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HELICS™: Co-Simulation for Better Grid Efficiency and Resilience

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- Liang Min, Lawrence Livermore National Laboratory
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- Bryan Palmintier, National Renewable Energy Laboratory
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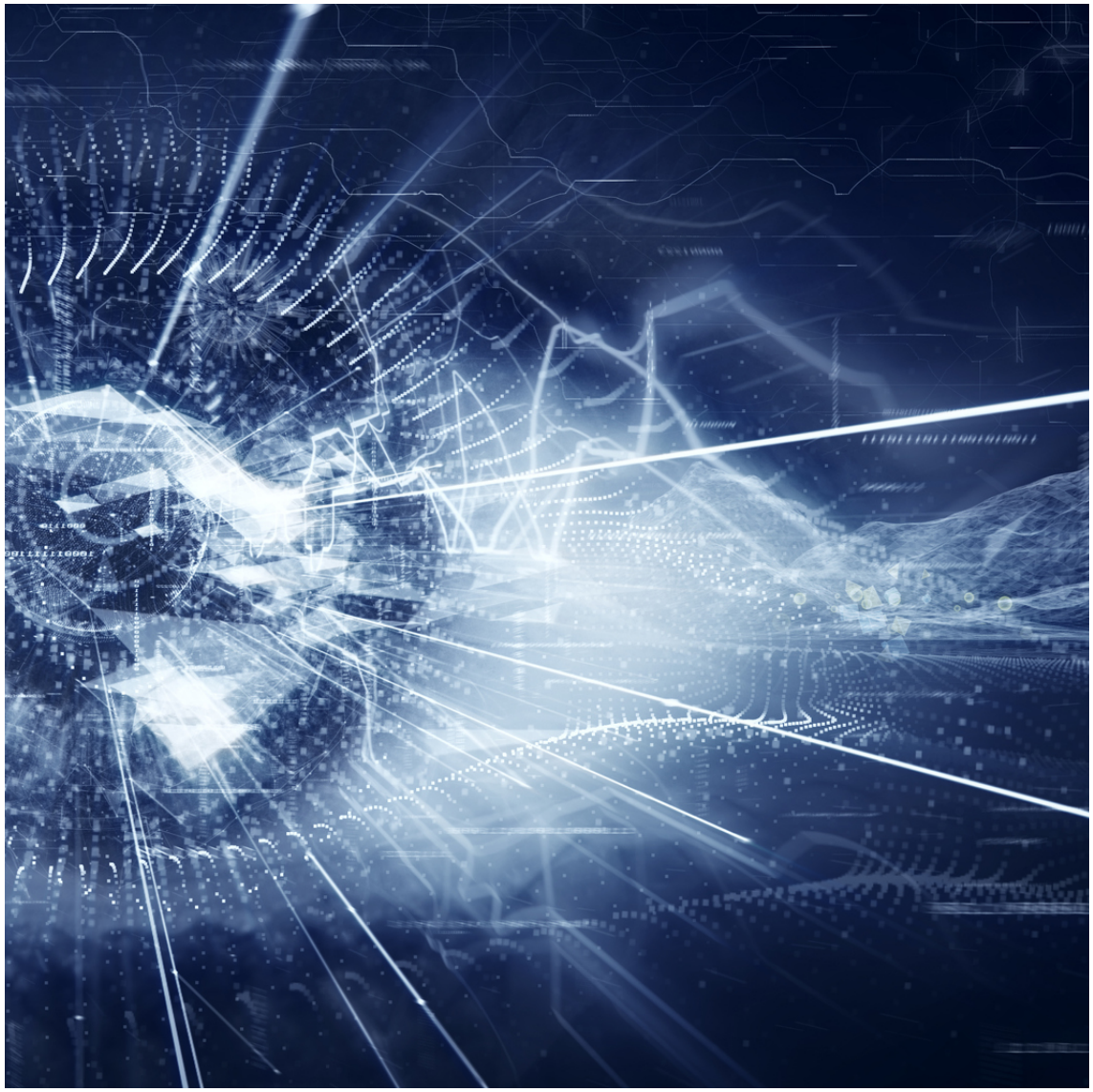

Acknowledgement

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OAK RIDGE National Laboratory
Sandia National Laboratories
INL Idaho National Laboratory

Technical Review Committee

20+ members: academia, vendors, and industry experts

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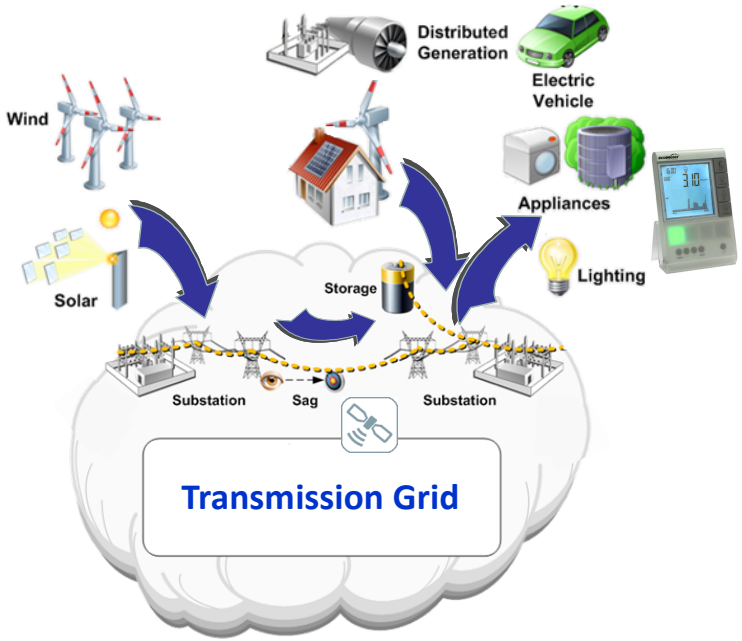
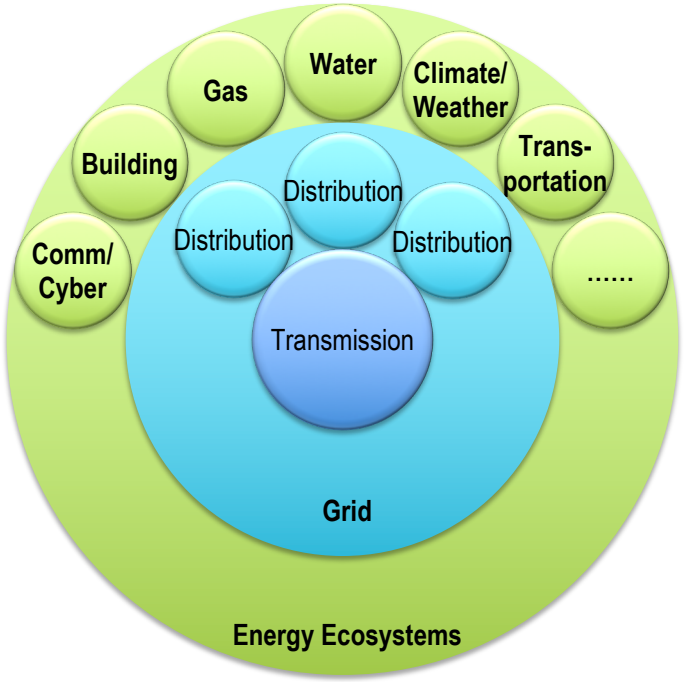
Grid evolution blurs the boundaries: T+D+C and more



EIA predicts 33% DERs in 2020



Grid depends on other systems for resources and/or supports them as consumption

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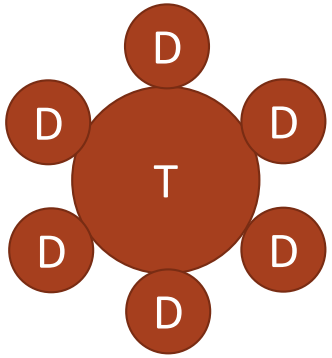
Some big driving questions…

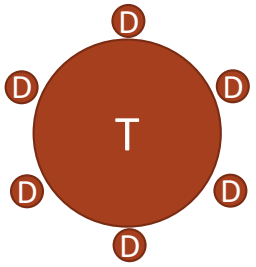
- How much cyber dependency does the grid have in terms of cyber failures and threats, sensing, command and control)? (Grid + Comms)
- Can DERs be used for blackstart and emergency response and thus improving grid resiliency? (Grid [T+D] + Comms)
- How would hurricane damages propagate through distribution to transmission? (Grid [T+D])
- Would DERs destabilize the grid due to reduced inertia and added uncertainties? (Grid [T+D])
- How to assess fuel security due to supply interruptions or competing needs? (Grid + Gas, etc.)
- How to predict, assess, and recover from damages due to natural disasters? (Grid + Weather, Transportation, and Comms)

To be answered by modeling & simulation, but how?



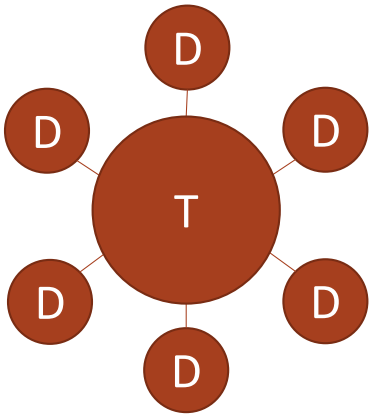
Full Model

- Preserve all details
- Not feasible to solve



Simplified Model

- Loss of details
- Fitting existing tool
- E.g. Composite Load Model



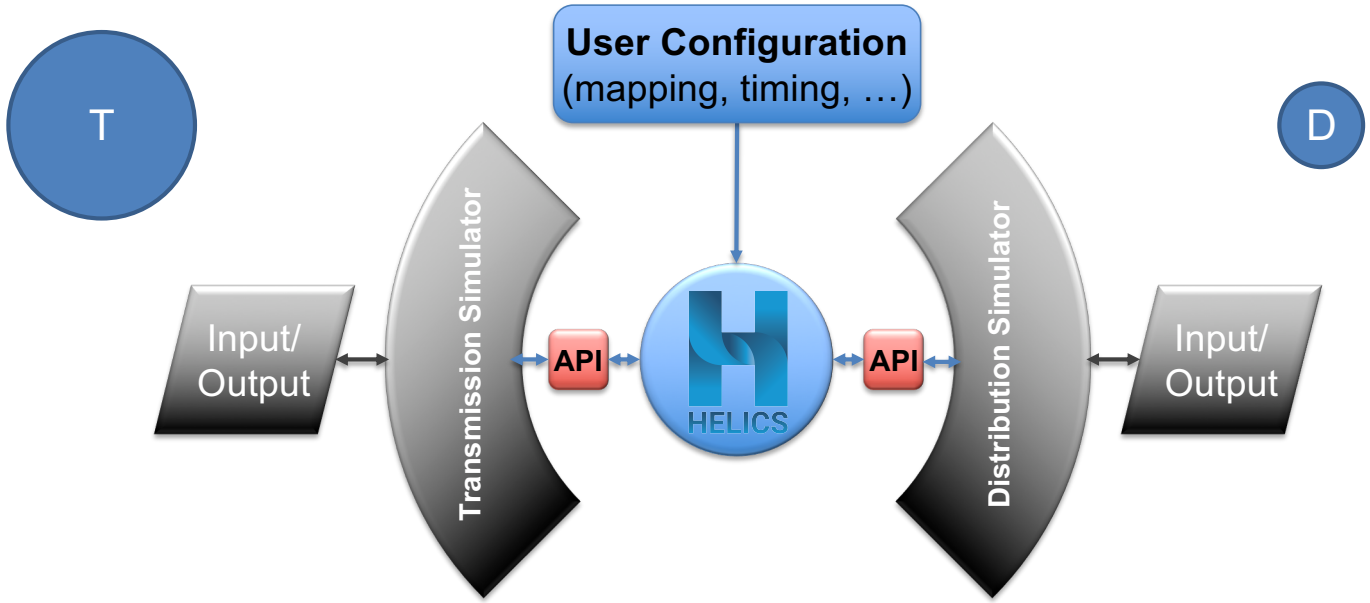
Co-Simulation

- Preserve all details
- Fitting existing tools

HELICS: Objectives

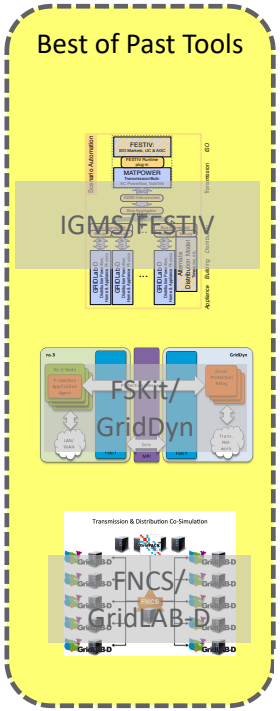
- Enable large-scale TDC interdependency studies through a flexible and scalable, open-source co-simulation platform for the following industry drivers:
  - Gap in modeling and simulation that inhibits integrated planning and assessment across multiple domains for better grid resiliency and security
  - Unlikely for the grid community alone to develop capabilities to overcome stovepipes
  - US DOE's leadership in initiating and creating foundational tools that support both research and industry
- Extensible to include other infrastructures

HELICS: a facilitator, not a simulator

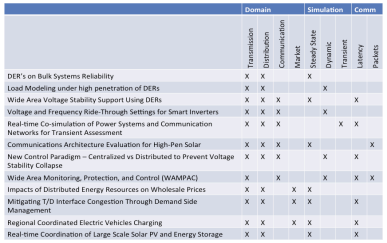


HELICS: Best-of-the-best technical strategy

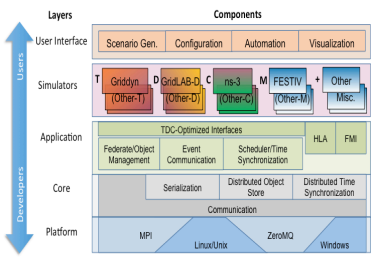
- Use-case-driven development
- Modular and scalable design
- Consolidated technologies from multiple national labs

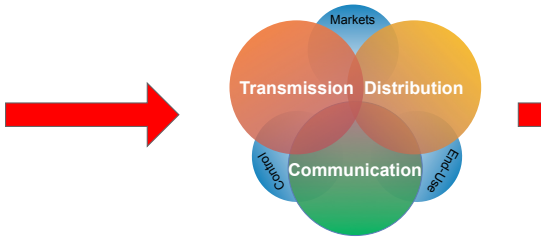


Use Case Requirements



New Platform Design





"TDC Tool"

HELICS

IGMS: Integrated Grid Modeling System
FSKit: Federated Simulation Toolkit
FNCS: Framework for Network Co-Simulation

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HELICS: Ready for user applications

- HELICS v2.0 released, https://github.com/GMLC-TDC/HELICS. Open-source, cross-system, cross-language co-simulation platform.
  - **Scalable** from 2 to 100,000+ domain simulators.
  - Continuous + **discrete**, steady-state and dynamic simulation.
  - Compatible with **standards** (FMI and HLA).
  - APIs to key domain simulators, e.g. GridDyn (T), MATLAB (T/D), GridLAB-D (D), **NS3 (C)**, FESTIV (M);
  - Supports C/C++, MATLAB, Python, Java, Julia.
- Validation and outreach:
  - Demonstrated validity and value by multiple use cases. Public use-case repository https://github.com/GMLC-TDC/HELICS-Use-Cases.
  - HELICS mini-tutorials developed, https://www.youtube.com/channel/UCPa81c4BVXEYXt2EShTzbcg
  - HELICS tutorial at IEEE PES T&D Conference in April 2018; Updated tutorial scheduled for IEEE PES General Meeting in August 2019.
  - HELICS 8-session webinar series (August 2018).