Formally Verified Autonomous Hybrid Control

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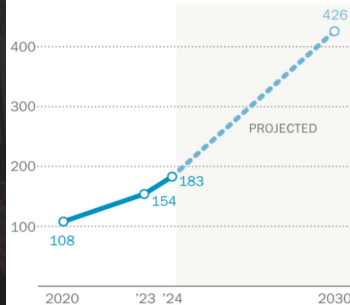
University of Pittsburgh

November 29, 2025

The United States stands on the precipice of a severe energy crises

Electricity consumption at U.S. data centers is expected to more than double by 2030

Total electricity consumption by U.S. data centers (terawatt-hours)

426

PROJECTED

183

154

108

2020   '23 '24   2030

Source: Pew Research Center, Data from IEA

How much baseload power increase is this?

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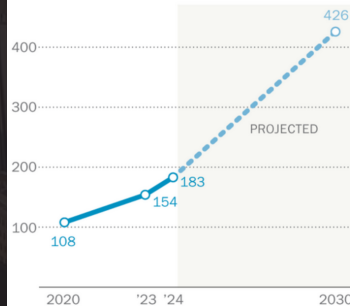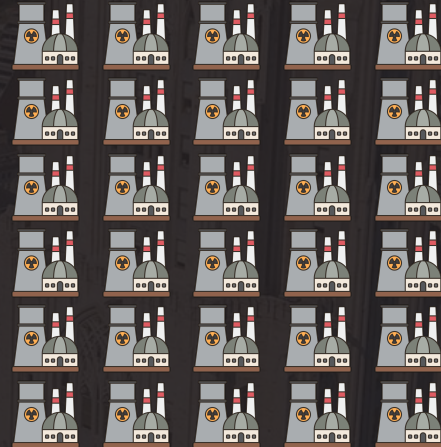*Total electricity consumption by U.S. data centers (terawatt-hours)*

Source: Pew Research Center, Data from IEA
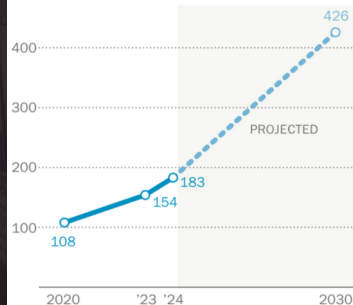
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How many reactor operators are required to staff this new fleet?

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One shift requires:

2 Senior Reactor Operators

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24/7 operations require ∼6 shifts:

12 SROs

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24 licensed operators per reactor

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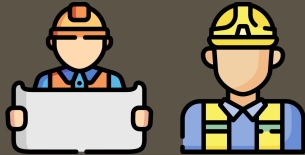**To meet demand we require 2,400 new licensed operators!**

We currently have only 3,600 licensed operators total...

Nuclear reactors are operated with prescriptive handbooks

Human reactor operators have key limitations that limit nuclear buildout

Humans cannot meet labor demand

Human reactor operators have key limitations that limit nuclear buildout

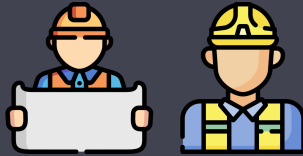**Humans cannot meet labor demand**

Procedures are not exhaustively verified

Human reactor operators have key limitations that limit nuclear buildout

Humans cannot meet labor demand

Procedures are not exhaustively verified

Human factors cannot be trained away

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1. Translate written procedures into discrete control logic
2. Verify continuous control behavior across discrete mode transitions
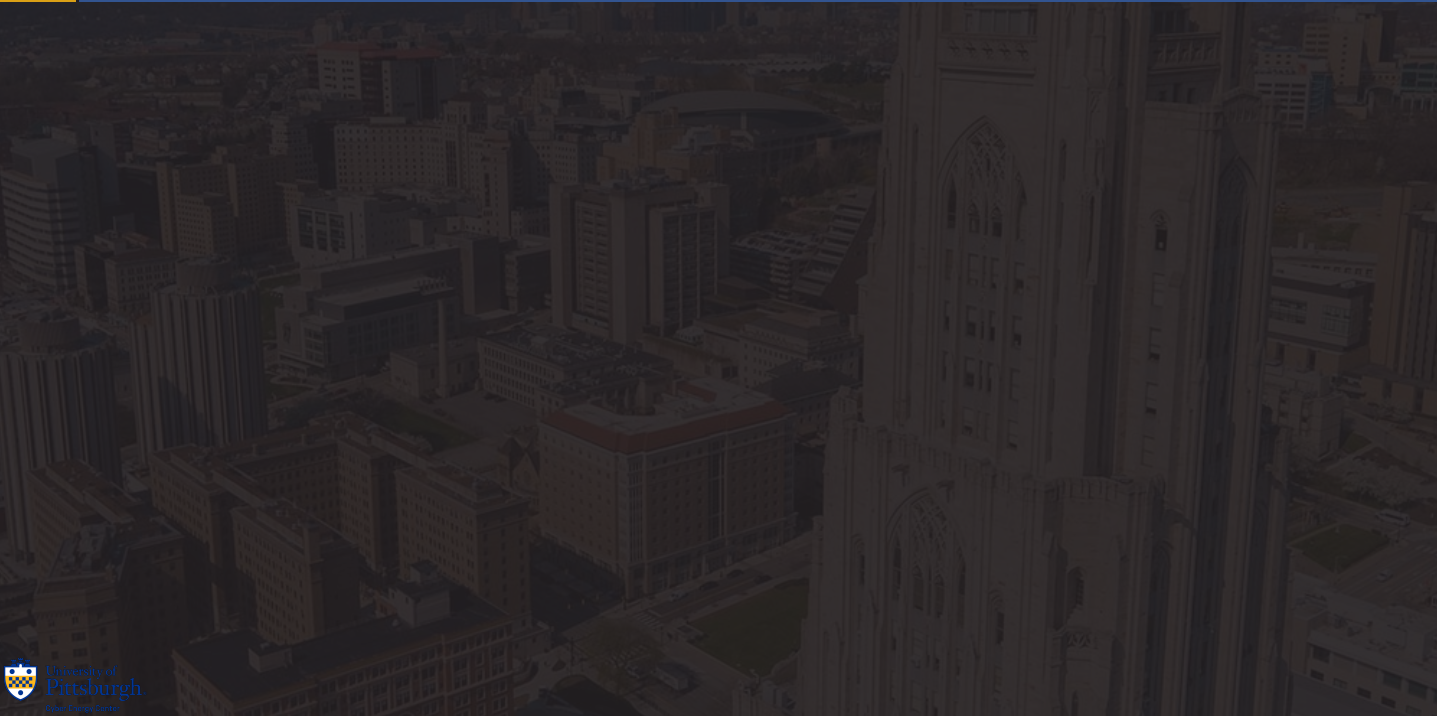3. Demonstrate autonomous reactor startup with verifiable safety guarantees

First, we will formalize written procedures into logical statements

Second, we will use the logical formulae to generate discrete automata
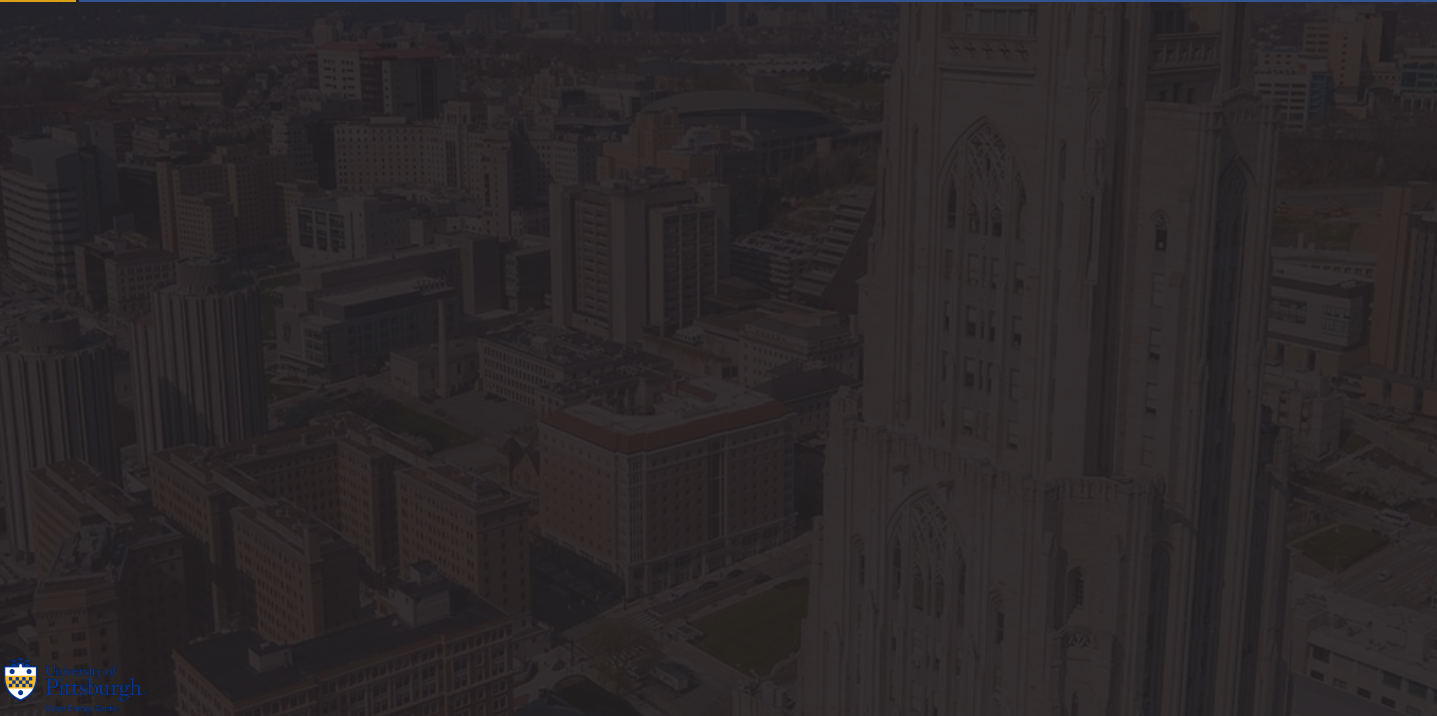
Finally, we will build continuous controllers to move between discrete states

Verified autonomous controllers can be created by building this chain of proof of correctness