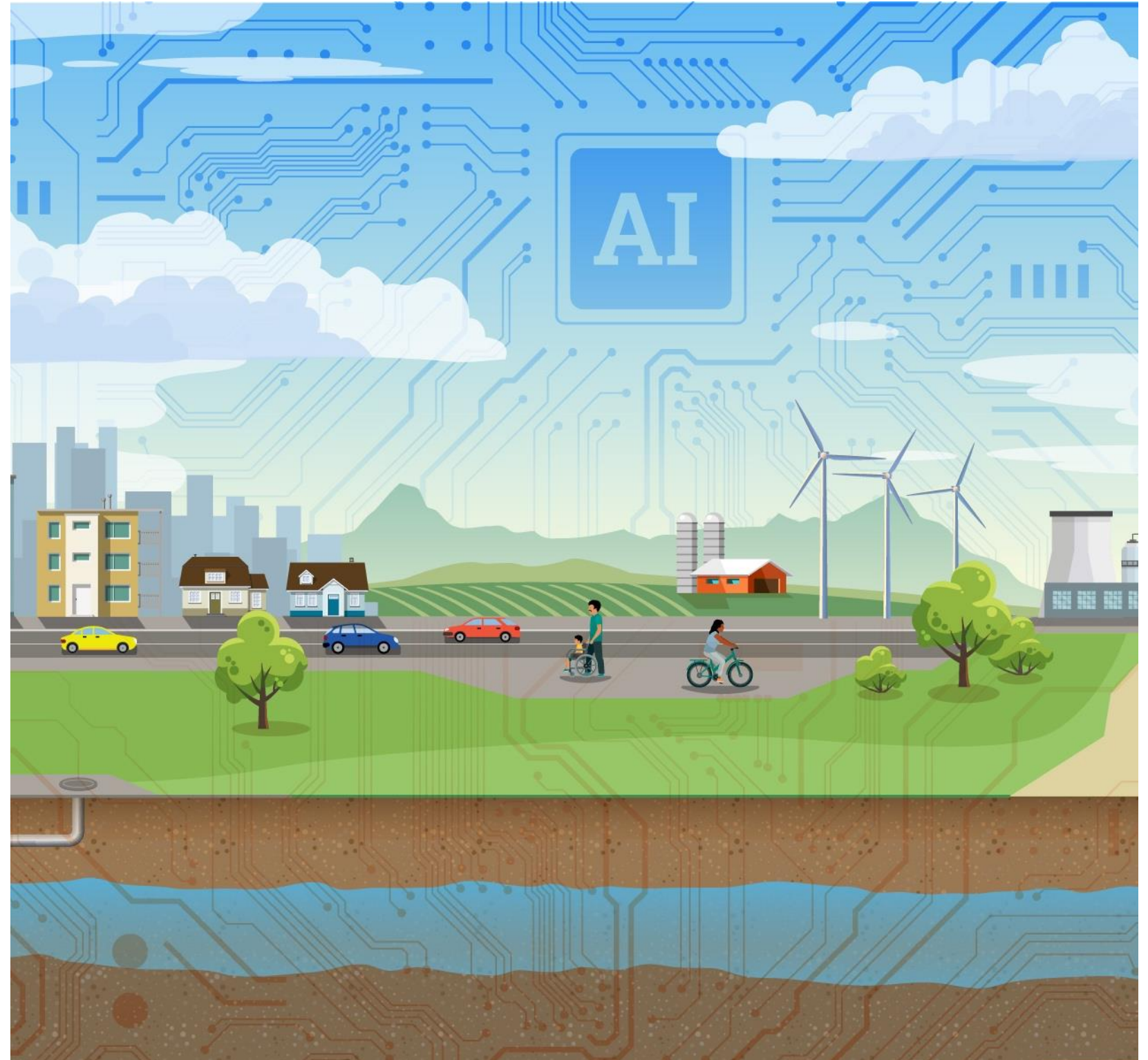
Karl Pazdernik  
(Advisor)



Ann Miracle  
(Advisor)

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# Thank you

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