

American Modelica Conference 2022

Industrial User Presentations

Use of TRACE® 3D Plus Models with Spawn

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NoE – Modeling and Simulation

Trane Technologies

Oct 27, 2022

Agenda

- 1 Introduction

- 2 Need

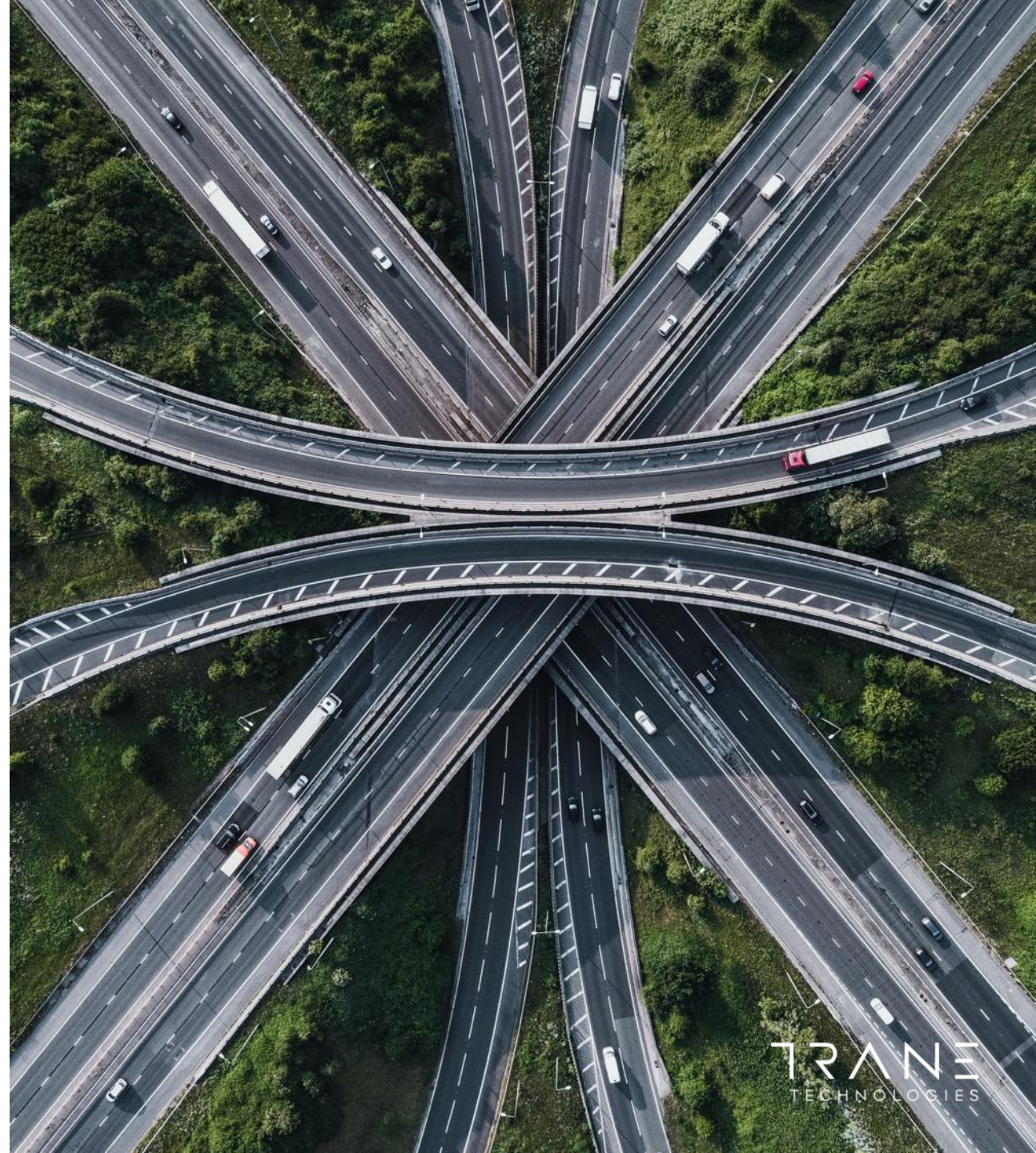
- 3 Previous and Existing Approaches

- 4 Workflow

- 5 Conclusion

Trane Technologies solves sustainability challenges through innovation in the heating and cooling industries.

Trane Technologies (NYSE:TT) is a global climate innovator. Through our strategic brands Trane® and Thermo King®, and our portfolio of environmentally responsible products and services, we bring efficient and sustainable climate solutions to buildings, homes, and transportation.

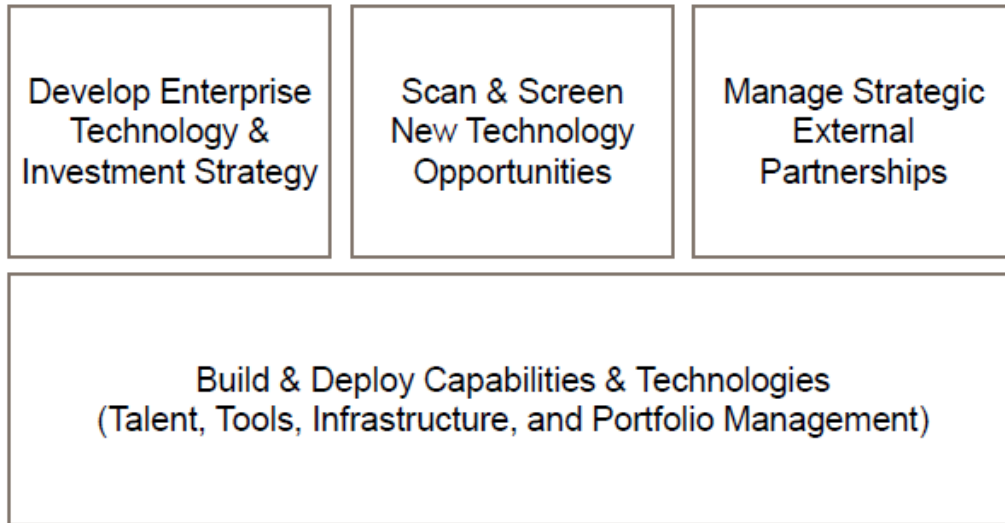


Advanced Technologies Teams

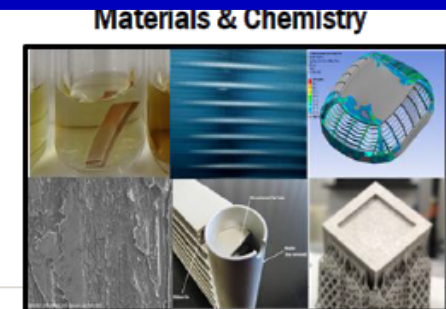
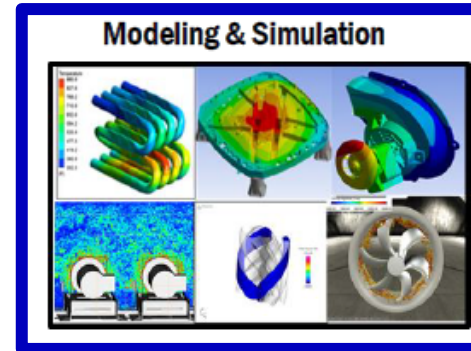
Networks of Excellence

Advanced Technology Teams are global teams with the responsibility of keeping Trane Technologies on the leading edge of their respective technical domain. They are responsible for defining and delivering advanced technology by leveraging external partners and transferring technology to the business units through defined projects. We refer to these teams as Networks of Excellence (**NOE**)

Network of Excellence (NOE) functions



Technology Domains



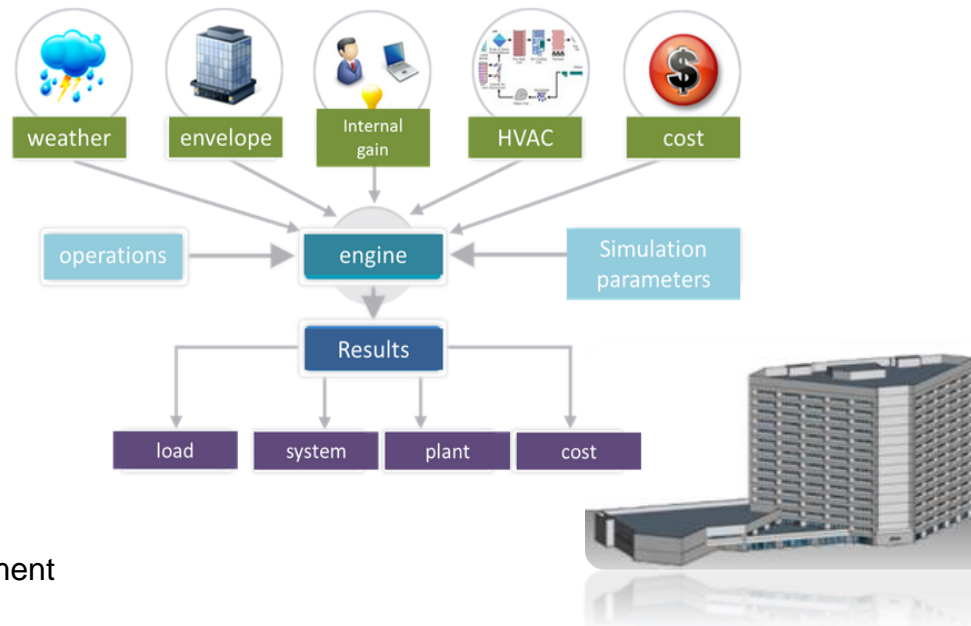
Compression Technologies



TRACE 3D Plus

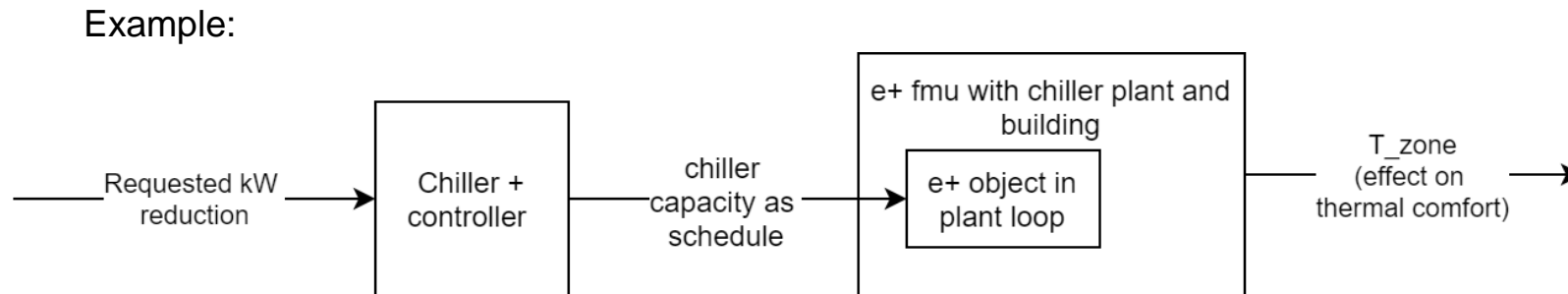
- TRane Air Conditioning Economics
- Built on US DOE's EnergyPlus engine
- Simplifies use of EnergyPlus engine
- Inherits all EnergyPlus features + custom features and controls added based on internal experience and listening to customers
- Building wizard, 3D drawing tool, building type templates simplify and drastically reduces model creation time

- HVAC equipment sizing
- Building design options
 - HVAC and Non-HVAC
- Code compliance
- Building energy usage
- Building rating systems
- Life cycle cost analysis
- Economic justification
- Utility rebate opportunities
- Environmental impact
- Systems research and development



Need

- Research focused requirements: experimental, limited for a specific problem or heavily driven by controls
- Rapid development and simulation of high-fidelity building models with high-fidelity controls
 - Example: Integrating chiller controls with multiple compressors with multiple stages with building model
- Integrating building models with embedded code (use of Simulink's code generation feature)
- Exporting building-only fmus



Previous and Existing Approaches

	Approach	Status
1	EnergyPlus - EMS	Used by e+ domain experts
2	Tuned RC circuit models	Used by controls engineers if data available to tune R-C values
3	BCVTB	No traction in SBU
4	MLE+	No traction in SBU
5	Building models in Modelica	Simpler geometries
6	TRACE 3D Plus fmu export	Domain expertise
7	Load profile from TRACE fed to Modelica model	Simpler approach, weak coupling

Spawn

- Released with Modelica Buildings Library (MBL) in 2021
- Reuses the envelope and daylighting modules of EnergyPlus
- Couples building models with HVAC and control models in Modelica through FMI

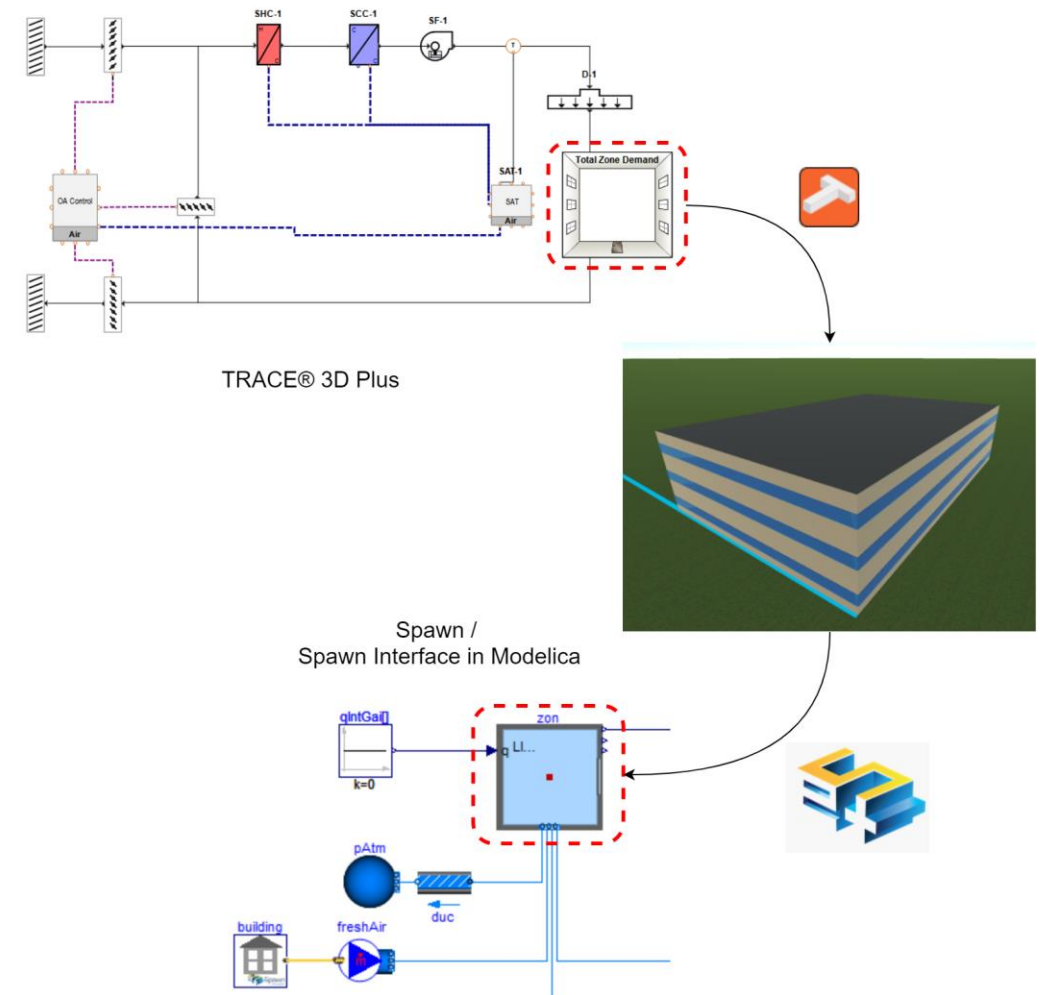
<https://lbl-srg.github.io/soep/>

Lifting The Garage Door On Spawn, An Open-source BEM Controls
Engine

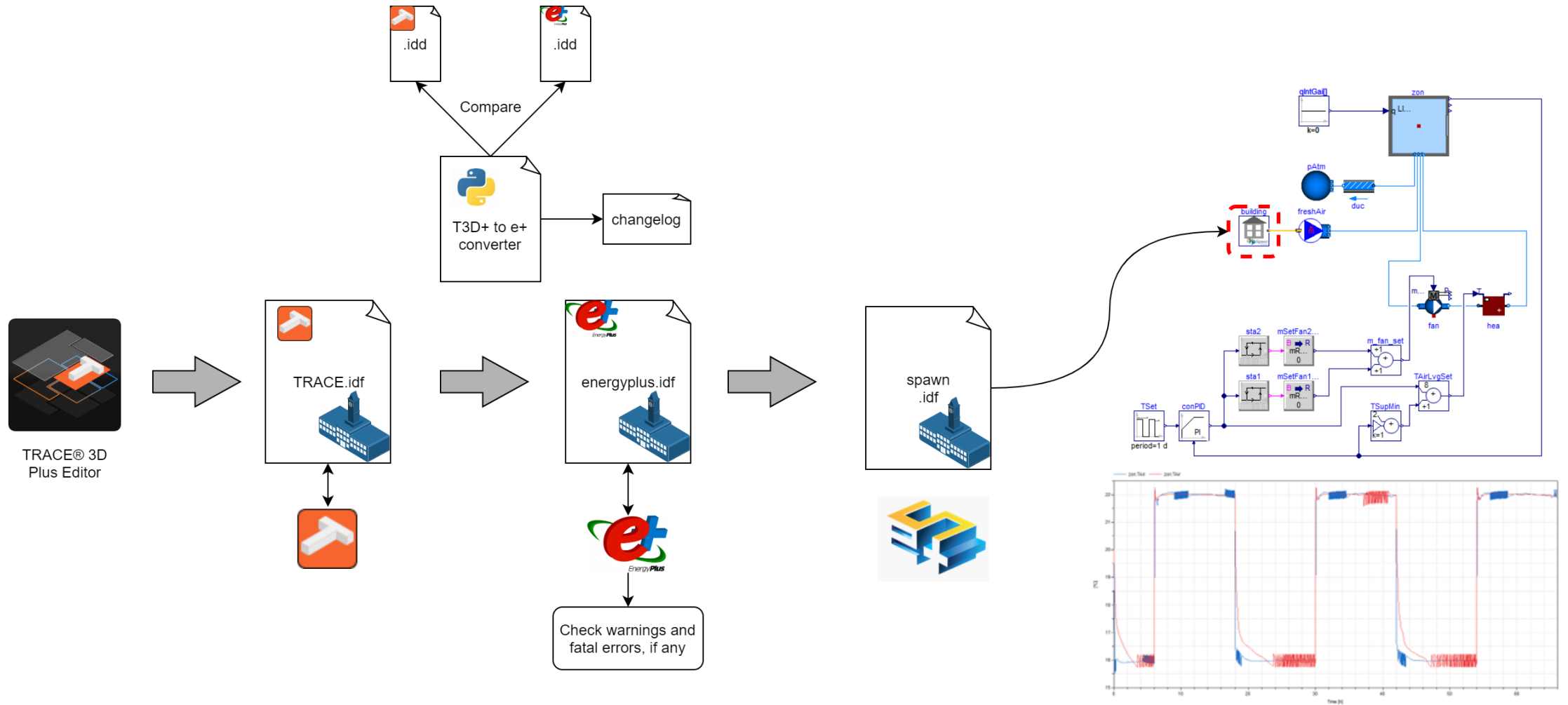
Wetter, Michael; Benne, Kyle; Gautier, Antoine; Nouidui, Thierry S; Ramle, Agnes; Roth,
Amir; Tummescheit, Hubertus; Mentzer, Stuart; and Winther, Christian.

Target Workflow

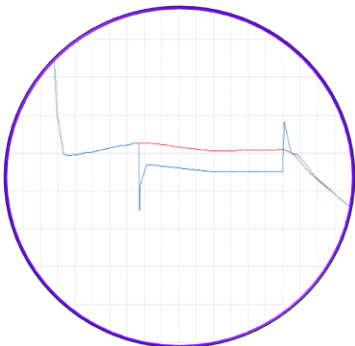
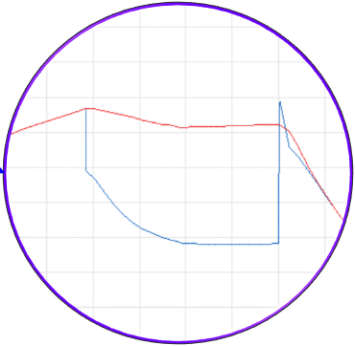
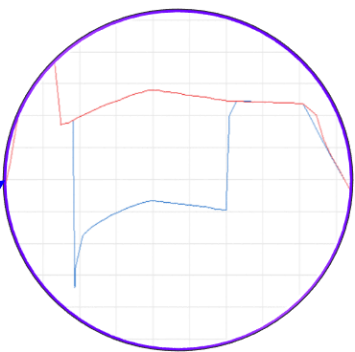
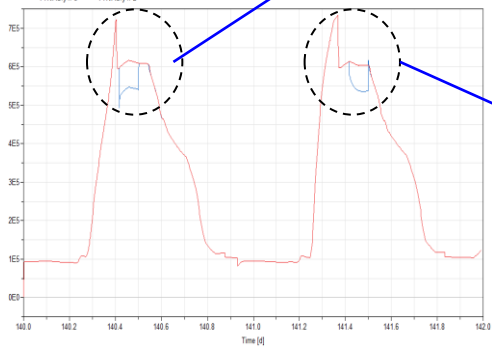
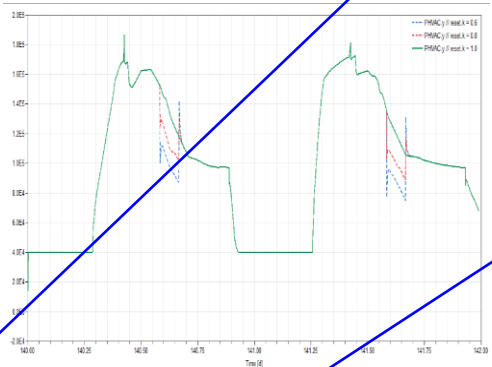
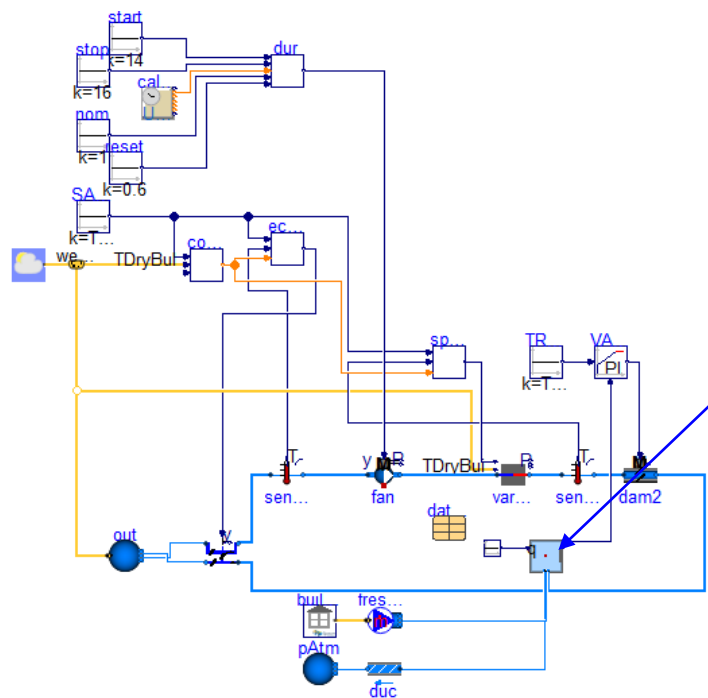
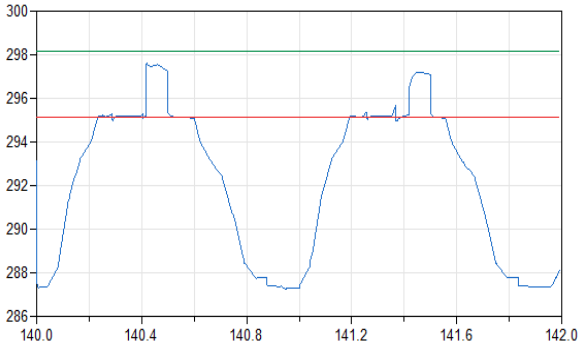
- Create the building model in TRACE and select template for building type
 - Building wizard
 - Draw
 - gbxml import
- Add plant from templates
- Simulate and get TRACE idf
- Apply idf conversion process
- Use the idf in Spawn interface from Modelica Buildings Library



TRACE 3D Plus to Spawn



Workflow



Conclusion

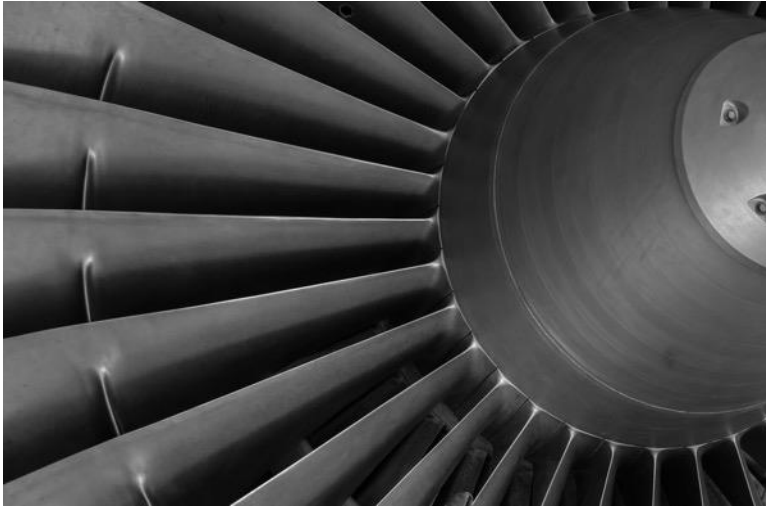
- **Reduced model development time:** the workflow has enabled rapid model prototyping in Modelica with high fidelity building model developed in TRACE
- **Integration with controls:** Equipment level controls now can be simulated with building models built in TRACE
- **Current applications:**
 - Demand response modeling – testing of short-term resets and demand reduction strategies
 - Building-only fmus for federated learning – easy to export and use TRACE models on multiple platform
- **Ease in model sharing and deployment:** Customization and control over model complexity exposed to the user

Acknowledgement

We greatly appreciate continuous support from Dr. Michael Wetter (Berkeley Lab), Scott Munns, Matt Biesterveld, Nagappan Chidambaram, and Jim Spielbauer (Trane Technologies).

Thank you!

Appendix



COMPANY HISTORY

Trane incorporated in 1913.

Thermo King was founded in 1938.

Trane Technologies (formerly Ingersoll Rand) debuted as a climate-focused innovator in 2020 after separating its Industrial businesses and renaming the remaining company.



COMPANY HEADQUARTERS

Trane Technologies is headquartered in Swords, Ireland.



NEW YORK STOCK EXCHANGE

Trane Technologies (NYSE: TT) has been listed on the New York Stock Exchange since March 17th, 2020.

Trane Technologies' stock ticker is TT.

OUR BUSINESSES CORPORATE OVERVIEW



COMMERCIAL HVAC

Innovative solutions geared toward making high-performance buildings reliable and safe, as well as healthy, comfortable and efficient



RESIDENTIAL HVAC & SUPPLY

Heating, cooling, thermostat controls and home automation for the residential market and a complete selection of innovative parts, options and accessories for optimal performance and reliability

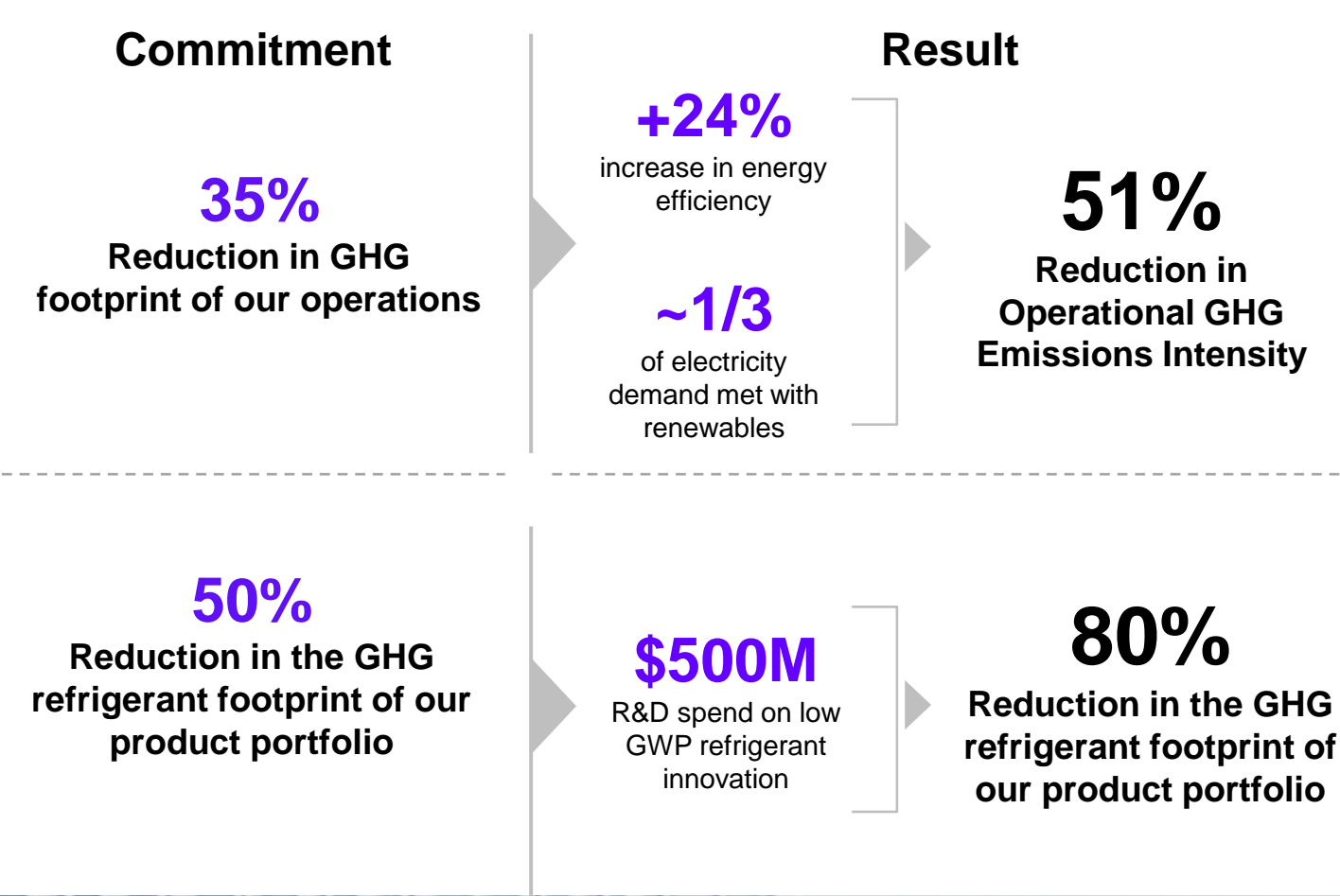


TRANSPORT REFRIGERATION

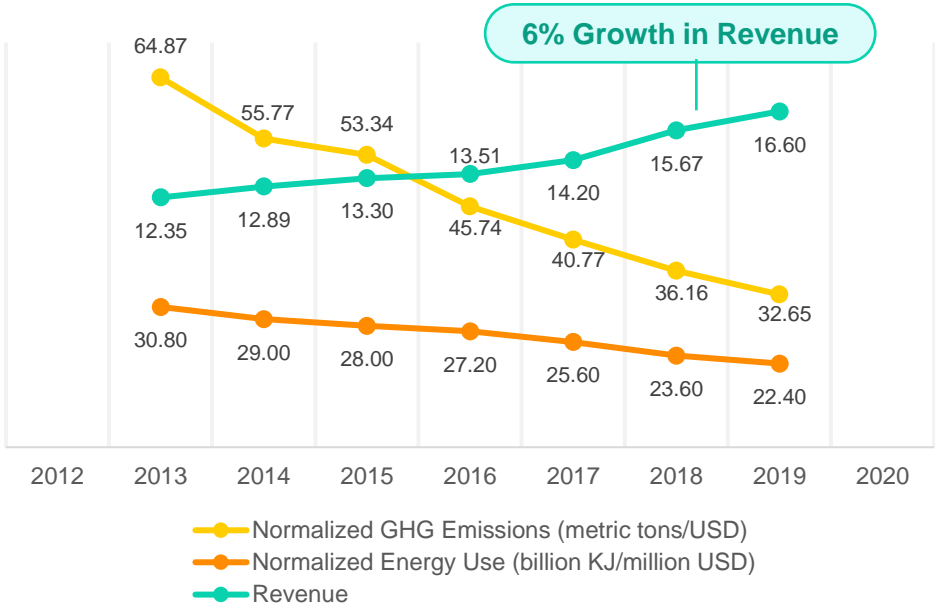
Manufacturing and innovation of transport temperature control systems for a variety of mobile applications, including trailers, truck bodies, buses, shipboard containers and rail cars




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Growth with Fewer Resources





World & North America Index in 2021

11 Consecutive Years



Top 100, 5th consecutive year