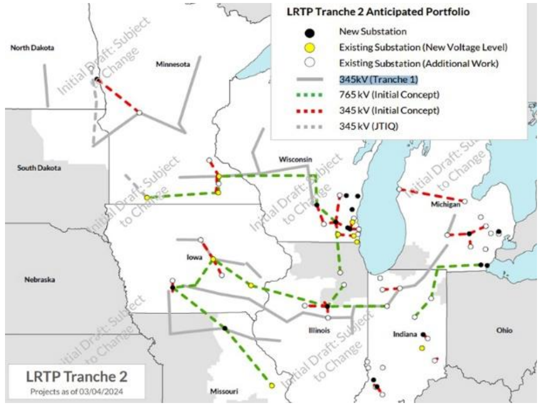
PLAN IOWA ENERGY (PIE)

https://home.engineering.iastate.edu/~jdm/pie/index.htm

Evaluating & Strengthening Iowa's Power Grid for High Wind/Solar Penetration Levels

A 3-Year Project

MISO TRANCHE 1



MISO TRANCHE 2

Project Advisory Board Meeting

Monday, Dec 16, 2024, 3:30-4:30pmCT

James McCalley & Colin Christy, Investigators

Gustavo Cuello-Polo, Yanda Jiang, Charlie Phillips, Dut Ajang, Aladdin Adam, Ph. D. Students

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J. McCalley Project coordinator	C. Christy, Resilience & visions analysis	Y. Jiang, 1800 bus Model and ACEP	G. Cuello-Polo ACEP+GE-MARS	C. Phillips Climate Data and Resilience	D. Ajang Folding Horizon Simulation	A. Adam, impact of inertia on ACEP

Request to PAB Members: Could you pull up an email to jdm@iastate.edu and type your questions /comments on it as we go along? Then, if time runs short, you can just click "send" at the end.

Presentation Overview

1. Project objective & motivation; key tools,… and where we are now
2. 250 bus model, ACEP with resource adequacy, 7 futures
    a. Core investment comparison to Tranche 1
    b. Core investments vs. adaptations
    c. Influence of storage
3. 1800 bus model (with Tranche 1), ACEP, 3 futures
4. Preliminary survey results
5. Next steps

1. PIE Project Objective and Motivation

- Objective:
  - Identify several 20-year plans
    - (what, when, where, how much GTD)
      - to position Iowa's low carbon electric infrastructure to perform well
        - under normal and climate-influenced extreme events & conditions.
          - Compare/contrast to RTO/utility plans.

- Why?
  - Energy planning is done for regions, for utility areas, but not for **Iowa**.
  - Iowans have different **visions** for what they want.
  - Can we "build in" to our models/analyses ability to handle **uncertainty**?
  - Handling **climate change & resilience** in pwr sys planning is a new frontier!

- Some new technological options of interest:
  - Storage (battery and H_2)
  - Demand control
  - Data centers
  - Small modular reactors
  - HVDC
  - Small ICE's that burn various fuels

Iowa's Energy Visions

Vision 1 ➔

Emphasize energy cost

Maintain avg annual R/C/I cost of 12, 10, 6 ¢/kwh (EIA).

Vision 2 ➔

Emphasize CO2 reduction

Cut 2038 CO_2 levels by 80% of 2005 levels

Vision 3 ➔

Emphasize energy export

Produce 2 times in-state electric energy requirements.

Vision 4 ➔

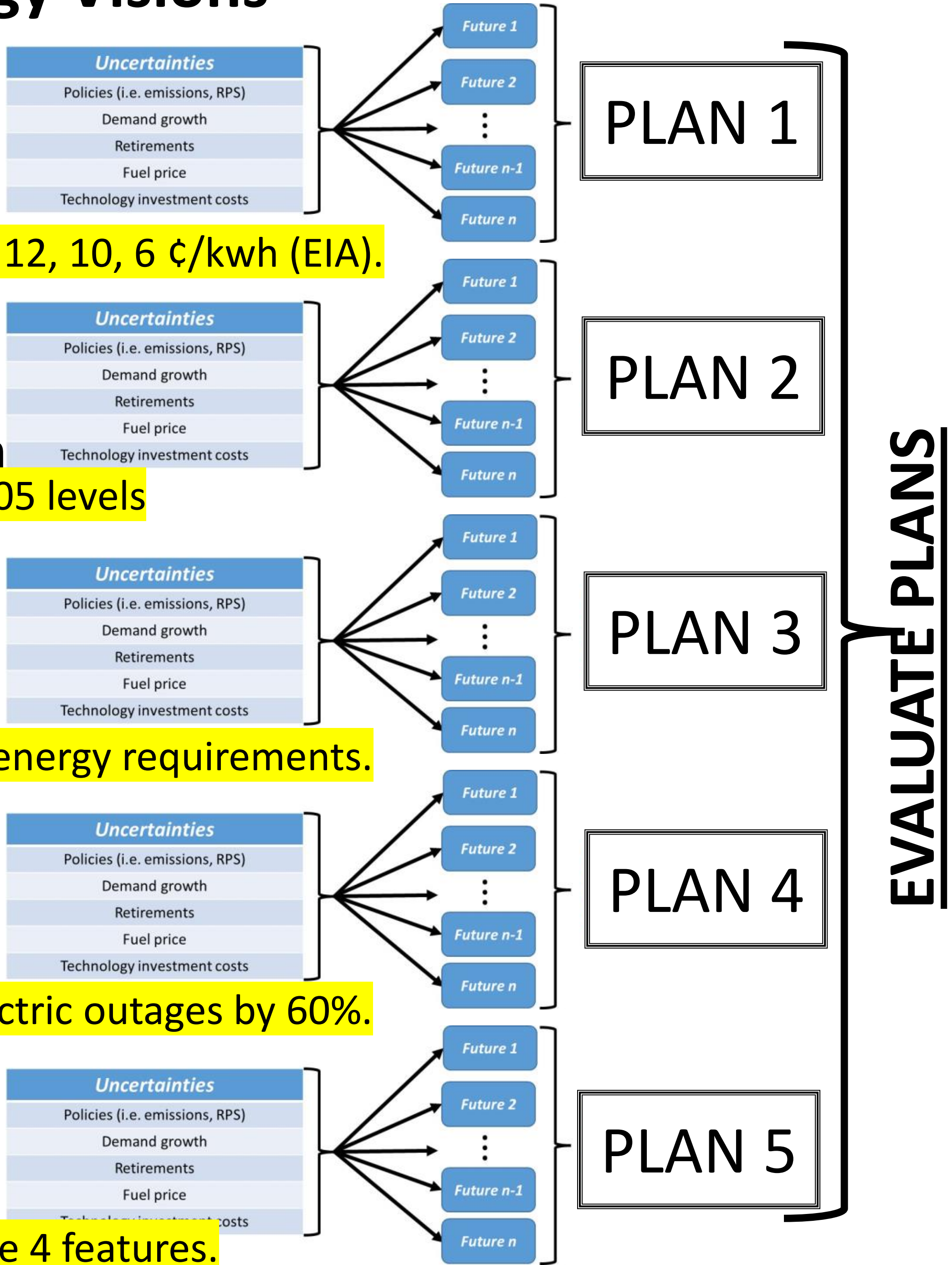
Emphasize resilience

Reduce extreme event cost of electric outages by 60%.

Vision 5 ➔

Balanced

Seek a balanced portfolio of above 4 features.



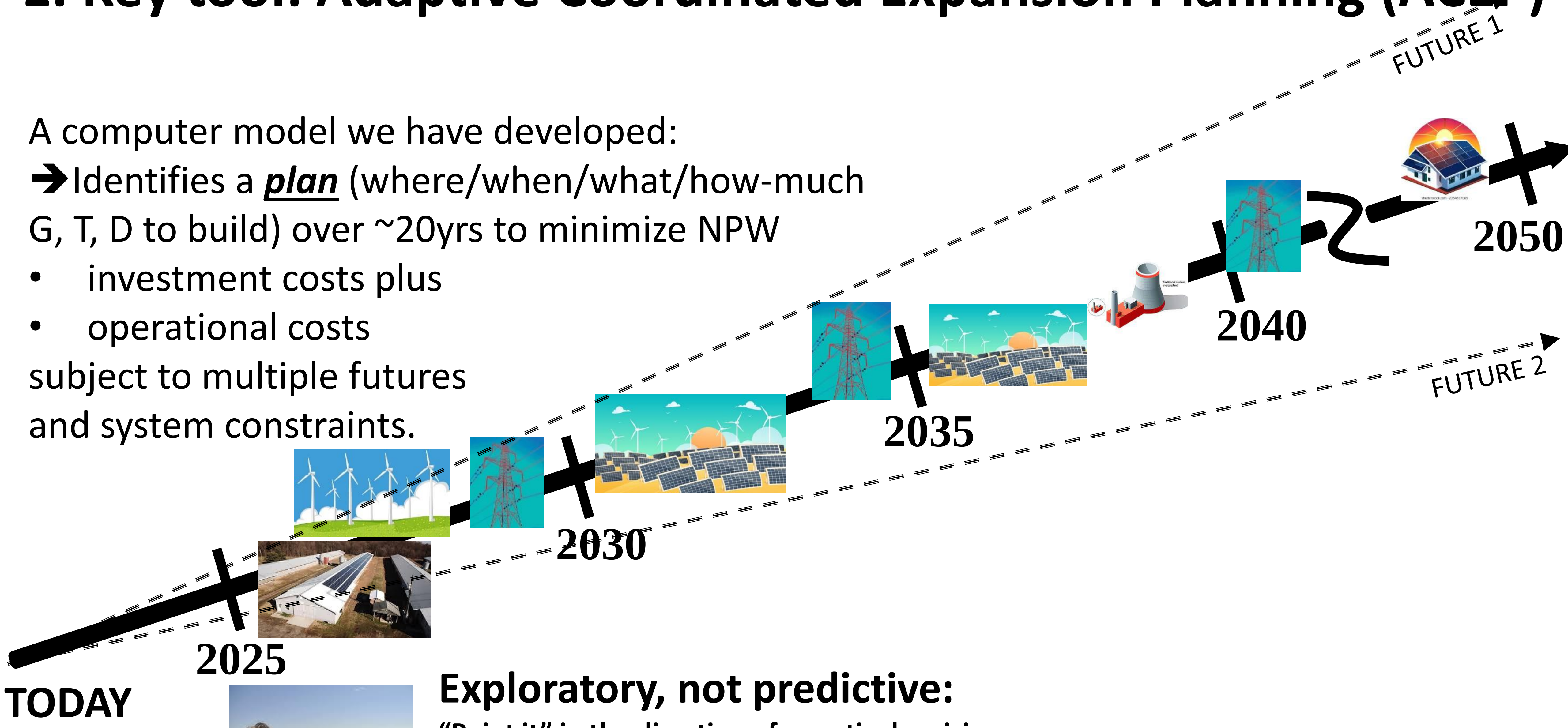
FERC Order 1920A: (Nov. 21, 2024) At least once every 5 years, transmission providers are required to conduct Long-Term Regional Transmission Planning, a process that includes looking ahead over a 20yr transmission planning horizon. *This process further requires developing at least 3 plausible and diverse Long-Term Scenarios that are based upon known drivers of transmission needs, informed by best available data; analyzing impacts of events like extreme weather under each Long-Term Scenario; & evaluating potential Long-Term Regional Transmission Facilities.* This evaluation includes assessing whether these facilities would yield reliability & economic benefits to transmission customers and, if so, identifying those benefits. *Together, these reforms ensure that transmission providers, state regulators, and stakeholders possess the information necessary for each transmission planning region to identify, evaluate, and select (i.e., determine whether to pursue the development of facilities) more efficient or cost-effective transmission facilities that provide significant benefits for customers.* E-1 | RM 21-17-001 | Federal Energy Regulatory Commission

1. Key tool: Adaptive Coordinated Expansion Planning (ACEP)

A computer model we have developed:
➔Identifies a ***plan*** (where/when/what/how-much G, T, D to build) over ~20yrs to minimize NPW

- investment costs plus
- operational costs

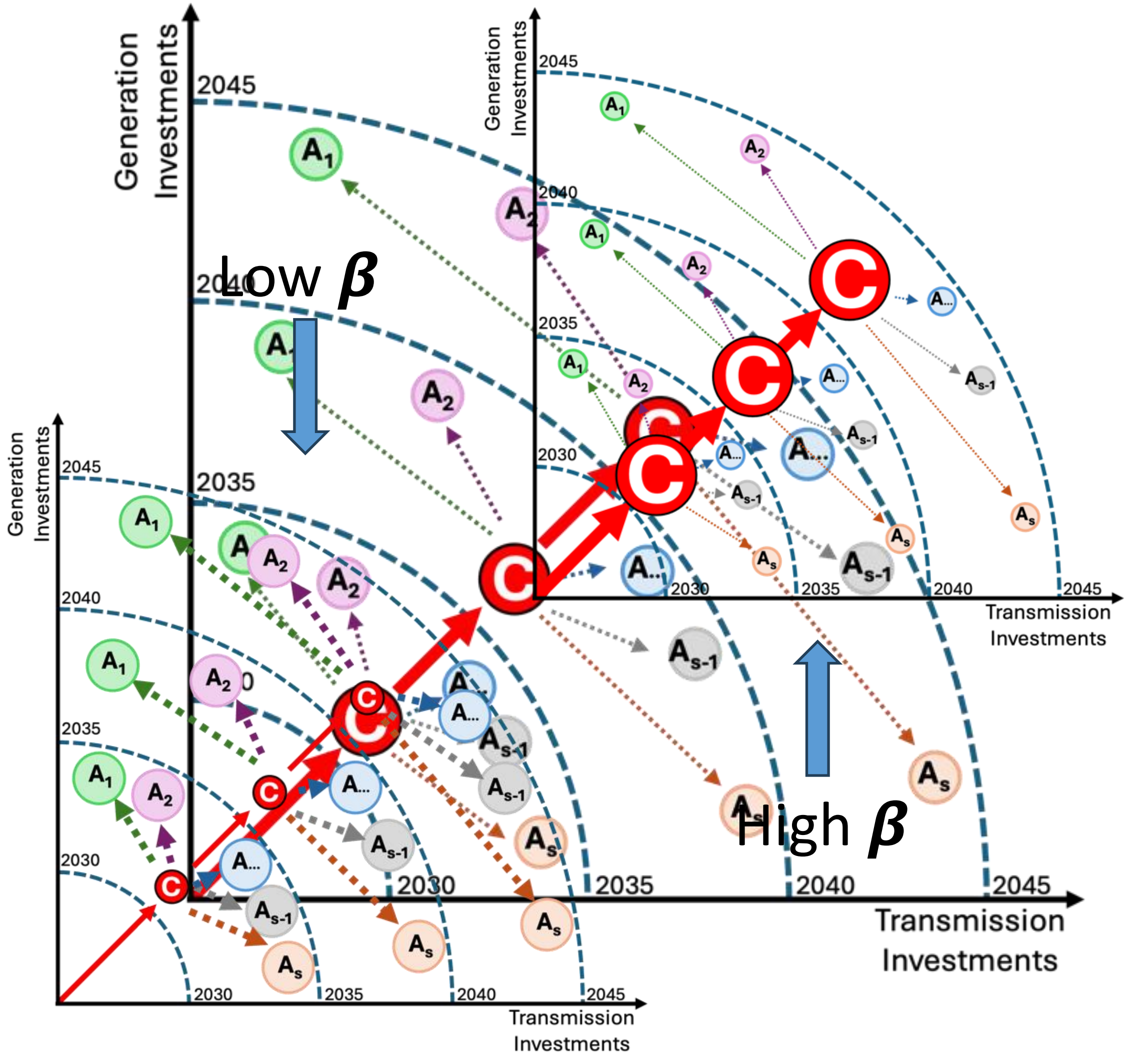
subject to multiple futures and system constraints.



Exploratory, not predictive:

"Point it" in the direction of a particular vision.
Identify several "futures".
It gives least-cost G,T,D plan for that vision subject to specified futures & sys constraints.

1. Key tool: Adaptive Coordinated Expansion Planning (ACEP)



Approach:

Identify generation & transmission investments to:

$$minimize$$
$$[Cost\ of\ Core\ (red)] +$$
$$\boldsymbol{\beta} \times [Prob\{Future\}$$
$$\times\ Cost\ of\ Adapting\ Core\ to\ each\ Future]$$

$subject\ to\ (for\ each\ Future)$

- $network\ flow\ laws, flow\ limits, generation\ limits$
- $reserve\ requirements$
- $environmental\ targets\ or\ constraints$
- $investment\ targets\ or\ constraints$
- $resource\ adequacy\ constraints$

1. Key tool: model reduction process

1. PREPROCESS
a. Trim & map
b. Identify study system
c. Reduce ext system

2. DIVIDE
a. Key branch ID using rolling sim
b. Identify zones

MODEL REDUCTION;
minimize expansion tools compute time; maximize model fidelity

3. RETAIN
Identify buses to keep.

4. ELIMINATE
Apply Ward to each zone.

5. AGGREGATE
a. Topology-based
b. QG

6. ESTIMATE
a. Capacities
b. Exp cost

7. EXPANSION TOOLS

8. TRANSLATION

Expanson Planning Tools used in Step 7 require reduced models

Step	Tool	Purpose	Futures
7	ACEP w/GE-MARS	Identify 20-yr investments w/ resource adequacy target	3-10
7	Resilience-CEP	Identify 20-yr investments w/ extreme events modeled	1
7	Folding horizon sim	Evaluate/refine investment plan wrspt 100 futures	100

Above model reduction procedure implemented twice to build 2 reduced models

# of buses	Source of full network	Compare to…	Purpose	Fidelity level
250	From 2024 HS MMWG	Tranche 1	Tool testing/refinement	Medium
1800	From MISO, w/ Tranche 1	Tranche 2	Final PIE project results	High

1. Project objective & motivation …*and where we are now*

A

Preliminary MISO model (250 buses)	ACEP with GE-MARS

DONE, WILL SHOW RESULTS

B

Final MISO model (1800 buses)	ACEP

IN PROGRESS, WILL SHOW INITIAL RESULTS

C

IN PROGRESS

Tool refinement	ACEP with GE-MARS
	ACEP with resilience
	Folding-horizon simulation

D

NOT STARTED

Identification of G&T plans for each vision	ACEP with GE-MARS
	ACEP with resilience
	Folding-horizon simulation

Planning Results for each Vision

V1 V2 V5 V3 V4

Conclusions /recommen-dations

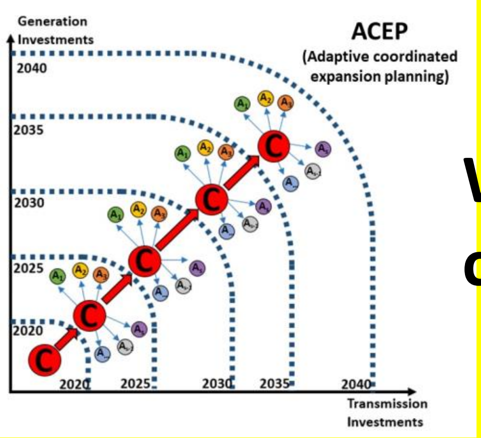
E

ALMOST DONE

Iowa Survey

2. ACEP with resource adequacy (RA)

Adaptive Coordinated Expansion Planning (ACEP)



With PRM constraint

GE-MARS

GE MARS is a full sequential Monte Carlo simulation

Chronological system simulation performed by combining:

- Randomly generated operating histories of units through time
- Hourly chronological load cycles
- Transmission links

Years are simulated until a convergence criterion is met, or for a set number of samples

Applied by season & by MISO LRZ.

LOLE≈ 0.1 days/yr ?

NO → **ADJUST PLANNING RESERVE MARGIN**

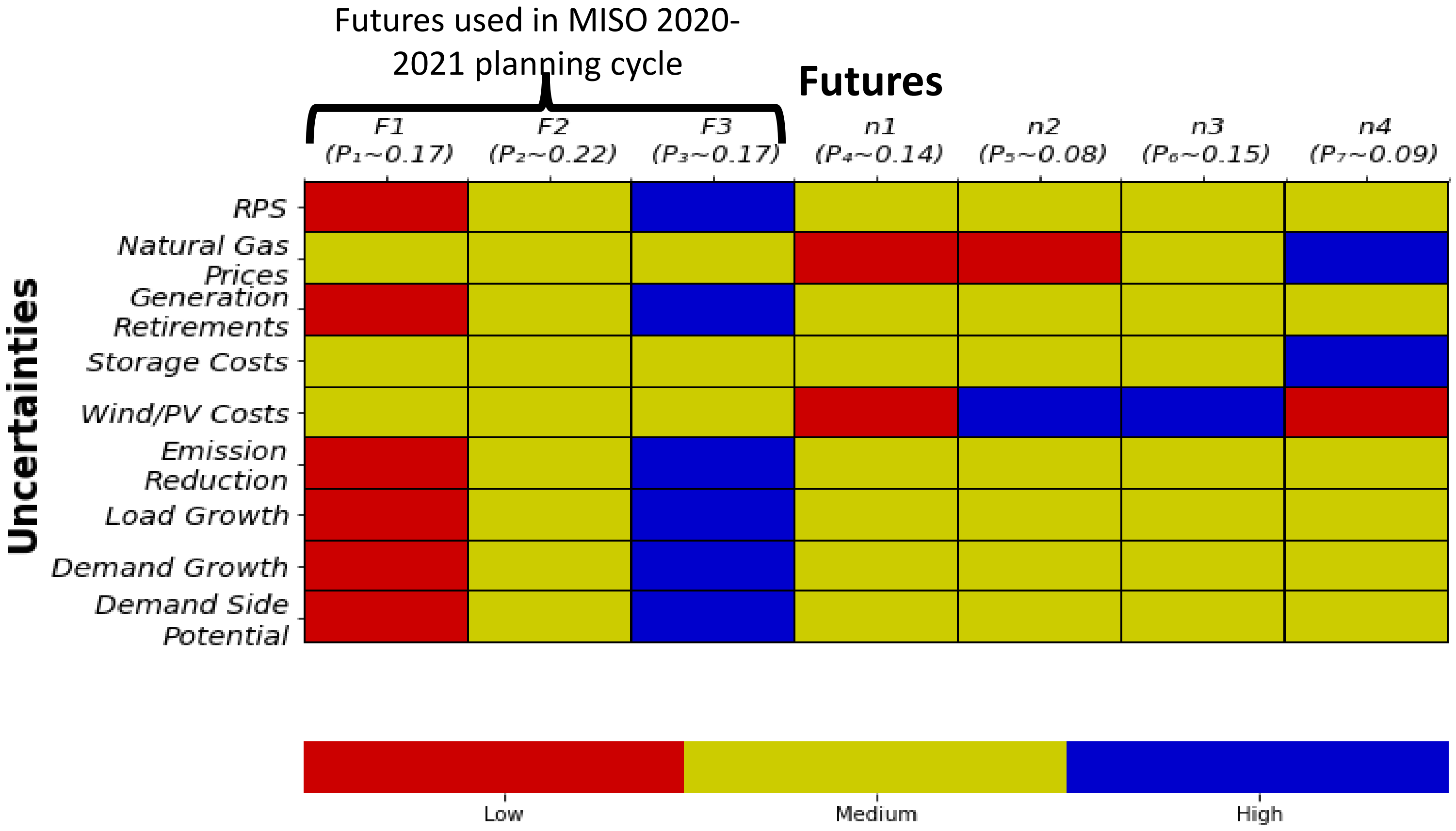
YES → **DONE**

Could also include EUE here, for energy adequacy.

2. 250 bus model, ACEP with RA, 7 futures

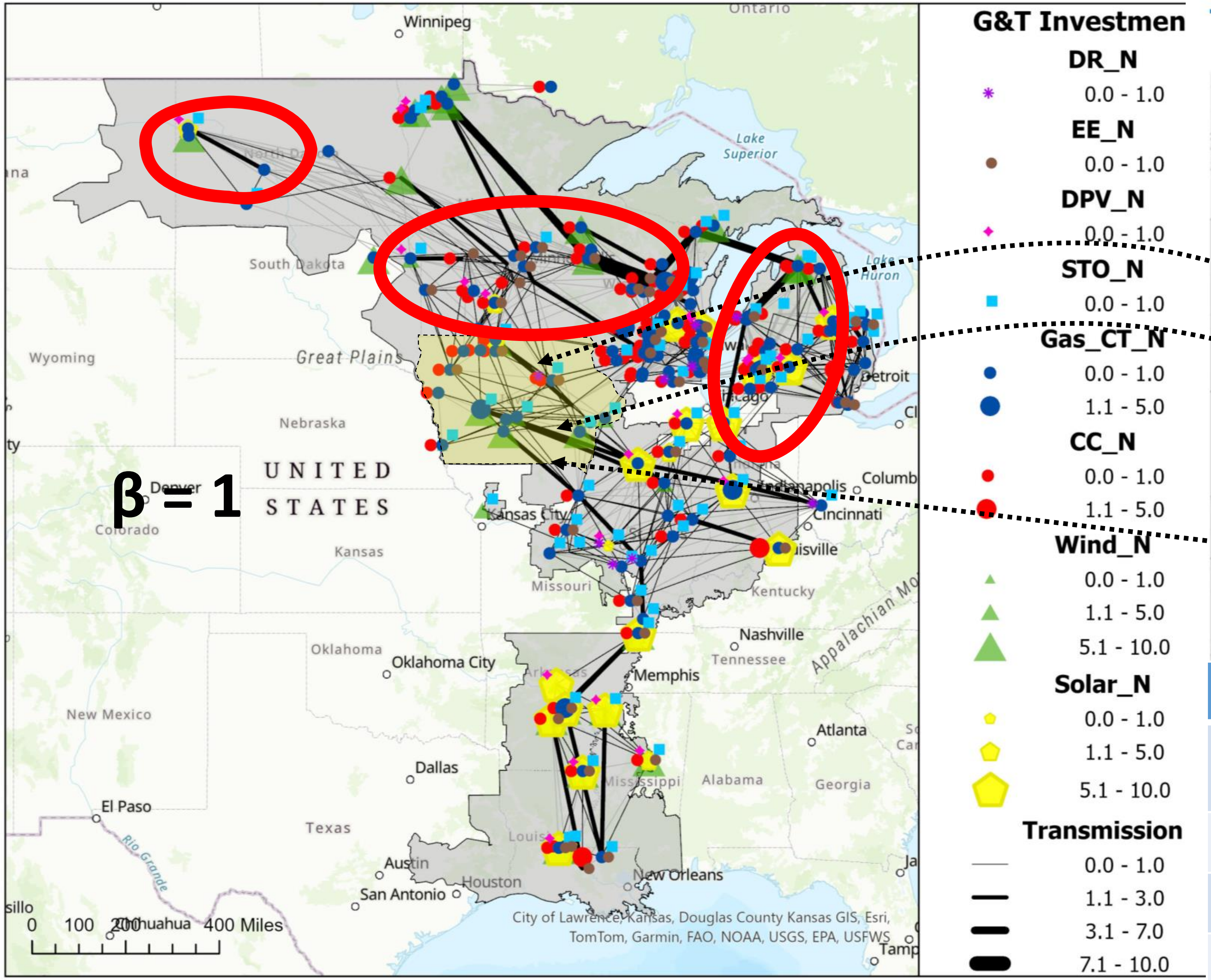
Input/assumptions:

- **Used MMWG HS24 case to start model reduction procedure (no tranche 1 or tranche 2 modeled)**
- **20-year planning horizon was considered (2025–2044).**
- **Investments limited to MISO region.**
- **Fixed capacity credit values for each technology considered throughout the planning horizon.**
- **Seven futures modeled per below**

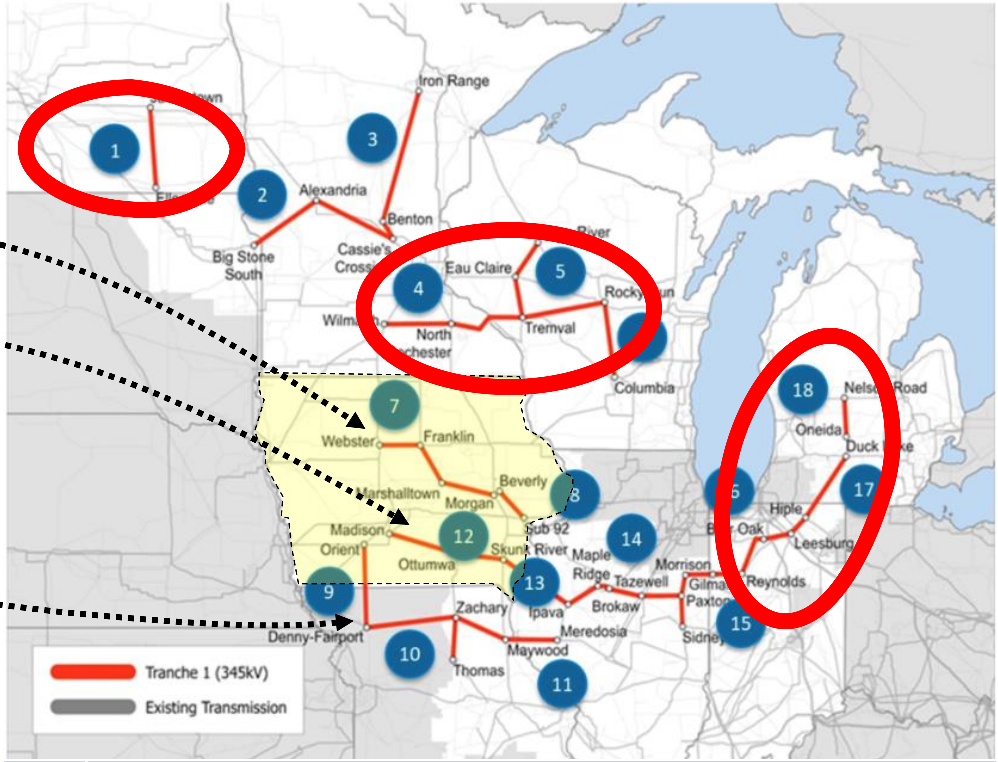


2. 250 bus model, ACEP with RA, 7 futures

Core Investments - compare to Tranche 1

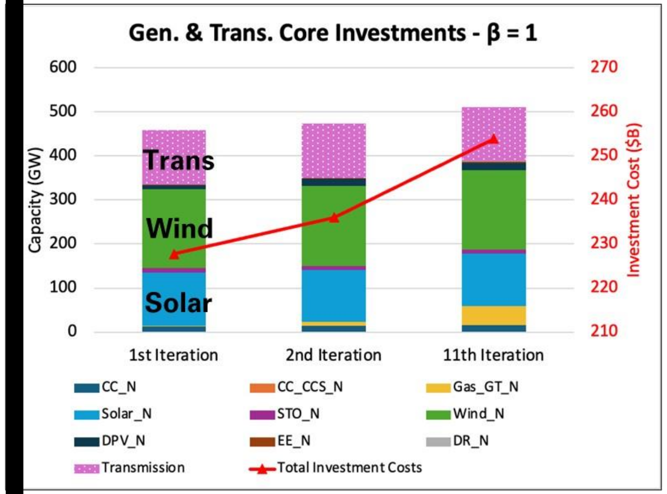
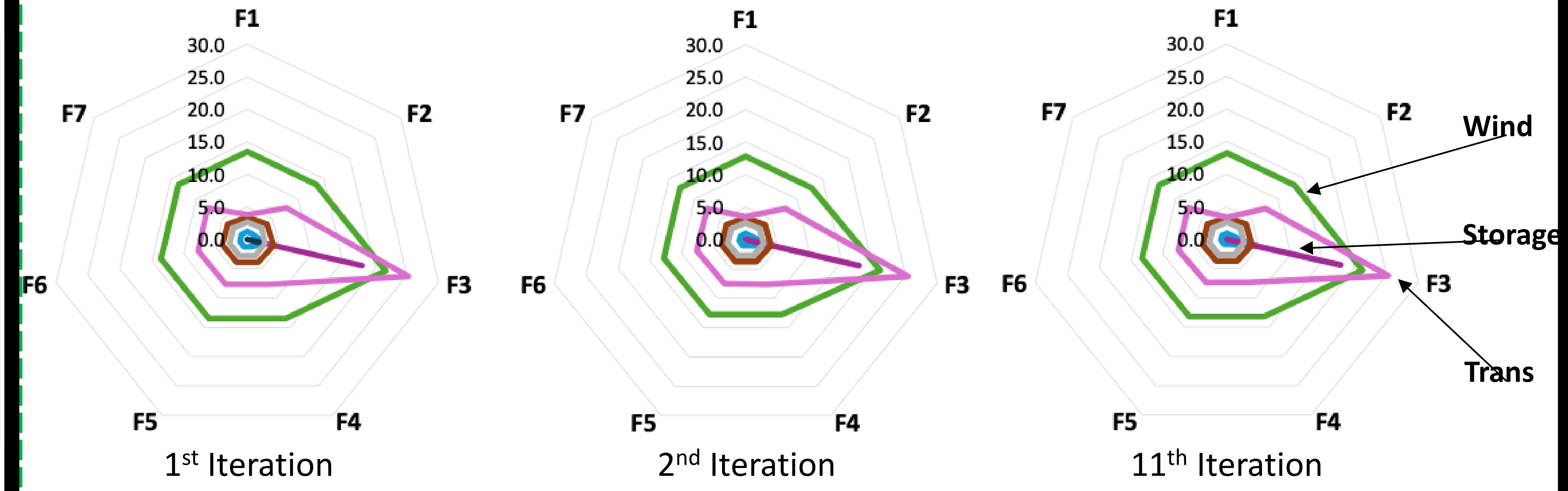
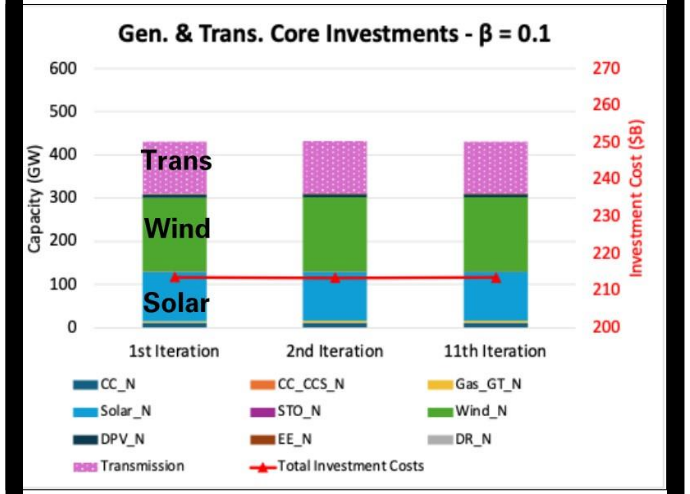
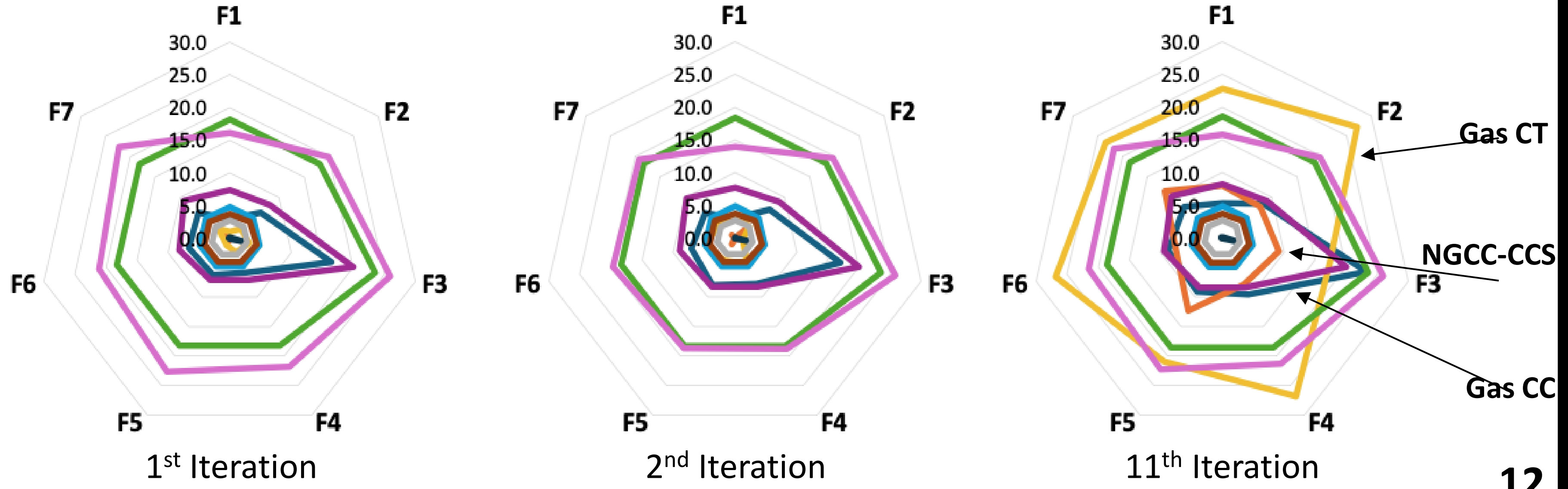


Tranche 1 - Approved July 2022

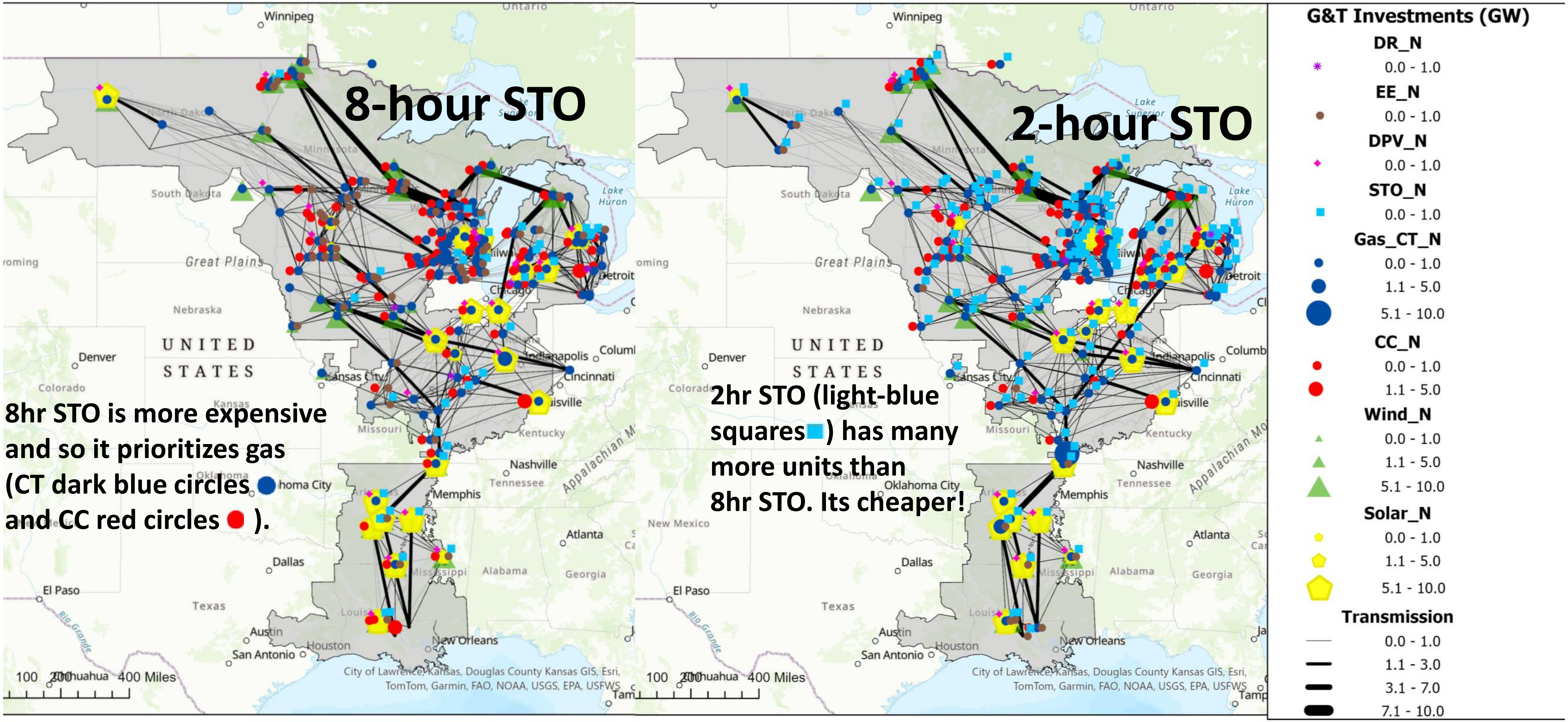


#	Reasons why differences exist
1	ACEP identifies resource type/location purely by economics, not by gen queue.
2	ACEP uses medium fidelity (250 bus) model
3	ACEP uses 7 futures; Tranche 1 based on Future 1.
4	Some ACEP investments may be in adaptations

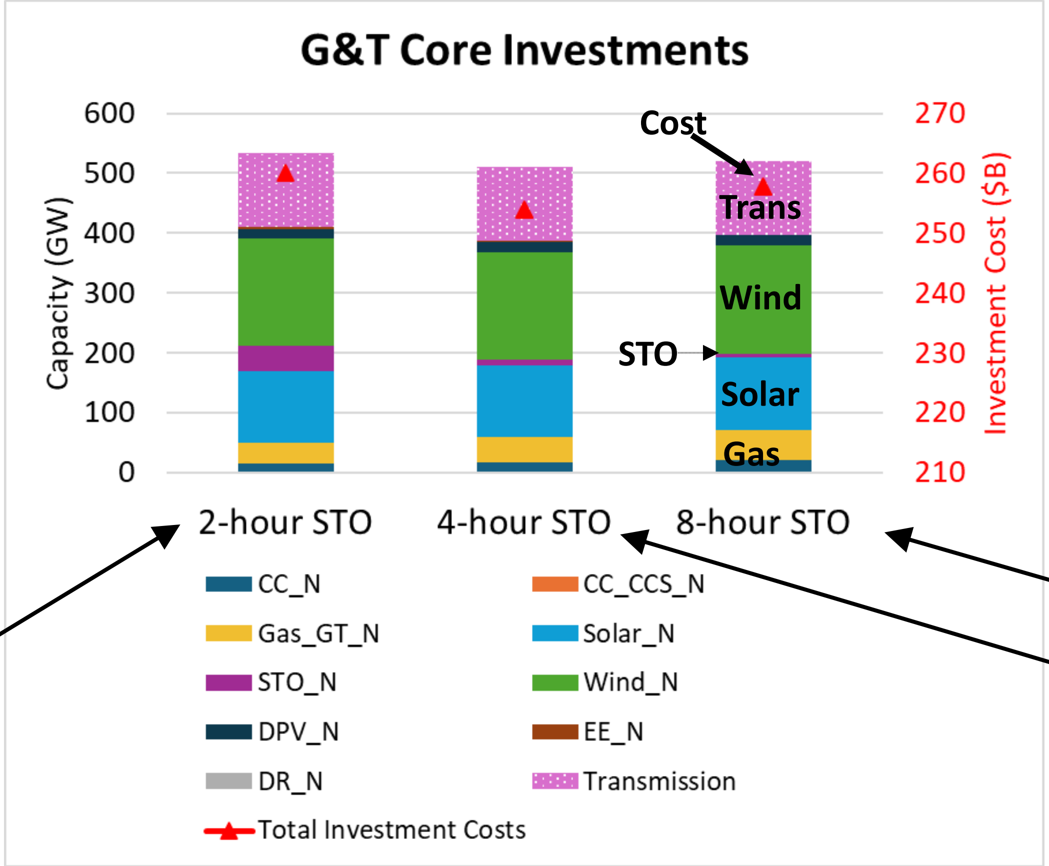
2. 250 bus model, ACEP with RA, 7 futures: core vs. adaptations

	CORE	ADAPTATIONS
β = 1		
β = .1		

2. 250 bus model, ACEP with RA, 7 futures: beta=1, effect of storage



2. 250 bus model, ACEP with RA, 7 futures: beta=1, effect of storage

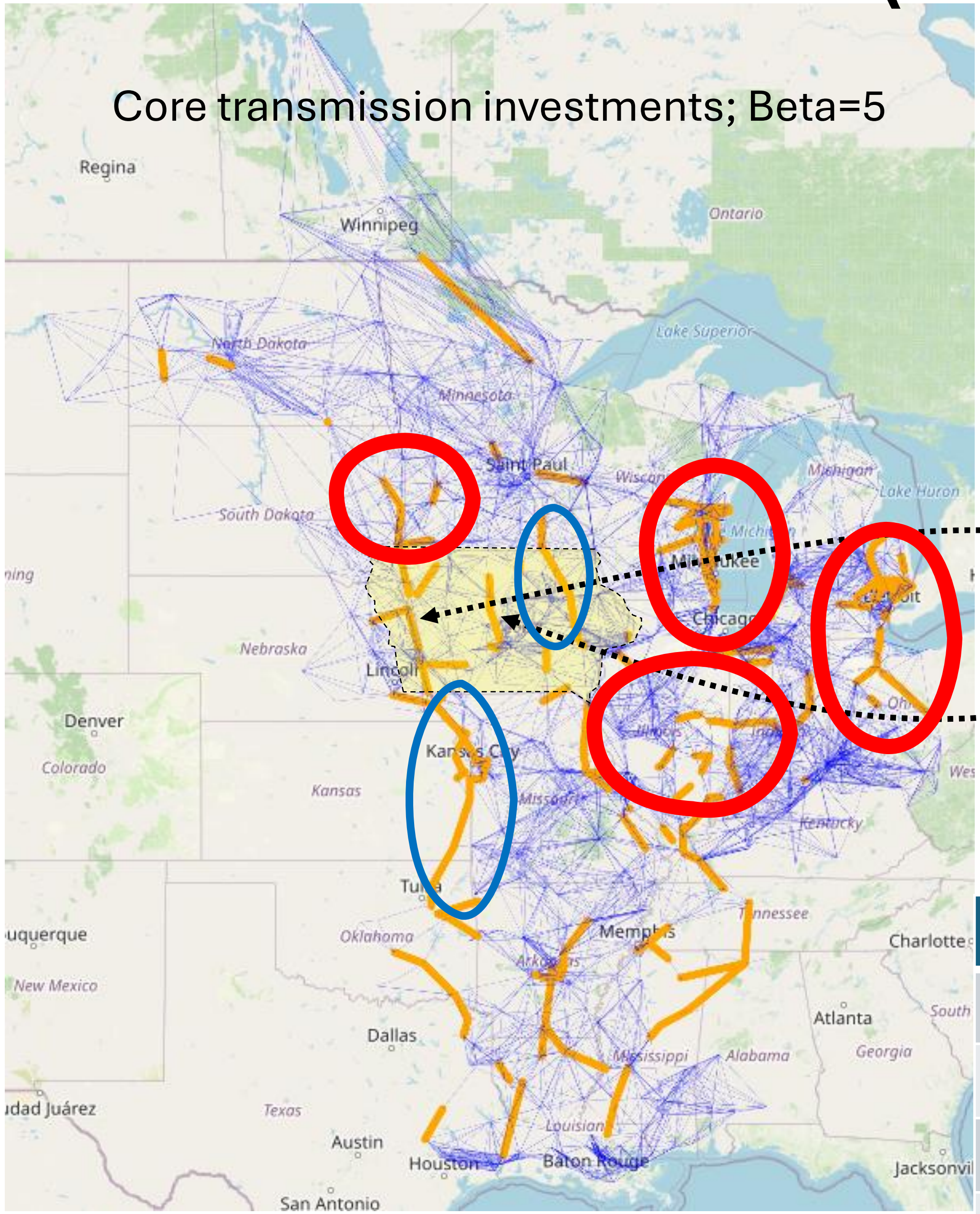


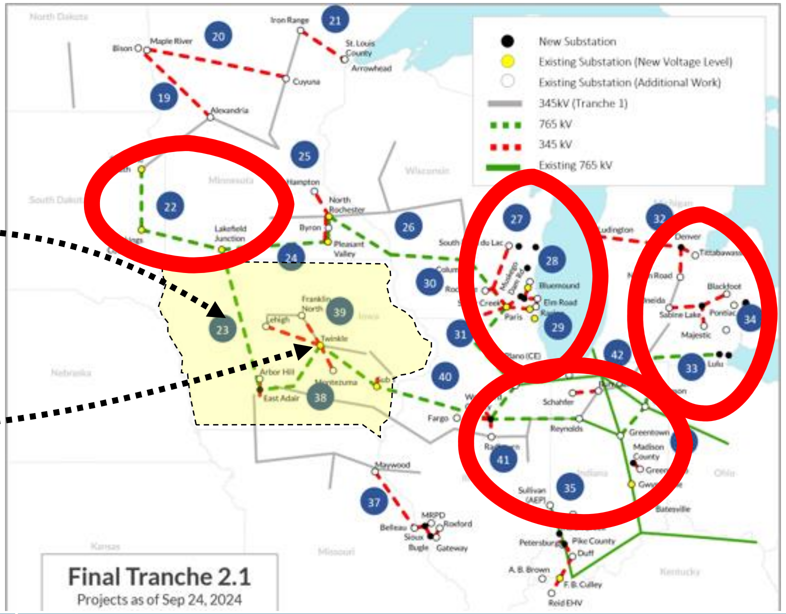
2-hr storage:
- lowest $/MWhr cost and so invests more
- but is less effective in satisfying LOLE requirements and so total capacity (and cost) is highest

8-hr storage:
- highest $/MWhr cost and so invests less
- shifts reserve needs to gas which is more effective in satisfying LOLE than storage

4-hr storage balances STO cost with gas performance showing benefits of balanced portfolio.

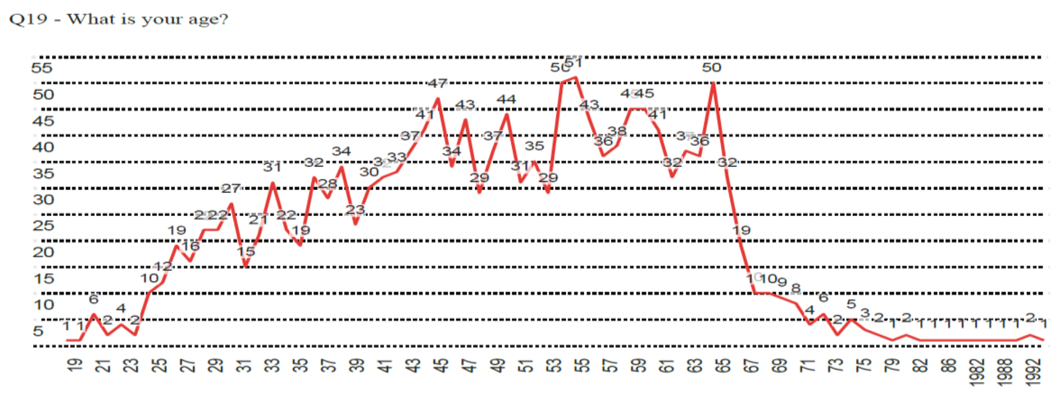
3. 1800 bus model (with Tranche 1), ACEP with 3 futures

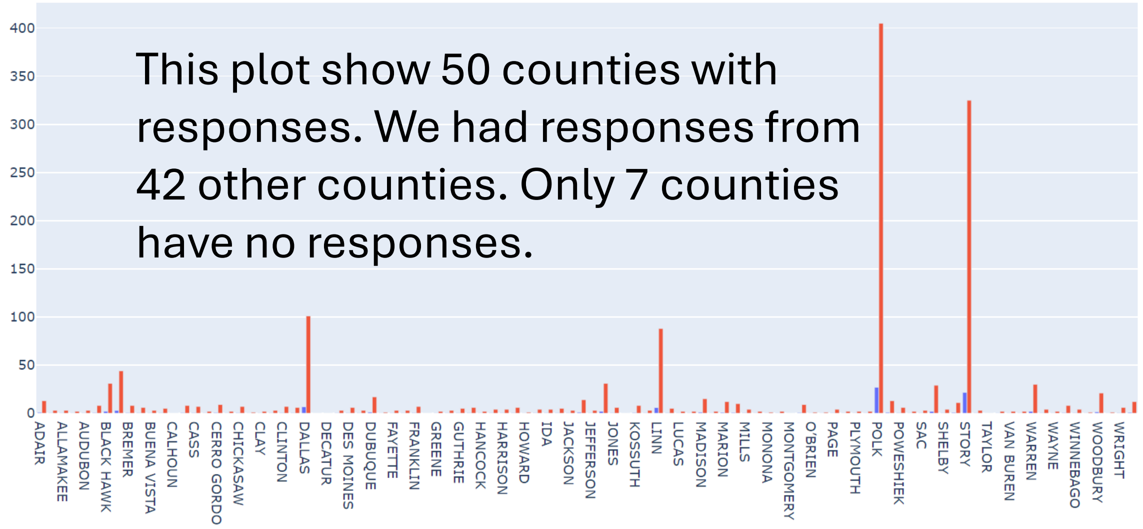




#	Reasons why differences exist
1	Did not allow for new 765 kV paths (correcting this now with new runs)
2	ACEP identifies resource type/location by economics, not gen queue.
3	ACEP uses high fidelity (1800bus) model, but still, differs from full model
4	ACEP uses 3 futures (1A, 2A, 3A); Tranche 2 based on Future 2A.

4. Preliminary survey results





~2100 respondents

These are preliminary, i.e., they are being synthesized now.

Rank	Ag land owners	$0-30k income	$91-120k income	Conser-vative	Liberal	W/wrk exp in enrgy sctor
1	V1-cost	V2-CO_2	V4-res	V1-cost	V2-CO_2	V4-res
2	V4-res	V1-cost	V1-cost	V4-res	V4-res	V1-cost
3	V2-CO_2	V4-res	V2-CO_2	V3-exp	V1-cost	V2-CO_2
4	V3-exp	V3-exp	V3-exp	V2-CO_2	V3-exp	V3-exp

These results are also “tip-of-the-iceberg” – i.e., there is much more…

- Many more categories, i.e., many more columns
- Ability to quantify not only ranking but level of support
- Ability to assess understanding of vision
- Ability to assess reasons for ranking/support

➔Intention is to express reasonable investment plan for reaching each of the visions and communicate Iowan’s support for each of those visions. Request to PAB: Please consider this and communicate any concerns.

5. Summary and next steps

1. PIE is to inform Iowans, in/out of industry
2. Intended to enhance/support MISO and individual utility planning.
3. ACEP, R-CEP, FHS – new/useful tools
4. We are seeing initial results that are sensible
5. Need to
   - focus it on Iowa, study five visions
   - apply it to illuminate new issues
     - Storage (battery and H_2)
     - Demand control
     - Data centers
     - Climate effects & resilience
     - Small modular reactors
     - HVDC
     - Inertia modeling
     - Small ICE’s that burn various fuels