PLAN IOWA ENERGY (PIE)

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

A 3-Year Project

Add Maison Bleam of IUB to future meeting announcements (per Sarah Martz).

Project Advisory Board Meeting

Wednesday, March 27, 2024, 10am-noonCT

James McCalley, Colin Christy, Ali Jahanbani, Investigators

Gustavo Cuello-Polo, Yanda Jiang, Aladdin Adam, Ph. D. Students

Dut Ajang, M.S. Student

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PAB Feedback

Please jot down your questions/comments during my presentation.
Or consider to enter them to the chat.

We do want your feedback! Provide it during discussion 11-12 or else by e-mail to jdm@iastate.edu or phone at 515-294-4844 (v) or 515-460-5244 (cell) at any time after the meeting, but within next 2-3 days.

Some questions of particular interest:

1. Do you see ways to modify our current work or next steps to make this project more valuable to you and/or to Iowa?
2. Do you find our report #3 useful/informative? Do you have questions related to it?
3. Any other questions, comments, suggestions, opinions you have?

Meeting Agenda

1. **Review key project features & previous work**
   - Objective, power system design tool
   - Visions/uncertainties/futures/plans
   - Summary of previous work
2. **New report on visions/uncertainties/futures**
   (see report #3 at https://home.engineering.iastate.edu/~jdm/pie/index.htm)
3. **Progress on model development**
   - Modeling process
   - Technology options considered
4. **Recent work**
   - Including resource adequacy
   - Including inertial/frequency constraints
   - New nuclear
   - Providing grid services
   - Iowa's preferences
5. **Next steps**
6. **PAB feedback & discussion (last hour)**

Objective:
Identify several 25-year investment plans to position Iowa's electric infrastructure to perform well under normal & climate-influenced extreme events & conditions.

Organization	Person	Title
STATE AGENCIES		
Iowa Economic Development Authority	Stephanie Weisenbach	Program Manager
Iowa Utilities Board	Sarah Martz	Board Member
Iowa Utilities Board	Edgard Verdugo	Utilities Regulatory Engineer
Iowa Office of the Consumer Advocate	Tim Tessier	Utility Specialist
Iowa Department of Transportation	Sam Sturtz	Chair, Iowa DOT Resiliency WG
OTHER AGENCIES		
Iowa Association of Municipal Utilities	Troy DeJoode	Executive Director
Iowa Association of Elect. Cooperatives	Ethan Hohenadel	Regulatory Affairs Director
Iowa Utility Association	Chaz Allen	Executive Director
Iowa Environmental Council	Steve Guyer	Energy Policy Manager
Iowa Industrial Energy Group	Amanda James	Executive Director
Iowa State Institute for Transportation	Shauna Hallmark	Director
REGIONAL TRANSM. ORGANIZATIONS		
Midcontinent Independent Sys Operator	Armando Figueroa-Acevedo	Sr. Engr., Strategic Assessments
Southwest Power Pool	Sunny Raheem Clint Savoy	Manager, Planning Policy&Rsrch; Manager, Interregional Strategy
INVESTOR-OWNED UTILITIES		
Alliant Energy	Mike Graves	Lead Engineer
MidAmerican Energy	Dehn Stevens	VP, Transm Planning & Dvlpmnt
ITC Transmission Midwest	Rob Wells	Supervisor, Planning
MUNICIPAL UTILITIES		
City of Ames Electric	Don Kom	Director
Cedar Falls Utilities	Ken Kagy	Principle Transmission Engineer
Muscatine Power and Water	Ryan Streck	Director, Utility Service Delivery
COOPERATIVE UTILITIES		
Central Iowa Power Cooperative	Ethan Tellier	Planning engineer
Corn Belt Power Cooperative	Tyler Baxter	Engineer III
Dairyland Power Cooperative	Ben Porath	Chief Operating Officer
Maquoketa Valley Electrical Cooperative	Nik Schulte	Distribution system manager

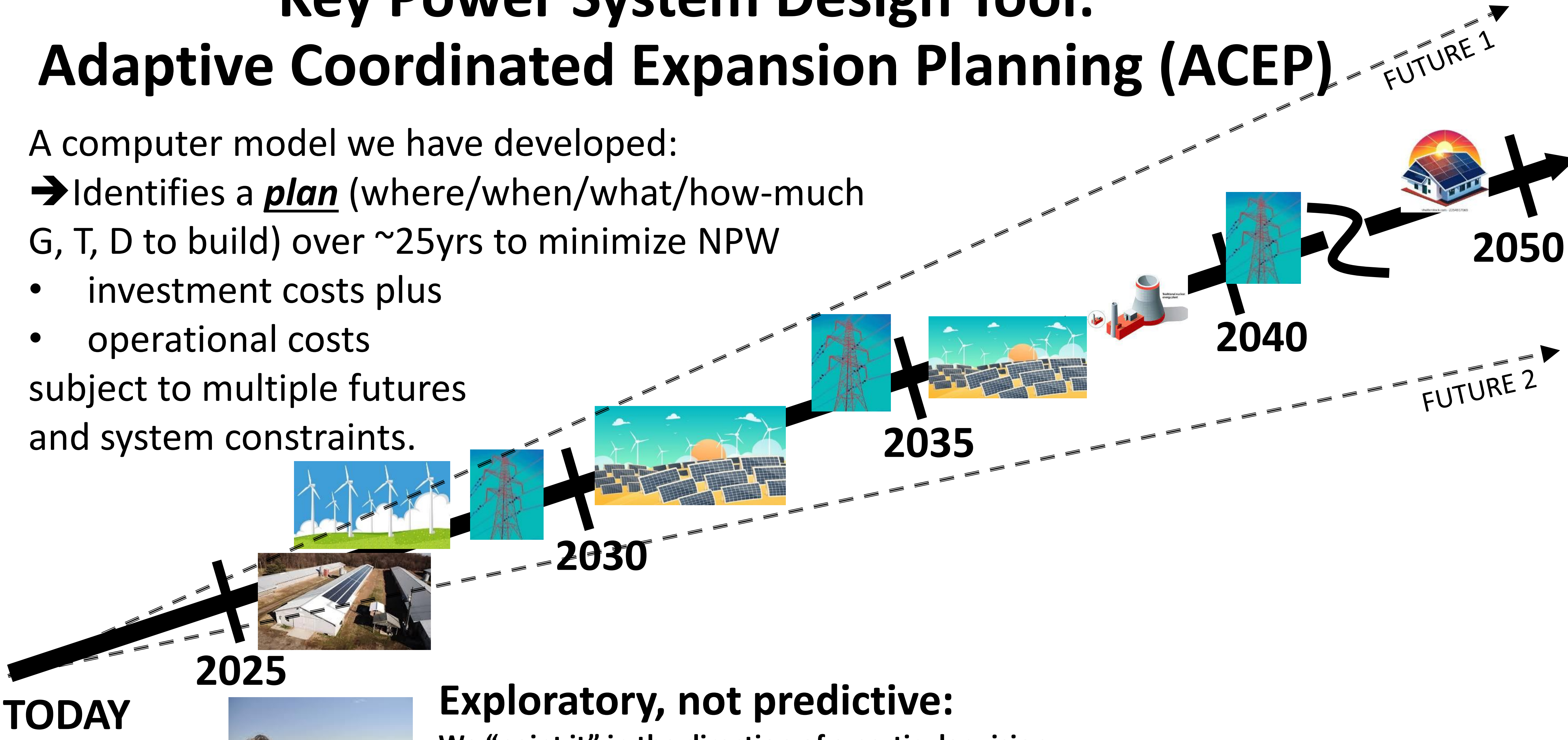
Key Power System Design Tool: Adaptive Coordinated Expansion Planning (ACEP)

A computer model we have developed:

➔Identifies a ***plan*** (where/when/what/how-much G, T, D to build) over ~25yrs to minimize NPW

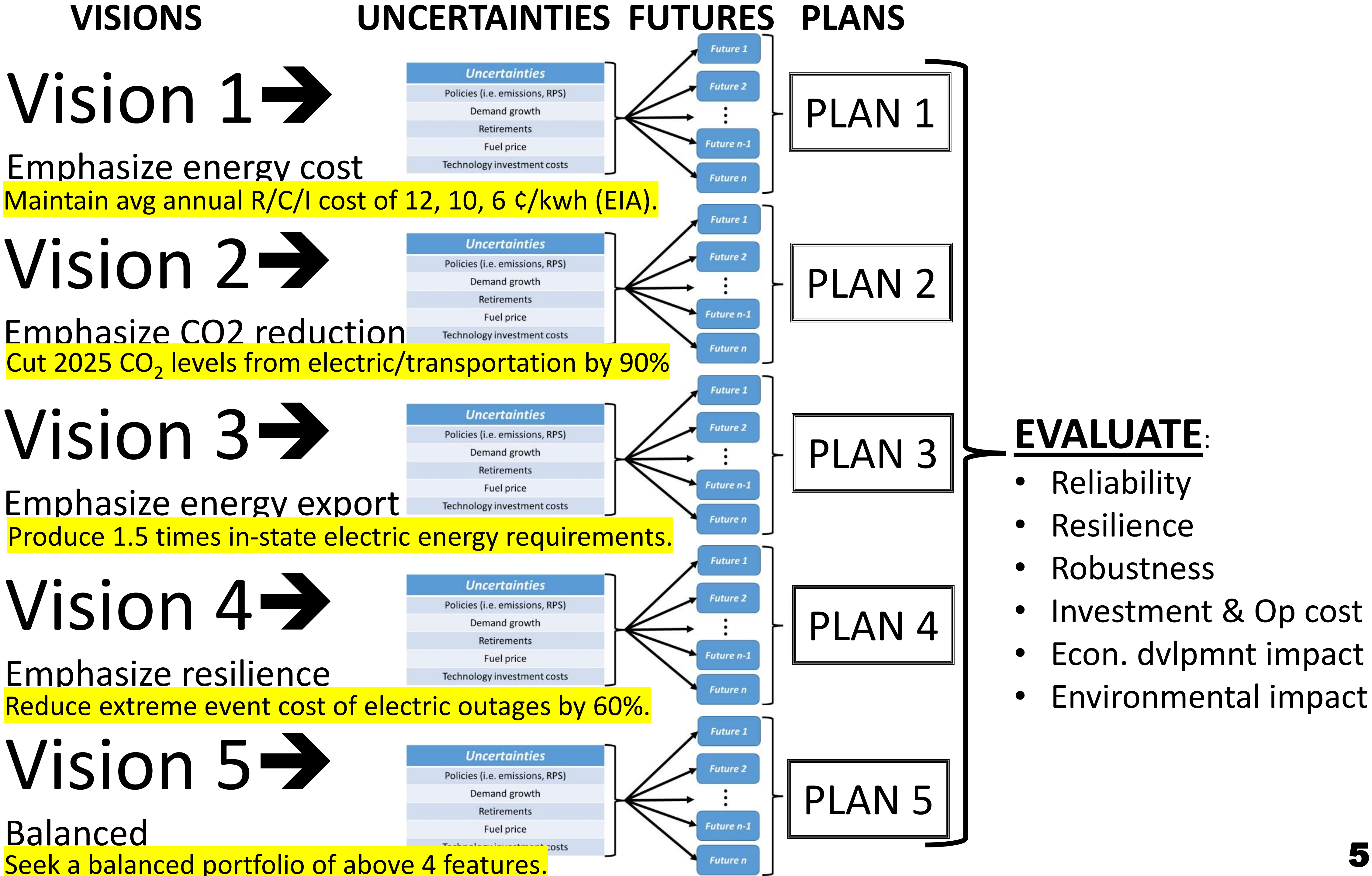
- investment costs plus
- operational costs

subject to multiple futures and system constraints.



Exploratory, not predictive:

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



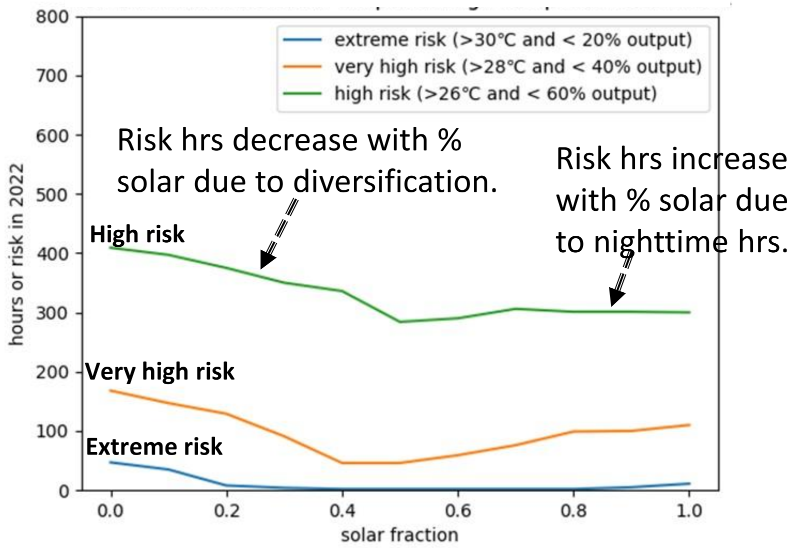
VISIONS
UNCERTAINTIES
FUTURES
PLANS
Vision 1
Emphasize energy cost
Maintain avg annual R/C/I cost of 12, 10, 6 ¢/kwh (EIA).
Uncertainties
Policies (i.e. emissions, RPS)
Demand growth
Retirements
Fuel price
Technology investment costs
Future 1
Future 2
Future n-1
Future n
PLAN 1
Vision 2
Emphasize CO2 reduction
Cut 2025 CO_2 levels from electric/transportation by 90%
Uncertainties
Policies (i.e. emissions, RPS)
Demand growth
Retirements
Fuel price
Technology investment costs
Future 1
Future 2
Future n-1
Future n
PLAN 2
Vision 3
Emphasize energy export
Produce 1.5 times in-state electric energy requirements.
Uncertainties
Policies (i.e. emissions, RPS)
Demand growth
Retirements
Fuel price
Technology investment costs
Future 1
Future 2
Future n-1
Future n
PLAN 3
Vision 4
Emphasize resilience
Reduce extreme event cost of electric outages by 60%.
Uncertainties
Policies (i.e. emissions, RPS)
Demand growth
Retirements
Fuel price
Technology investment costs
Future 1
Future 2
Future n-1
Future n
PLAN 4
Vision 5
Balanced
Seek a balanced portfolio of above 4 features.
Uncertainties
Policies (i.e. emissions, RPS)
Demand growth
Retirements
Fuel price
Future 1
Future 2
Future n-1
Future n
PLAN 5
EVALUATE:
Reliability
Resilience
Robustness
Investment & Op cost
Econ. dvlpmnt impact
Environmental impact

Summary of previous work

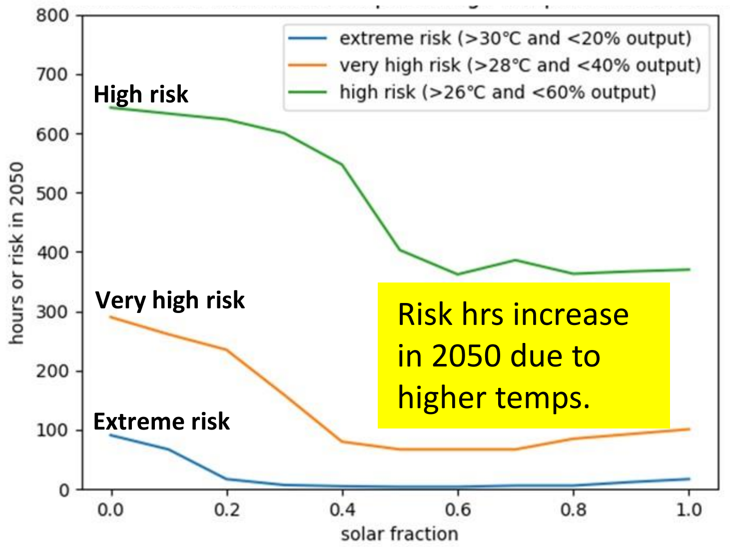
- **Project Report #1: MISO & SPP planning processes**
- **Project Report #2: High-risk conditions & events**

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

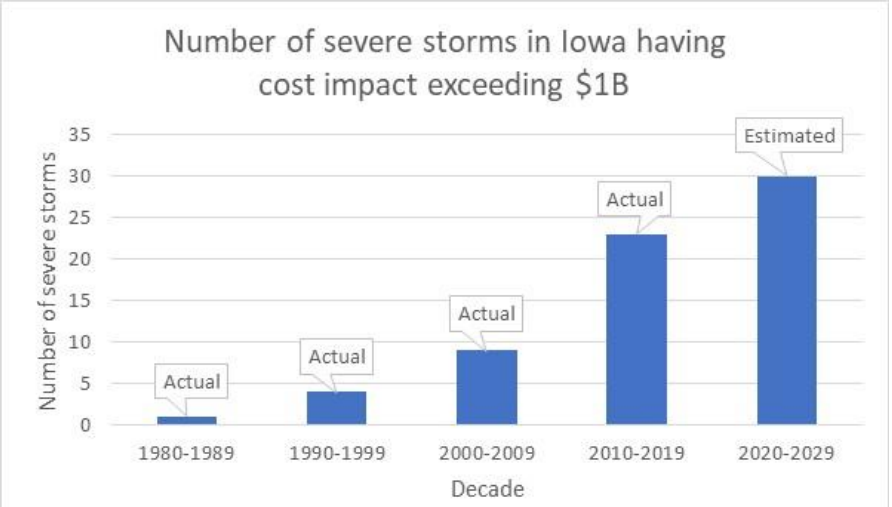
2022



2050



High-risk conditions (high temp & low wind/solar)



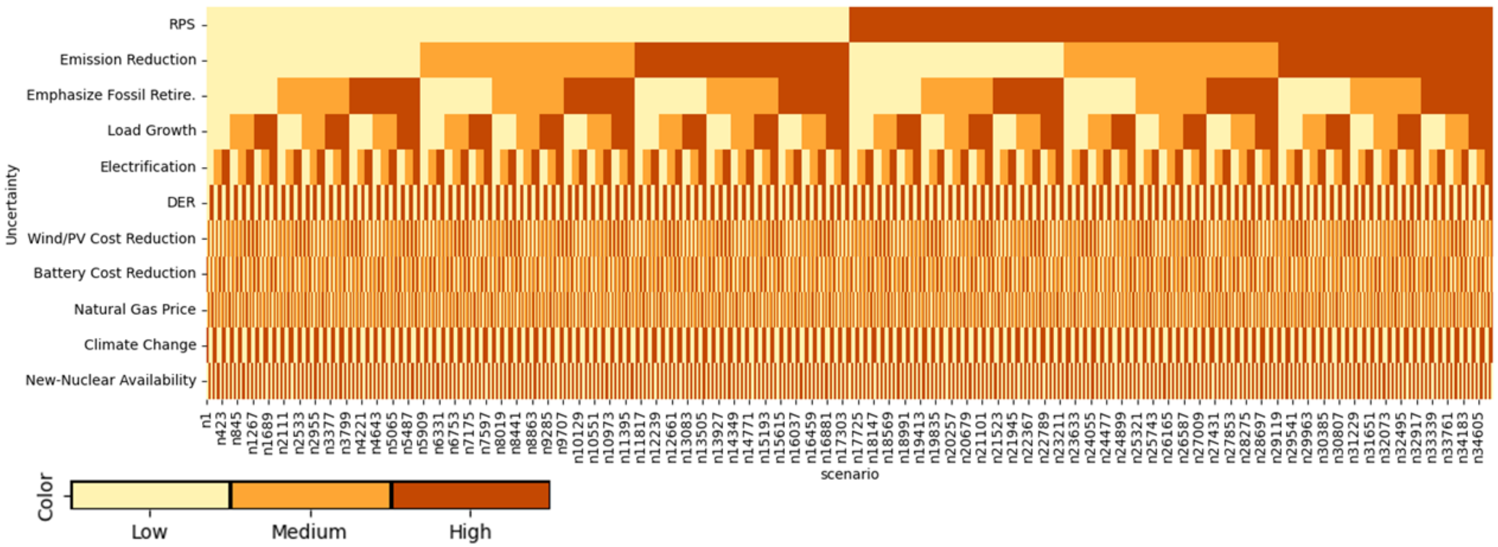
Extreme events (very high wind)

New report on visions/uncertainties/futures

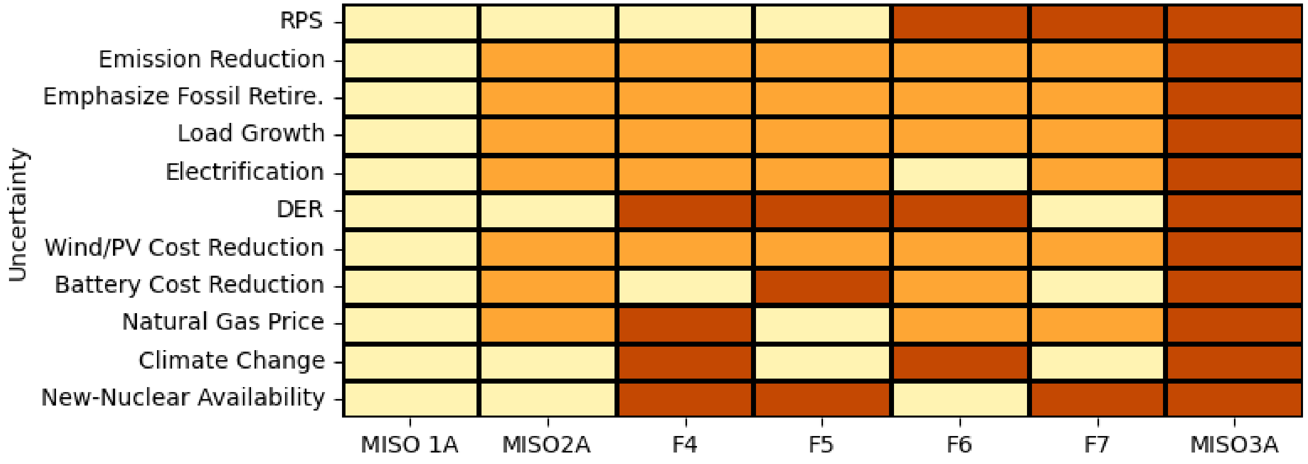
Uncertainties based on MISO Series 1A Futures +

Parameter	No. of values	Value 1	Value 2	Value 3	Uncertain in MISO LRTP Futures?
RPS	2	0		50	Yes
Carbon Reduction (%)	3	71	76	80	Yes
Load Growth Energy (CAGR) Demand (CAGR)	3	Low 0.63% 0.77%	Medium 1.25% 1.14%	High 1.95% 1.63%	Yes
Electrification (% of total energy growth)	3	2.0	15.2	31.8	Yes
Emphasis on Fossil Retirement	3	Low	Medium	High	Yes
DER:	2	Low		High	Yes
Wind/PV costs reduction	3	0.75	1	1.25	No
Battery Costs Reduction	3	Low	Medium	High	No
Natural Gas Price	3	Low (0.75)	Medium (1.0)	High (1.25)	No
Climate Change	2	Low		High	No
New-Nuclear Investible?	2	Low (No)		High (in 2040)	No
Discount Rate	N/A				No

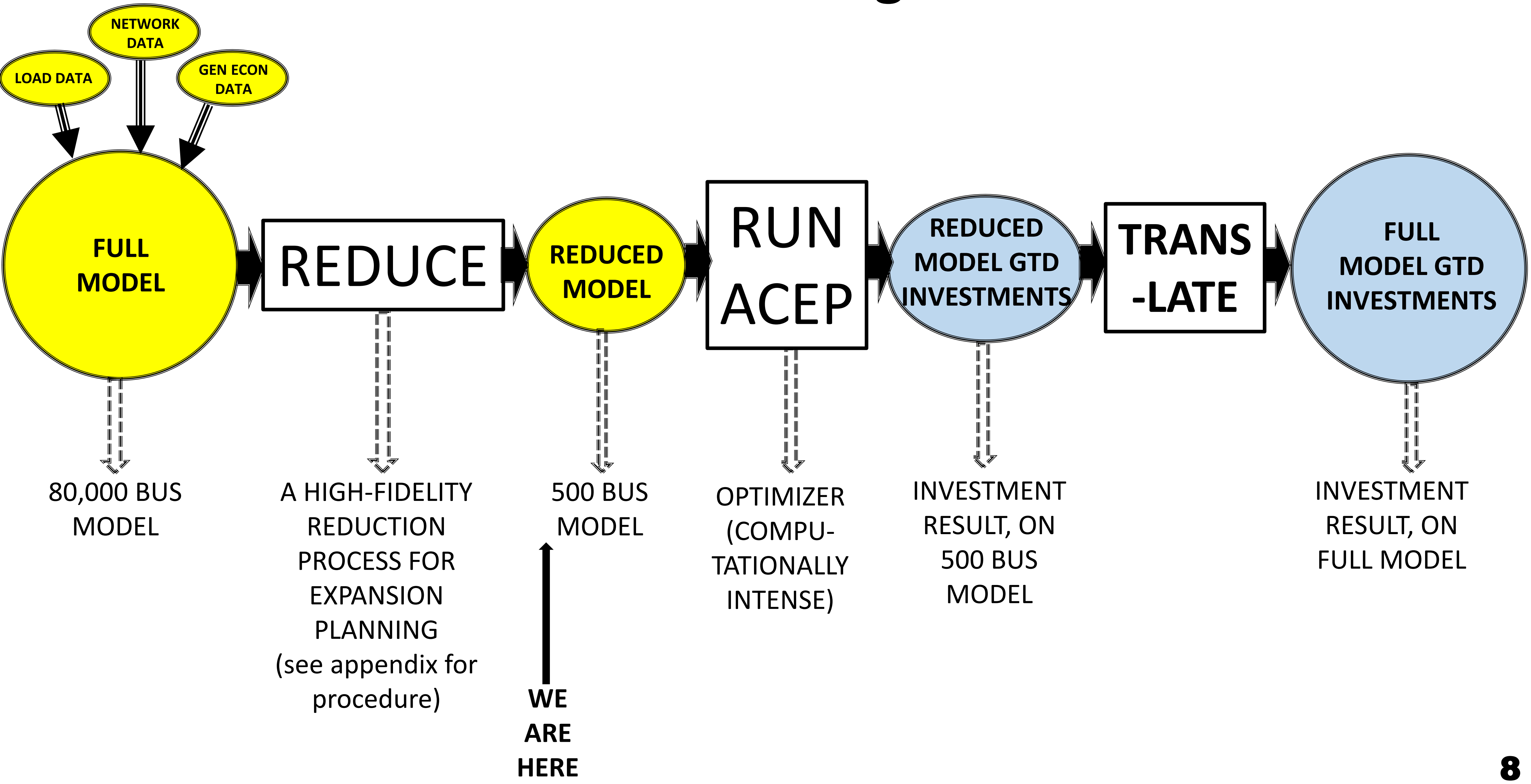
11 Uncertainties yield 34,992 potential futures!



Scenario reduction algorithm to find 7 best.



Network Modeling Process



Technology options considered

Generation resources:

- Wind
- Solar
- Gas-CTs w&w/o CCS
- Gas-NGCC w&w/o CCS
- Coal with CCS
- Nuclear – SMR
- Reciprocating ICEs
- DER:
  - Res, Com, Ind rooftop solar
  - Community solar
  - Energy efficiency
  - Demand response

Storage:

- Bulk hydrogen
- Bulk battery
- Distributed battery

Transmission:

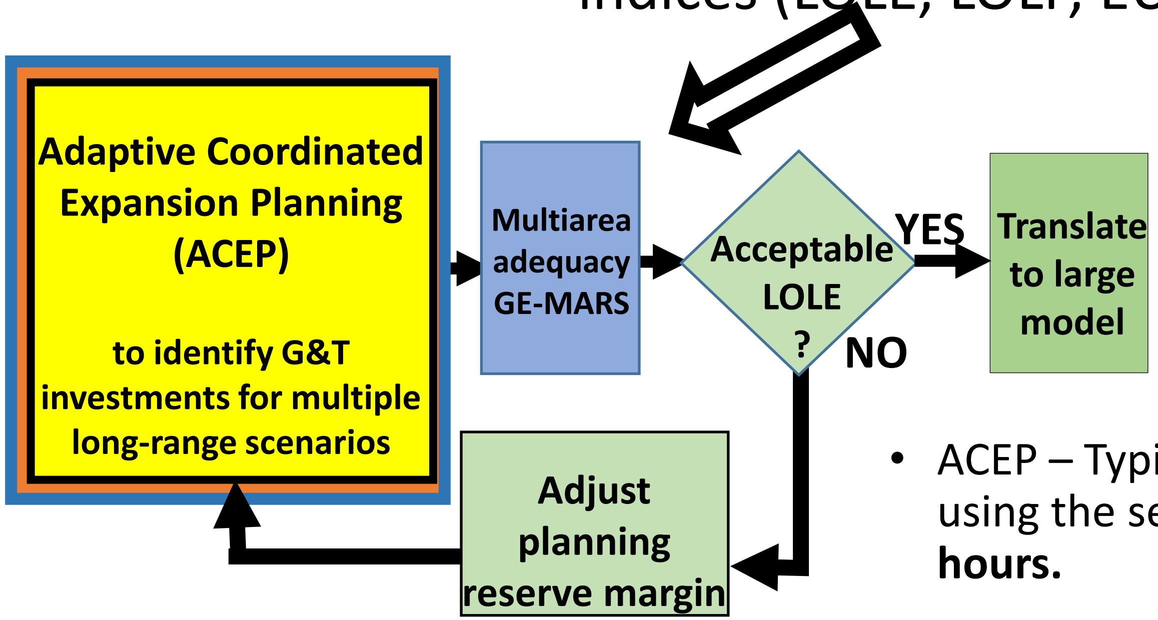
- 230, 345, 765 kV AC
- P2P HVDC overhead
  - ±600 kV
  - ±800 kV
- P2P ±525 HVDC ugnd
- Multi-terminal HVDC

Recent work – resource adequacy (RA)

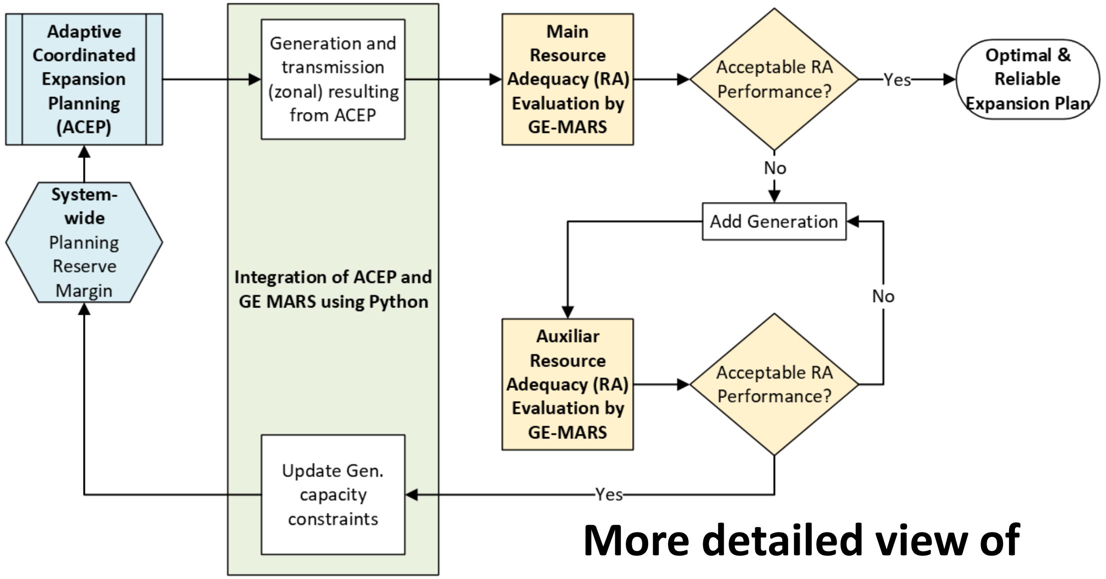
We desire ACEP result to satisfy RA requirement (LOLE<= 1day in 10 years).
Embedding RA calculations within ACEP causes excessive solve times.

Solution: Iteratively run ACEP and externally perform RA, then modify ACEP PRM to correct.

GE-MARS calculates RA indices (LOLE, LOLP, EUE).



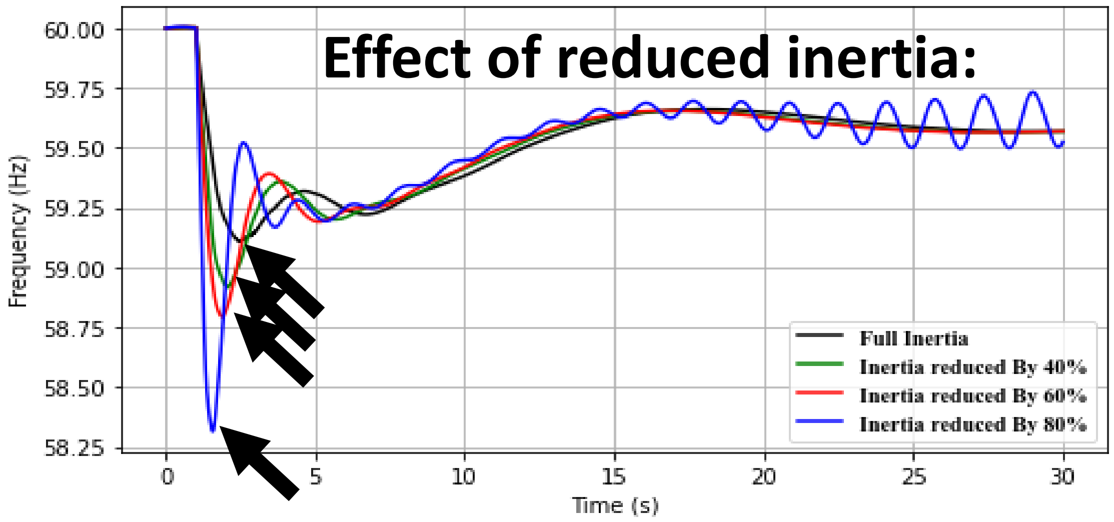
- ACEP – Typical run time using the server: **7-8 hours.**
- GE-MARS – Typical run time using desktop CPU: **35 minutes.**



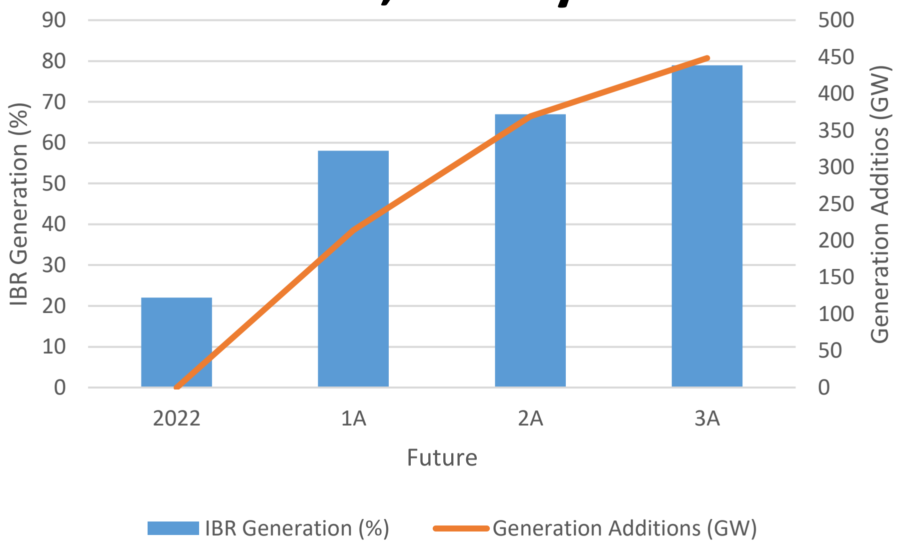
$$\sum_{i,j} Cap_{i,j,t,\mathrm{w}} \geq (1+r) \sum_{i} \tilde{\mathrm{d}}_{i,\mathrm{peak},t,\mathrm{w}}, \ \forall t.$$

More detailed view of diagram on the left.

Recent work – inertial constraints



Future: More IBR, less synch. machines



Minimize InvestCost+OpCost

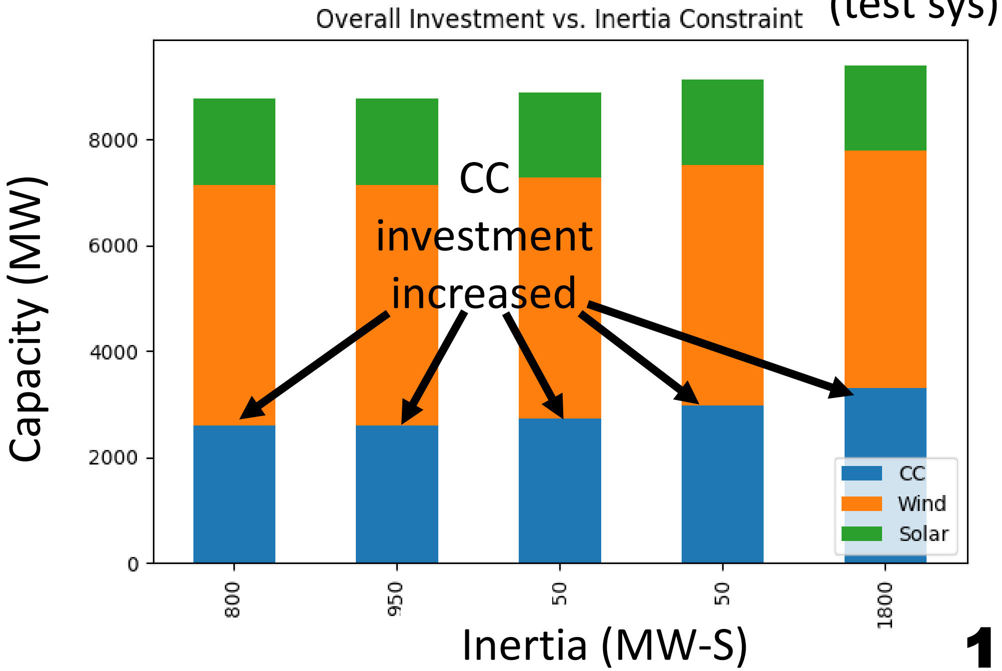
Subject to

Operational constraints

Inertia ≥ minimum inertia

- Inertia comes from synchronous machines.
- It may also come from wind & solar if equipped with inertial emulation.

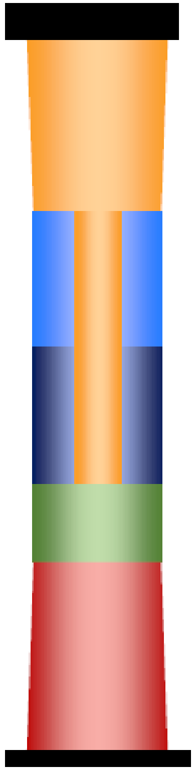
(test sys)



Recent work – providing grid services

Deviation-based reserves

- Regulation reserves
- Ramping reserves
- Short-term reserves



Product	Requirement (MW)	
Short-Term Reserve		
Market-Wide	~ 3,600	30 Minute Response
Sub-Regional	dynamic	
Local	dynamic	
Ramp		
Up Ramp	0-1,800	10 Minute Response
Down Ramp	0-1,800	
Contingency Reserves		
Spinning Reserve	930	10 Minute Response
Supplemental Reserve	1,105	10 Minute Response
Regulation	400	5 Minute Response
Energy		

Histograms (distributions) on netload deviations widen with increase in wind&solar.

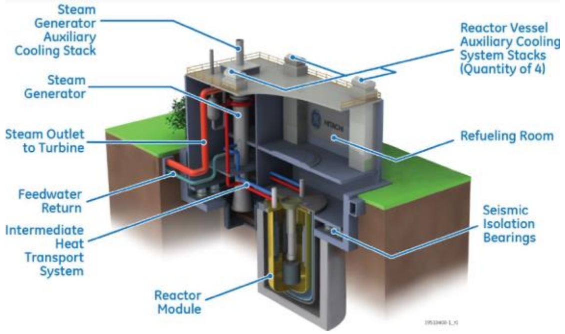
➔We model requirements on deviation-based reserves as a function of wind&solar.

➔Conventional synchronous machines provide reserves; certain load types can as well.

Recent work – new nuclear

Natrium by TerraPower

Prism by GE HITACHI



SMR-160 by Holtec International

	Natrium by TerraPower [3], [4], [5], [6]	VOYGR by Nuscale [15],[16],[17],[18]	Prism by GE Hitachi [11],[12],[13],[14]	SMR-160 by Holtec International [9],[10],[19]	BWRX-300 by GE Hitachi [1], [2], [8]	ARC-100 by ARC Clean Technology [7]
Reactor Type	Sodium fast Reactor	Pressurized Water-Cooled Reactor	Sodium fast Reactor	Pressurized Water Reactor	Boiling Water Reactor	Sodium Cooled Reactor
Power Output (MWe)	345	308 (4 modules), 462 (6 modules), 924 (12 modules)	311	160	300	100
Overnight Cost (first in class)	$4 billion	$9 billion	$3-4 billion	$1 billion	$1 billion	$ 400 million
Overnight Cost (nth type)	$1 billion	$3.6 billion	$1.5-2 billion	$1 billion	$700 million	$400 million
Estimated Construction Period	36 months	36 months	36 months	36 months	27 months	34 months
Refueling Cycle	18 months	12-24 months	12-24 months	24 months	12-24 months	20 years
Benefit-to-cost Ratio		0.777777778				
Operational Date	2030	2029	2026	2029	2028	2030
Important Features	Thermal energy storage	Passive cooling, scalable output	Modular construction, passive cooling	Air-cooled condensers for flexible deployment in various climates	Natural circulation cooling	Passive Cooling, Cheaper Metallic Fuel
LCOE ($/MWh)	$50-$60	$64	$58-60	$81.50	$35-50	$55
Thermal Efficiency	41%	30%	37%	30%	34.50%	38%

Identifying Revenues

Revenue streams from wind & solar

- Land lease payments
- Property taxes

⇨ These revenue streams are implicit in the cost data modeled in ACEP.
But they are identified explicitly as a function of each ACEP solution.

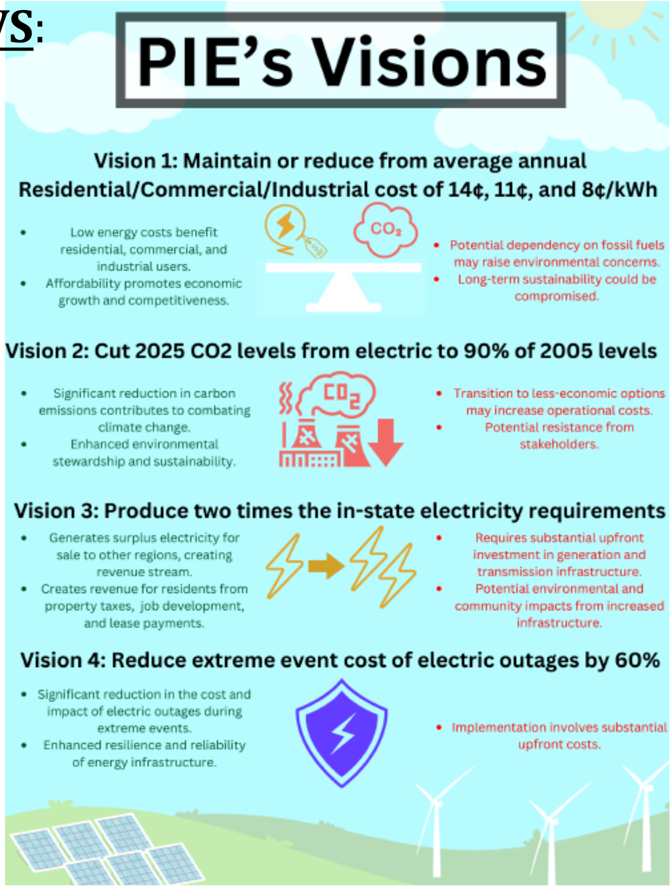
Recent work: 2-step process for learning Iowa’s preferences

SOCIO-POLITICAL-ECONOMIC DECISIONS TO BE MADE BY IOWANS:

- What CO_2 level should we reach?
- What resilience level should we obtain?
- How much energy should we export?

STEP 1: CONDUCT 16 INTERVIEWS:

1. Small farm, no wind farm
2. Small farm, wind farm
3. Large farm, no wind farm
4. Large farm, wind farm
5. Industry professional
6. Community advocate
7. Environmental advocate
8. Media energy expert
9. Metro county supervisor
10. Rural county supervisor
11. Mid-size county supervisor
12. Local Business Owner
13. Young Adult
14. Young Adult
15. Senior Citizen
16. Senior Citizen



STEP 2: DEVELOP SURVEY BASED ON INTERVIEWS:

➔ *We will survey 5000*
(i) energy-savvy and (ii) wind/-solar-affected Iowans.
Survey to be completed by the CyBIZ Lab, Iowa State Universities’ student consulting program.

Comments:

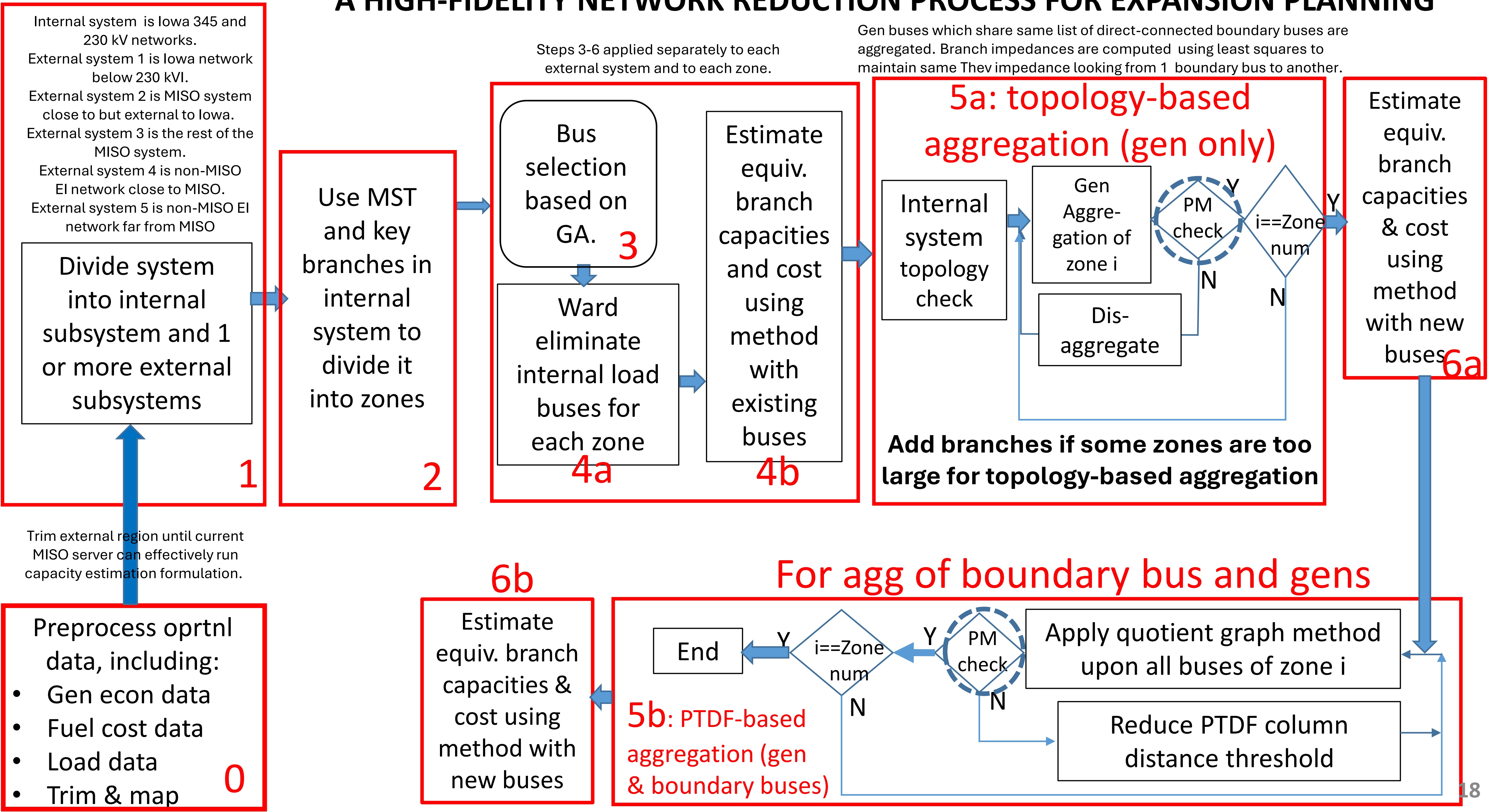
- Have learned that peer-pressure is important!
- This is not in our PIE project budget. Looking for partners to help offset some of $6000 cost.

Next Steps

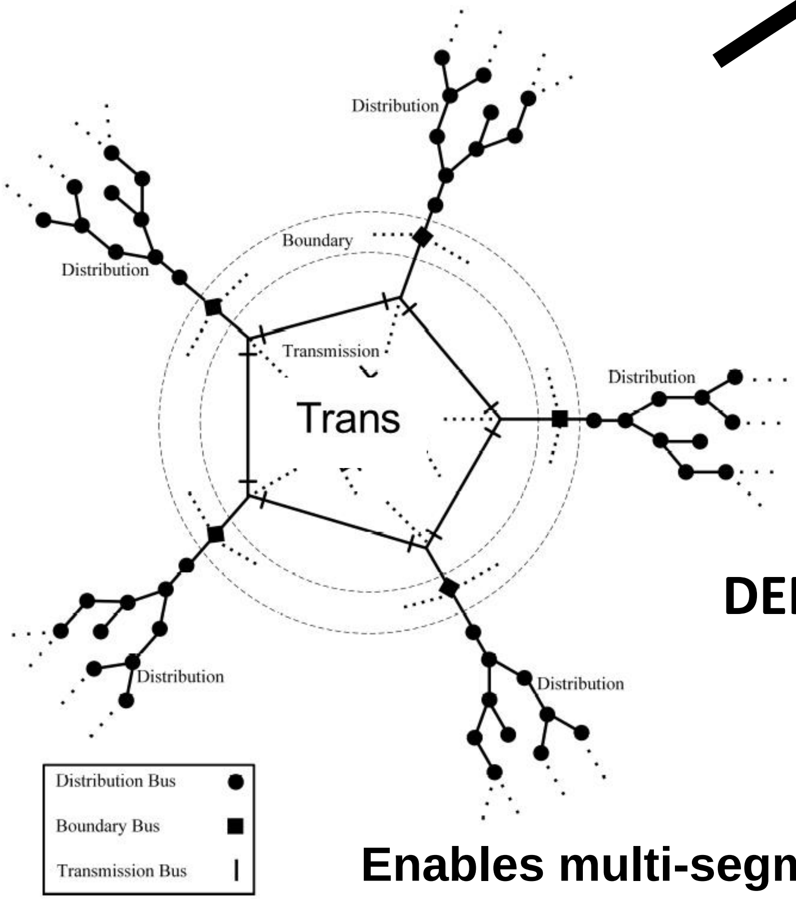
1. Generate results from ACEP/GE-MARS work.
2. Embed inertial constraints into ACEP.
3. Test ACEP reserve modeling functionality, including load provision.
4. Complete network model and begin generating ACEP-results.
5. Complete 15 interviews, summarize in a report, conduct survey.
6. Next PAB meeting: September, 2024.

Appendix

A HIGH-FIDELITY NETWORK REDUCTION PROCESS FOR EXPANSION PLANNING

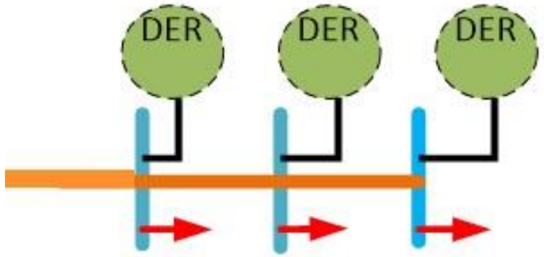


Modeling – DER Representation

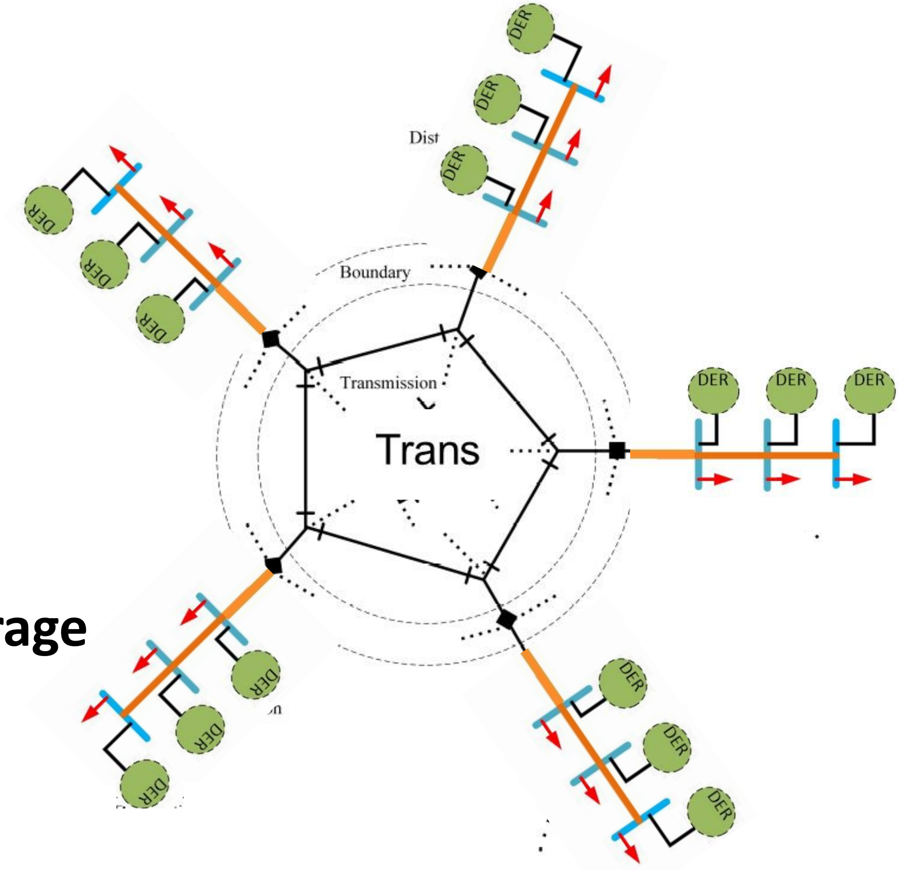


Model one N-seg feeder at each trans load bus.

N=3 segments



DER = EE, DR, D-PV, microT, & D-storage



Enables multi-segment loss representation & investment without increasing model size too much. Can choose N according to computation/fidelity needs.