Czero®
ENGINEERING TOMORROW

General Overview
June 2026

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Czero Background

Czero accelerates technology development using sophisticated, analysis-led engineering

Stats:

- 19-year-old firm founded in 2007
- Located in Fort Collins, CO
- Clients: DOE, DOD, National Labs, Universities, and companies of all sizes
- Primarily contract R&D/engineering services
- Technology agnostic – work on all sources of energy production, storage, conversion and use
- 16,000 ft^2 facility w/prototype build and test facilities: material receiving & handling, In-house machine shop, metrology, control panel build shop, and other critical operational infrastructure to deliver prototypes
- Test capabilities include: Hydrogen test cell, electric engine dynamometer, thermal chamber, high power hydraulics, HIL setup, etc.
- Czero's network includes suppliers with deep expertise in advanced fabrication and manufacturing capabilities such as additive manufacturing, material joining, machining, and other state-of-the-art manufacturing processes
- More than 450 projects completed

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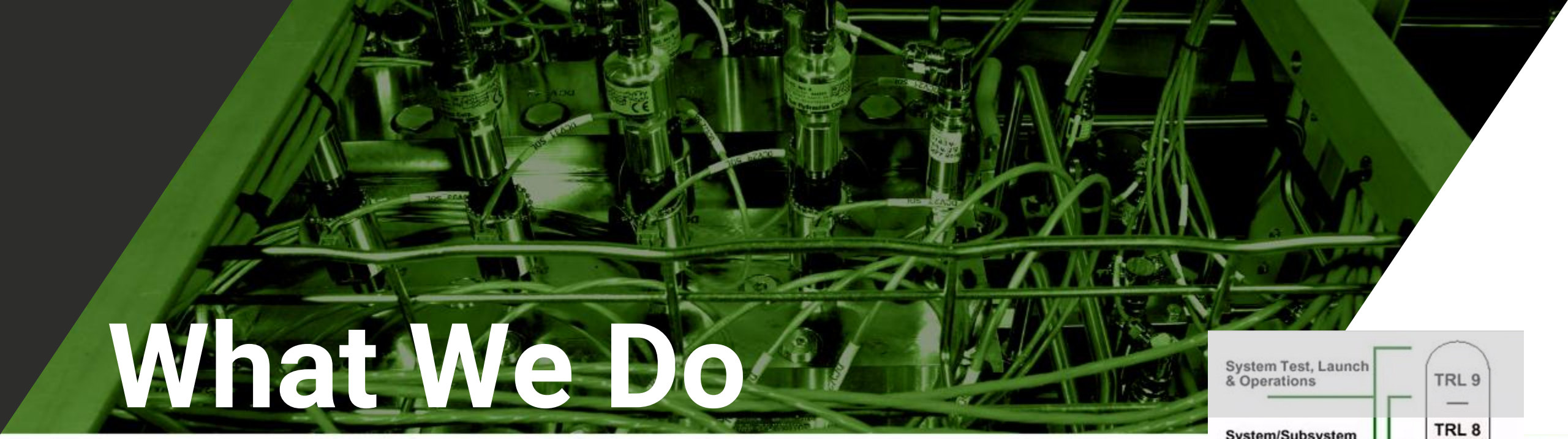
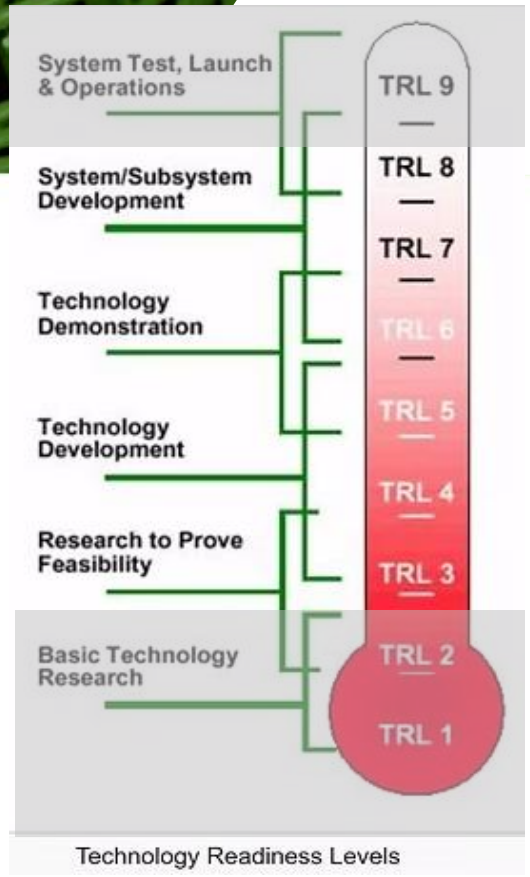


What We Do

Czero helps our clients develop innovative hardtech technologies in the energy space. *Typically low TRL*



Technology Readiness Levels

Two bookends on how we work with our clients:

1) ***Discrete workscopes:*** CFD, FEA, Dynamic Modeling, CAD, Controls, Prototype build, Testing, Technoeconomic analysis, Etc.
2) ***Complex system integration/Contract R&D:***
   - Complete napkin to working prototype

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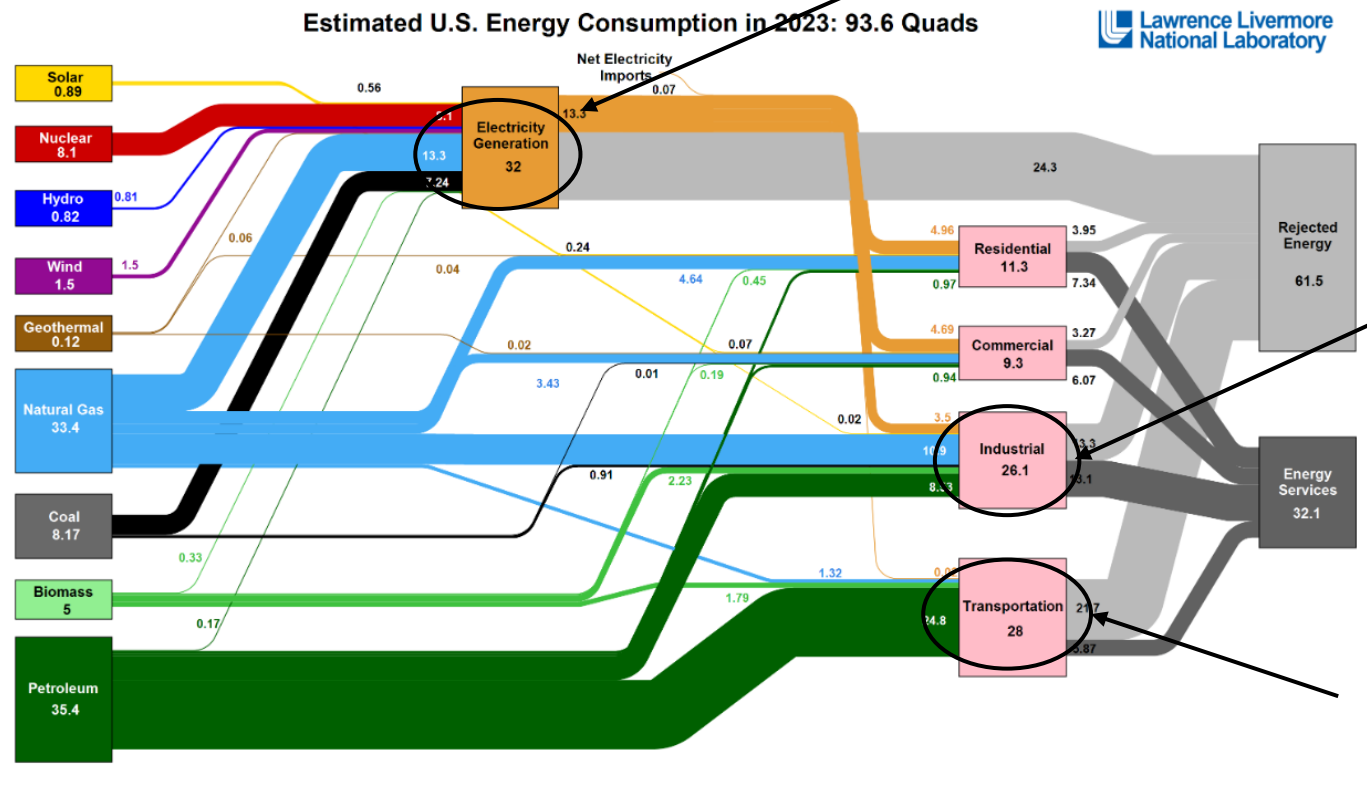
Czero is Technology Agnostic

Czero does a lot of work on renewable electricity (wave, tidal, wind, concentrating solar) and grid firming to further enable them. Grid firming projects are mostly non-battery storage (thermal, electrochemical, compressed air, hydrogen, gravity, etc). We work with (PEM, SOFC/SOEC, Alkaline electrolyzers, for electric production and/or hydrogen production

Czero has been involved in helping develop technologies for every energy source listed here except coal



More recently, Czero has been working on the hard to decarbonize industrial sectors. Steam, high temp heat, etc.

Czero's roots are in the automotive sector working on advanced combustion system, valvetrains, fuel injectors, hybrids and electrification and we continue to do work there. Now working on e-fuels

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Easy For You

Creative Insight

Broad, experienced team – the power of diversity to finding creative solutions to your toughest challenges.

Quality Service

Exceptional up-front engineering saves you time and money later.

Flexible Engagement

Close collaboration or fully autonomous delivery.

Responsive Engineers

You benefit from Czero's agility and thorough processes synonymous with R&D teams in large global corporations.

Disciplined Execution

You benefit from our proactive project management culture which ensures the project is delivered on time and within budget.

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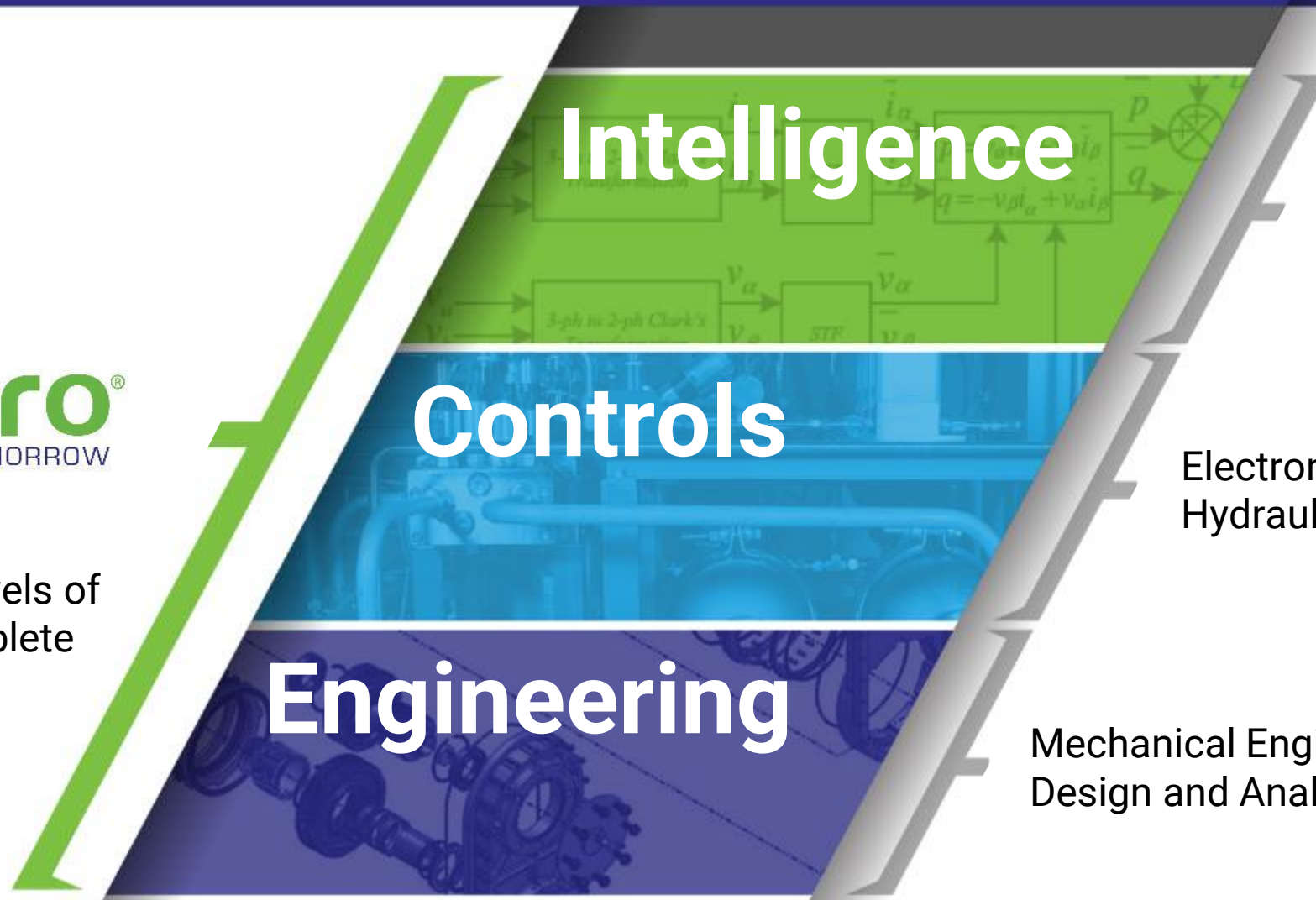
Integrated Solutions

Czero integrates all levels of engineering for a complete one-source solution.



Algorithms

Electronics and Hydraulics

Mechanical Engineering, Design and Analysis

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Core Expertise – Complex System Integration

We focus on early-stage technologies in the energy space

Can do entire workscope from napkin sketch to robust prototype systems

Or do a discrete part of a project

"Czero is one of the best companies I have worked with for analysis and simulation; including dynamic modeling, CFD and FEA. Their deep expertise and comprehensive quality system ensure accurate results. Czero's project management is excellent, providing clean concise information on progress, schedule and budget. Czero is a go-to source for projects ranging from analysis and simulation to prototype product development and testing. They deliver strong solutions to the challenges faced by Offshore and Subsea markets."

- Horst Moll, Former First Chief Engineer, Aker Solutions

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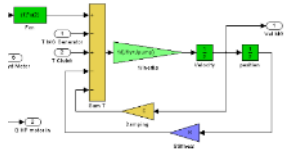
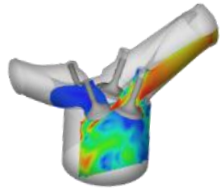
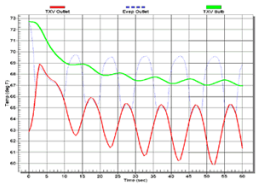
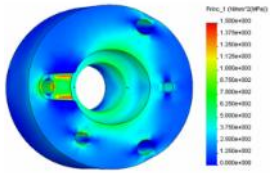
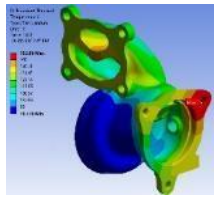
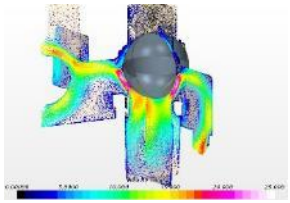
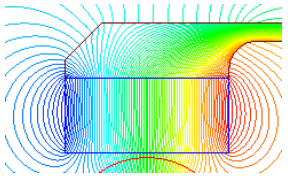
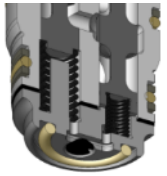
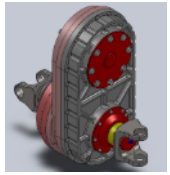
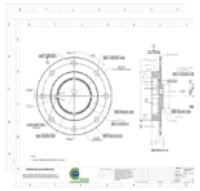
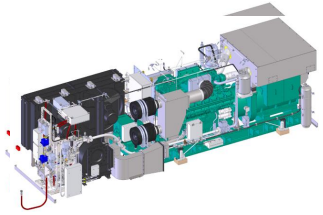
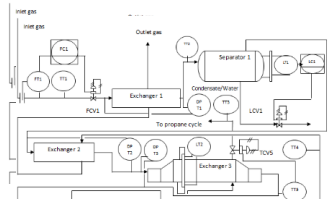
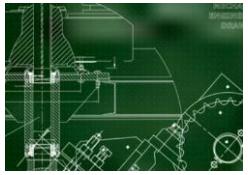
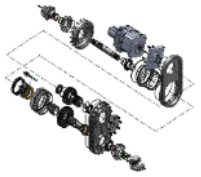
Three Groups – All highly integrated

Modeling & Simulation – Dynamic modeling, thermodynamic analysis, FEA, CFD, magnetic modeling

Mechanical Design – Solid Modeling, GD&T, System design, layout studies, tolerance stacks, etc. Process flow diagrams

Controls - Embedded controls, rapid prototyping systems, industrial automation, HIL, MIL, SIL systems, advanced controls algorithm development (dynamic programming, non-linear, optimal, and adaptive control, neural networks)

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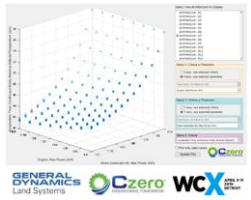
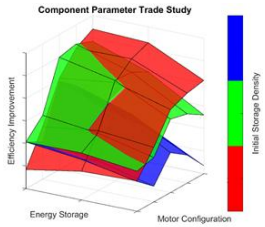
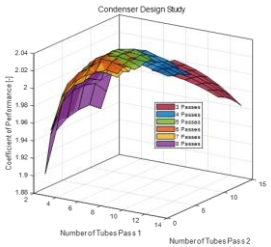
Dynamic Modeling and Simulation Capabilities

- 30+ years of experience modeling complex dynamic systems
- Czero's Modeling and Simulation team specializes in developing dynamic models for challenging applications:

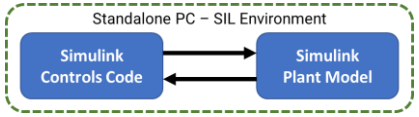






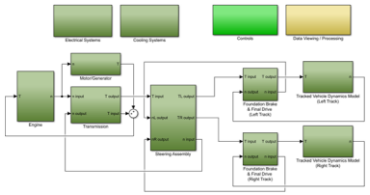
Modeling Domains

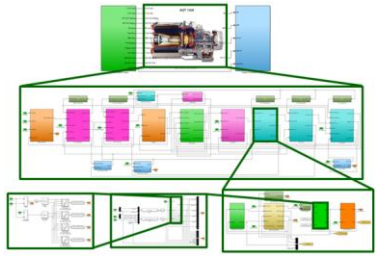
- Energy conversion
- Multi-species multi-phase gas and liquid dynamics
- Chemical processes
- Electrochemistry
- Thermodynamics
- Compressible and incompressible flow
- Electrical and magnetics
- Combustion
- Rigid body dynamics
- Multi-physics modeling



Use Cases

- Early-stage system design
- Trade studies and optimizations
- HIL/MIL/SIL plant modeling and integration
- Failure analysis





Software Packages

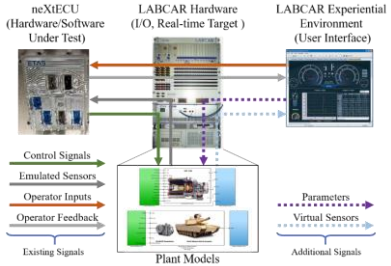
Causal:

- MATLAB/Simulink*

Acausal:

- MATLAB/Simscape
- GT-SUITE
- Amesim

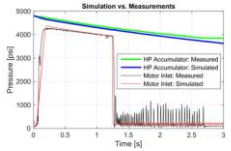
*Primary simulation tool featuring a large library of internally developed blocks

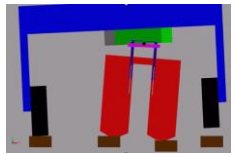


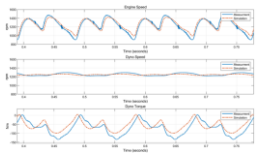
Select Applications

- Compressed air energy storage/ bottoming cycles/ power generation
- Chemical processes
- Fuel cells
- Compressors
- Gas turbines/ turbomachinery
- Hybrid powertrains
- High bandwidth hydraulics
- Fuel injectors
- Electromechanics/electrohydraulic actuators
- Engines
- Vehicle and suspension dynamics
- Refrigerant/ vapor compression cycles

MathWorks Partner







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Computational Fluid Dynamics (CFD) Capabilities

- 30+ years of experience performing all types of CFD analysis using common commercial CFD software packages
- Czero's CFD modeling expertise and capabilities include:

Tools

ANSYS CFX

ANSYS FLUENT

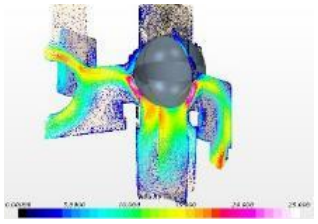
SIEMENS Simcenter STAR-CCM+

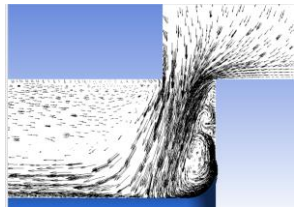
CONVERGENT SCIENCE

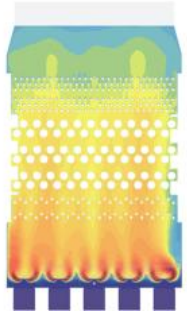
rescale

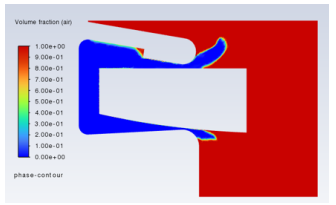
Czero ENGINEERING TOMORROW

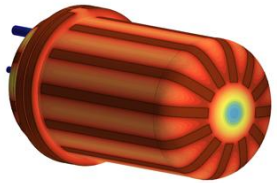
Steady and Transient Flow	Thermal Analysis	Two-phase Flow	Reacting Flow	Rotating Equipment
• Laminar and Turbulent • Gas, liquid or two-phase flow • Predict pressure drop, flow patterns, flow forces and mixing in 3-D flow passages, valves and pipes	• Steady or transient • Conduction, Convection, & Radiation • Thermal storage and heat loss • Heat exchangers • Fuel cells • Engines • Chemical reactors	• Boilers • Wet-Scrubbers • Condensers and Evaporators • Mixing Tanks • Fuel injectors	• Mixing based models • Chemical kinetics-based models • Commercial power plants • Gas turbine combustors • Natural gas burners • Internal combustion engines • Fuel cells • Chemical reactors	• Rotating frame of reference • Moving mesh • Gas Turbines • Wind Turbines • Turbochargers • Pumps • Compressors

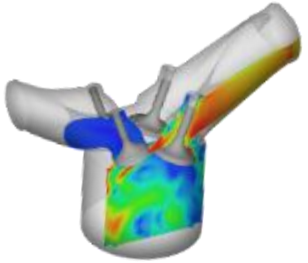


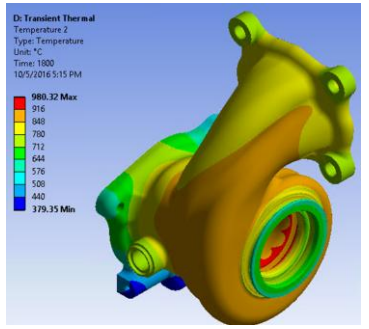












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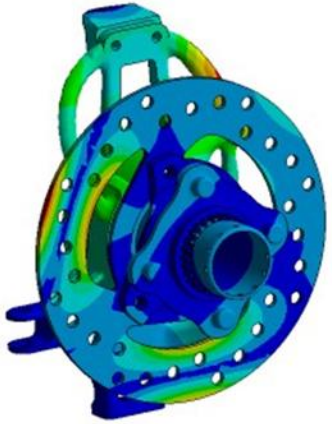
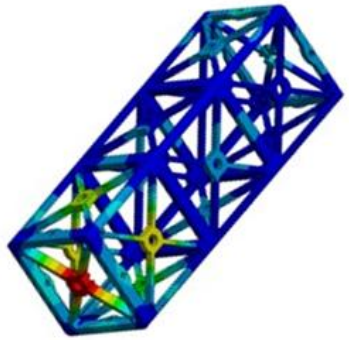
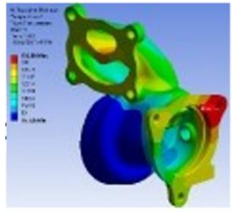
Finite Element Analysis (FEA) Capabilities

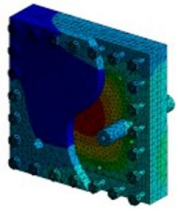
- 20+ years of experience brought to our customers
- Czero provides an extensive list of capabilities for FEA, including but not limited to:

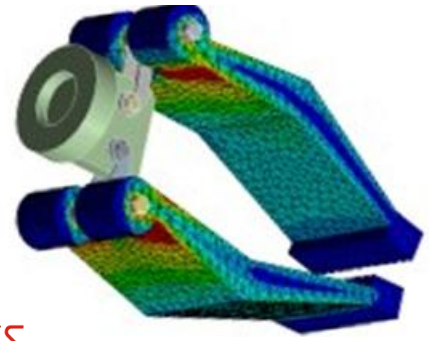


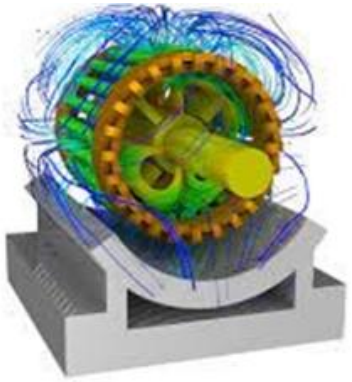


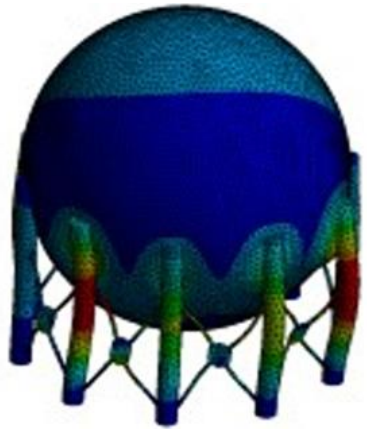
Static Analysis	Dynamic Vibration Analysis	Explicit Dynamic Analysis	Fatigue / Durability	Thermal Analysis	Optimization
• Linear analysis • Nonlinear analysis • Quasi-static analysis • Buckling analysis • Creep/stress relaxation analysis • Contact bolt joint analysis • Leakage, interference analysis	• Modal analysis • Transient dynamic analysis • Frequency response harmonic analysis • Random vibration analysis • Shock spectra analysis • Multi-body dynamics	• Impact analysis • Drop test analysis • Large deformation forming High velocity impact • Crack propagation	• Stress-life approach • Strean-life approach • ASME standard fatigue analysis • DNV standard fatigue analysis	• Steady-state thermal analysis • Transient thermal analysis • Coupled field thermal analysis • Transient weld analysis	• Topology optimization • Size, shape, and volume optimization • Topography optimization











Ansys

SOLIDWORKS SIMULATION

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Controls Capabilities

- 25+ years experience developing advanced control systems across multiple industries utilizing various hardware platforms
- Czero's controls expertise and capabilities include:

Tools

Expertise	Industries	Languages	Hardware Platforms	Comms Protocols
• System modeling and Analysis • Classical Controls • Advanced Controls • MIL, SIL, and HIL Development and Testing • Embedded Controls • Electrical Design	• Industrial • Automotive • Power Generation • Agriculture • R&D • Defense	• MATLAB/Simulink • C, C++, C# • Java • Python • CODESYS • SQL • LabVIEW	• Beckhoff • Motohawk • Woodward • TTControl • Bosch • ABB • Siemens • Wago • TI • STMicro • dSPACE • Speedgoat • Raspberry PI • Etc.	• TCP/IP, UDP • Modbus TRU & TCP • CAN, XCP, CCP, LIN • J1939 and J1587 • Serial • I2C • SPI • SCPI

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Mechanical Design Capabilities

- 25+ years experience. All design group members are degreed engineers (BSME or higher)

CAD/Design

- Analysis led design
- System integration and design
- Concept level to detailed design
- Component selection and sourcing
- Material selection and specification (alloys, het treatments, surface coatings and treatments
- Risk assessment, HAZOP/DFMEA, full system nodal analysis
- Testing development, test rig design, test procedure development.

Manufacturing Drawings

- ASME Y14.5
- Machined parts
- Weldments
- Sheet metal
- Casting
- Forgings

P&ID/Schematics

- Block Flow Diagrams (BFD)
- Process Flow Diagrams (PFD)
- Piping and Instrumentation Diagrams (P&ID)
- General schematic and schematic/system development

Procurement Assembly and Testing

- Vendor sourcing
- Procure all project hardware
- Manufacture parts, as necessary
- Full assembly and testing capabilities

Project Types

- Complex system integration
- Prototype development and testing
- Reverse engineering
- Machine design
- Mechatronics design
- Structural design
- Hydraulics valve and system design
- High speed actuator and mechanisms
- Clean Tech
- Automotive
- Fluid Power
- Oil and Gas
- Grid-firming technologies
- Hydrogen systems and fueling infrastructure
- Fuel cells
- Turbine systems
- Energy storage
- Energy conversion
- Vehicle electrification and hybridization
- Natural gas vehicles and mobile CNG compressors
- Renewable energy systems (wind, wave, solar)
- Carbon capture & storage
- Cleaner combustion
- Alternative fuel

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Facilities

Facility Details	Test Capabilities	Manufacturing and Assembly Capabilities
• 16,000 ft² facility including prototype build and testing areas • High-bay doors for large equipment access • Material receiving, storage, and handling infrastructure • Office workspace supporting 30+ staff members	• Electric engine dynamometer • Thermal chamber for environmental testing • High-power hydraulic systems • Hardware-in-the-Loop (HIL) testing setup • Additional custom testing capabilities • 600A, 480 VAC Power supply	• Full CNC machine shop (mill, lathe, grinding) • Metrology and quality inspection department • Welding bay • Panel build controls lab • Fully stocked tool crib • Hydraulic system plumbing and integration • Complete system assembly • Electrical wiring and integration • Paint and finishing operations

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Example Projects

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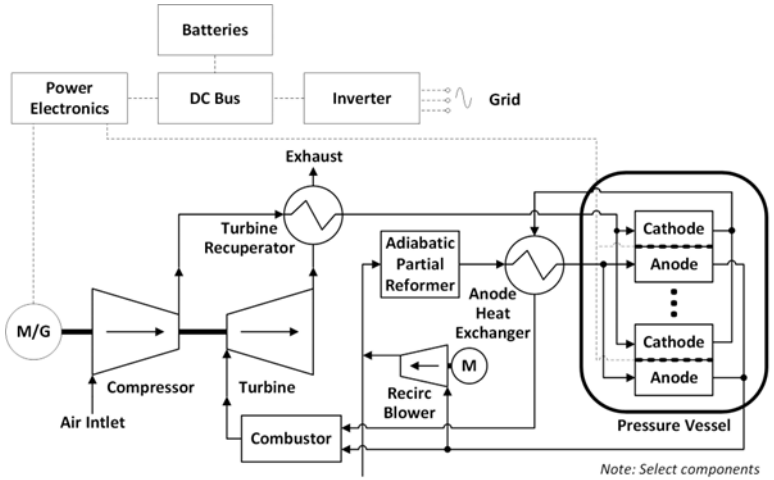
Solid Oxide Fuel Cell/ Gas Turbine Hybrid System

ARPA-E INTEGRATE Team:

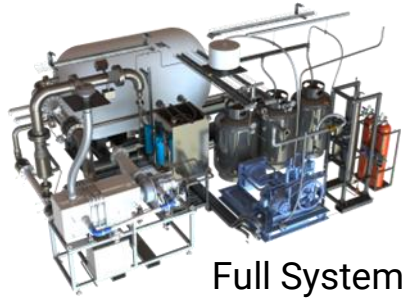
- Nexceris: PI and SOFC
- Czero: System architecture development, dynamic analysis, mechanical design, subsystem design, controls development, fabrication, and testing
- Brayton: Turbomachinery

Quick Project Facts:

- 70%+ efficiency @ 50 kWe
- Natural gas fueled
- Pressurized operation
- Operating temperatures:
  - 850°C (SOFC), 930°C (GT)
- Turbine speed: 90,000 rpm

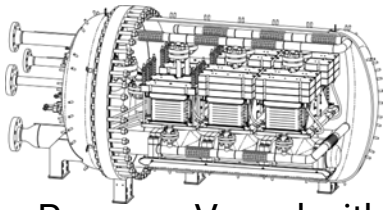


System Architecture

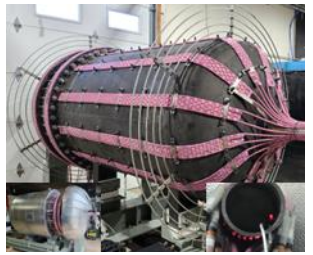


Full System Layout

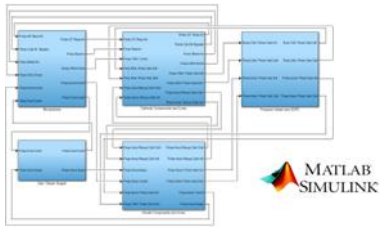
SOFC/GT Test Cell



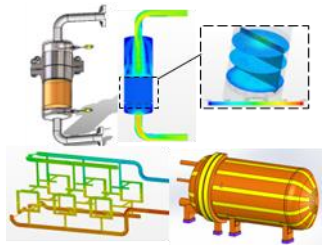
Pressure Vessel with SOFC Stacks



Pressure Vessel

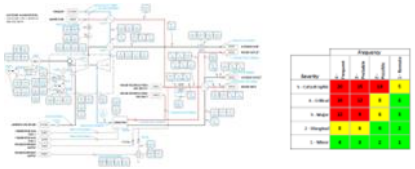


Dynamic System Modeling

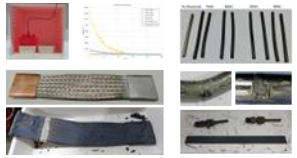


Component Development

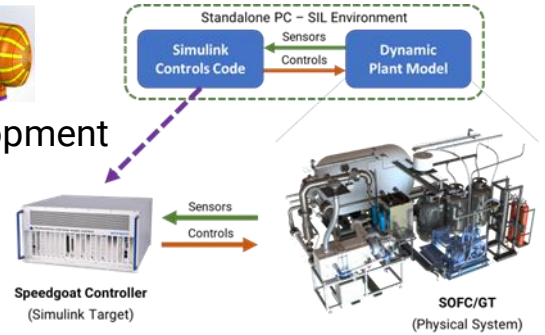
Balance of Plant



System P&ID Development and Safety Assessments



High Temperature Furnace Testing



MIL/SIL Controller Development and Validation

SCADA

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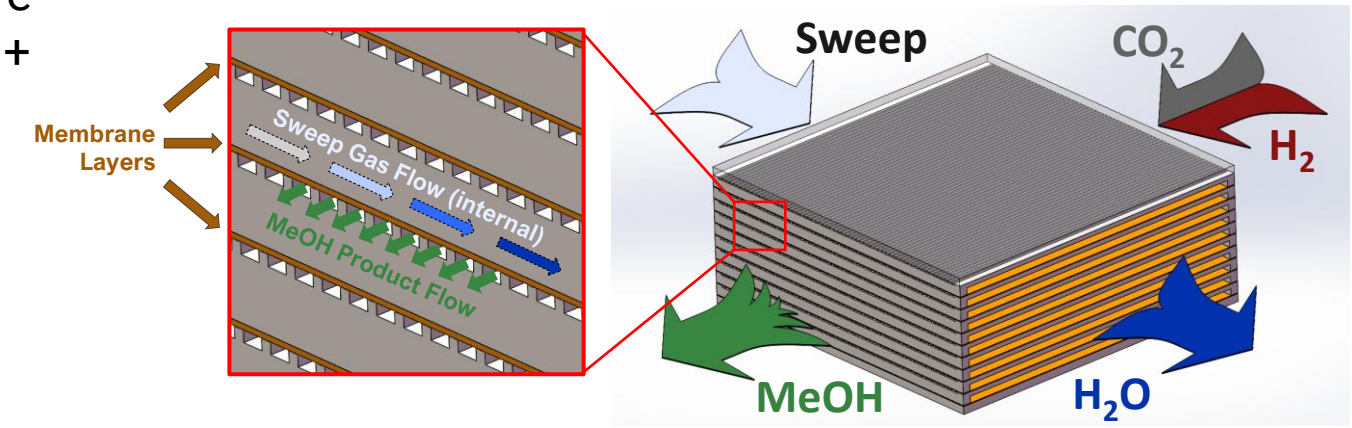
Direct CO_2/H_2 to Methanol Reactor Development

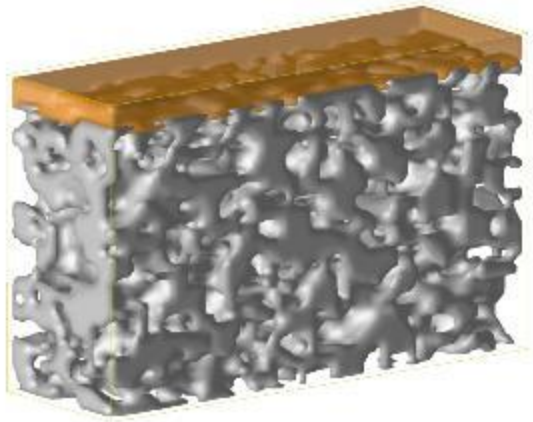
Czero is a sub-awardee on an ARPA-E GREENWELLS program led by Nexceris where the team is developing a novel low-cost CO_2 + H_2 to Methanol microchannel reactor which overcomes conventional equilibrium limitations by integrating membrane separation directly into the reactor

Czero is supporting the program through mechanical/BOP design and modeling, construction, and control system development

Microchannel Designs
Enhance Heat Transfer and Selectivity



HeatPath manages heat and mass transfer in channels



Membranes remove water to break equilibrium

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Cryogenic Carbon Capture - Controls Development and Facility Stand-Up

Czero supported Carbon America with developing a high availability fully automated control system for their novel FrostCC™ cryogenic carbon capture system and assisted with its stand-up at the National Carbon Capture Facility (NCCC) for testing

The control system monitored and controlled over 300 I/O points and utilized a Beckhoff IPC for control and a distributed I/O architecture spread across six electrical enclosures

Czero also supported the full facility stand-up process with Czero engineers on-site for over 15 weeks

Carbon America

Carbon America's FrostCC™ deployed at NCCC

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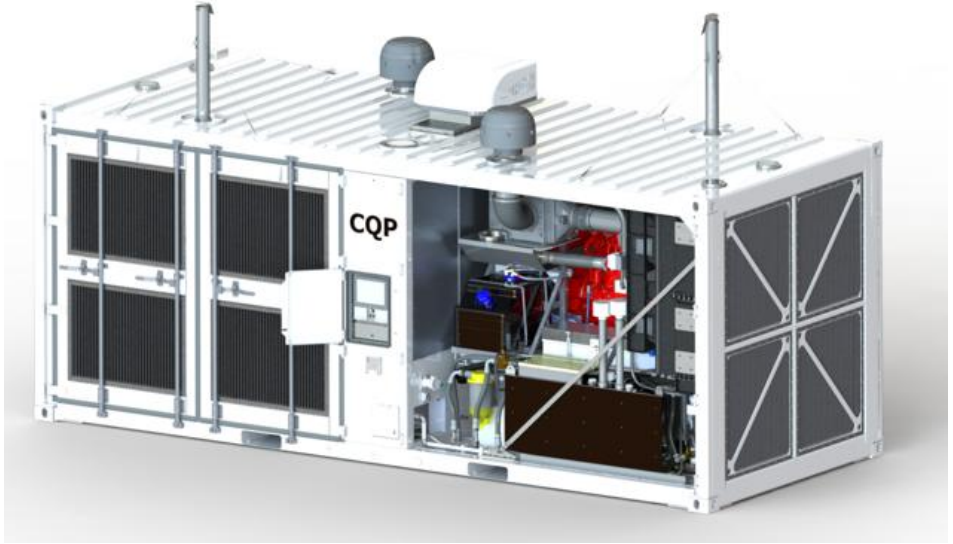
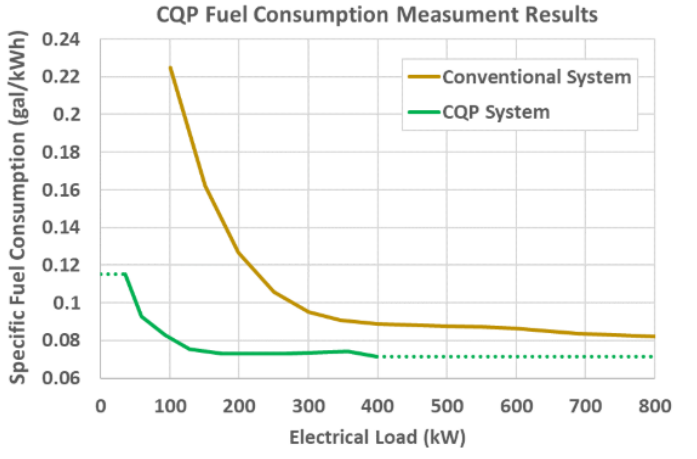
High Efficiency, Hybrid Genset/EV Charger



- Started with customer need
- Architectural studies
- Complete systems engineering, integration and controls
- Detailed design, development, prototype build and test
- Fully integrated control system (1 master and 5 slave control
- Full power management to maximize system efficiency
- Local and remote operation capable
- Grid tie and island mode capable



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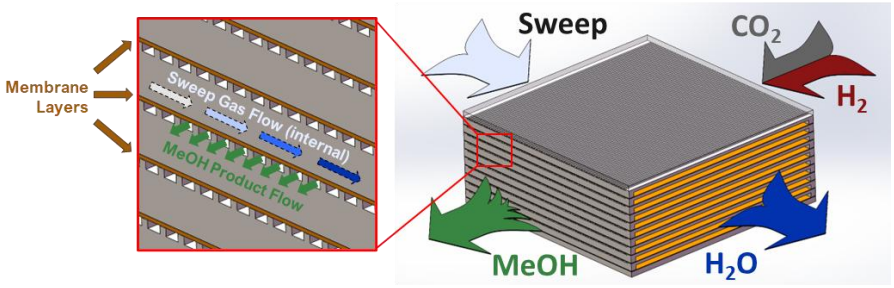
Planar Fuel Cells, Electrosynthesis, and Reactors

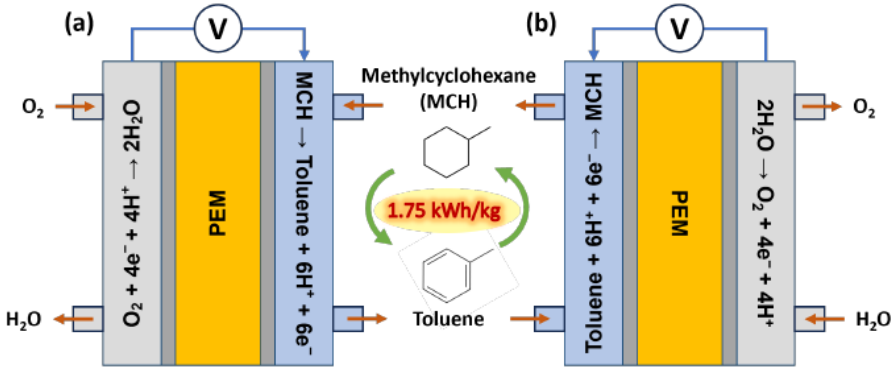
Czero has supported clients in developing a range of planar fuel cells, electrosynthesis, and reactors. While Czero is generally not involved with the detailed chemistry, Czero frequently supports clients with mechanical design such flow distribution through CFD, stack compressions, sealing, balance of plant, dynamic system operation and other similar efforts

- Solid Oxide Fuel Cells
- MCH <-> Tolune Fuel Cell/Electrolyzer
- Alkaline Electrolyzer
- Methanol Synthesis Planar Reactor
- Electrosynthesis for CO2 Capture
- PEM Fuel Cel



Nexceris' ARPA-E GREENWELLS Planar Reactor

Nexceris' Solid Oxide Fuel Cell tested at Czero



Johns Hopkins' Planar Fuel Cell/Electrolyzer

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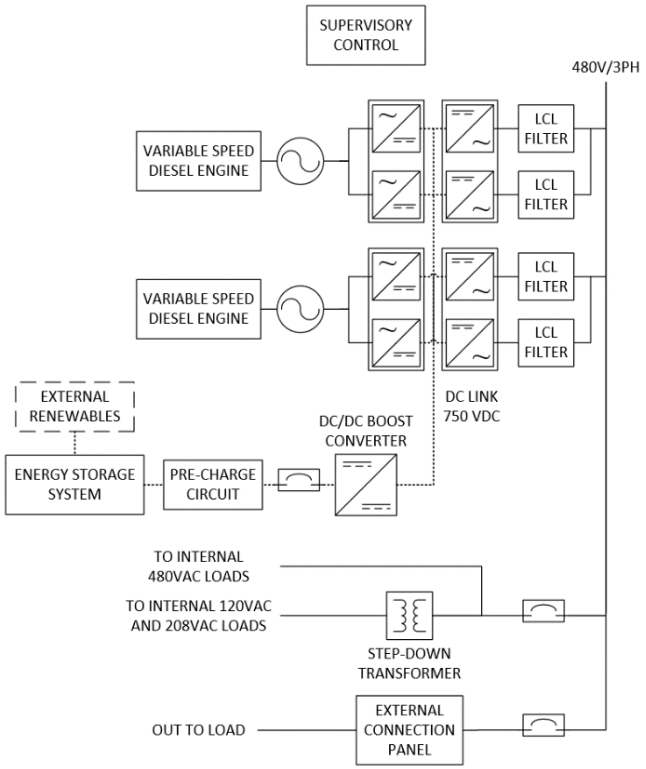
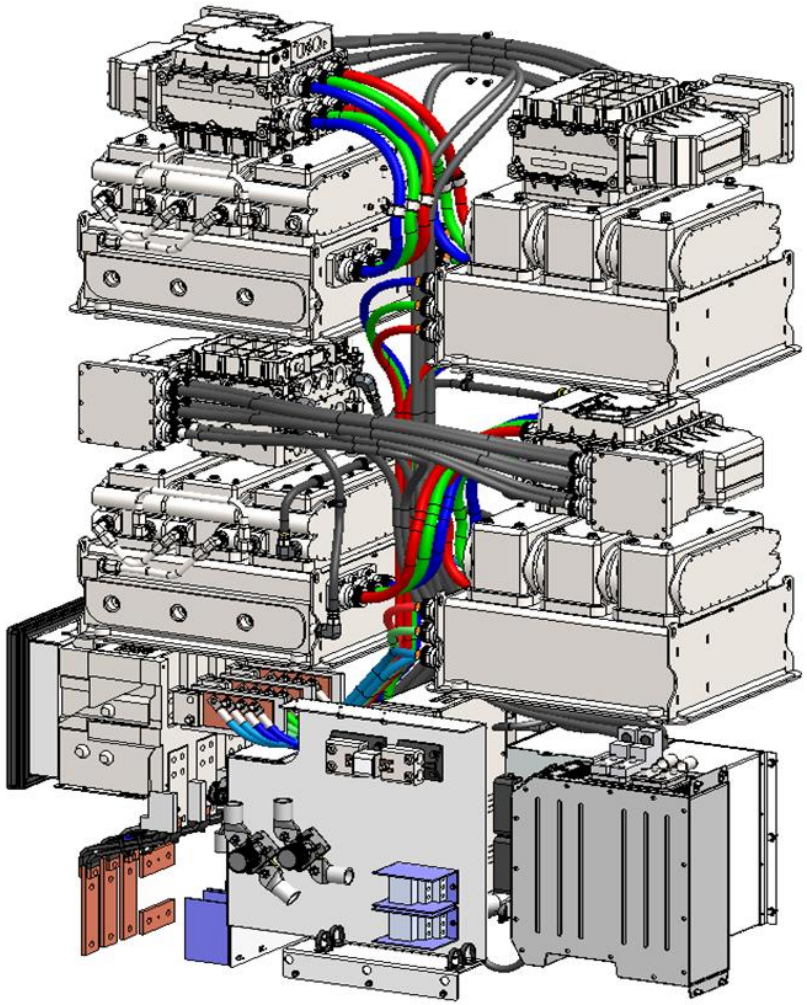
Control System for High Efficiency, Grid-Ready, Hybrid APU

- Synchronous control of five slave controllers by master controller
- Master controller monitored power demand and controlled AC power generation and utilization of stored DC power to maximize overall system efficiency
- Master controller had full system authority down to system cooling and heating in order to increase system efficiency
- System utilized multiple communication protocols



US DoD Application



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Monetizing By-products of Natural Gas Production

- Czero worked with the Gas Technology Institute (GTI), Oregon State University (OSU) and EcoCatalytic Technologies
- Developed a small-scale reactor engine for converting the longer-chain alkanes from oil and natural gas into more commercially desirable forms
- Czero's engineers modeled the gas reaction temperatures, evaluated multiple concepts and architectures, performed detailed design work, and made the first system prototype

Czero's work…has been instrumental in developing a completely new, innovative system. The in-depth simulation and analysis of the various concepts that Czero did ahead of time has built tremendous confidence that we are going down the right path.

– Devin Halliday, Principal Investigator
Gas Technology Institute

GTI ENERGY
solutions that transform

EcoCatalytic Technologies

OSU Oregon State University Cascades

Czero ENGINEERING TOMORROW

arpa·e

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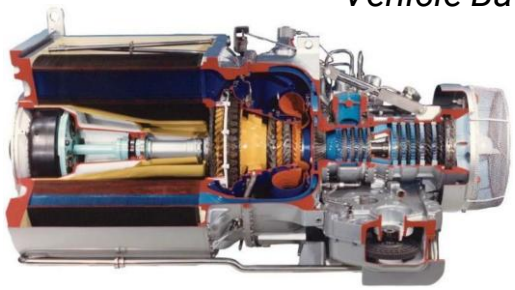
Gas and Vapor Compression – Select Prior Work

AC – Racecars

AC – Autonomous Vehicle Battery Cooling

AC – Military Vehicle

Gas – Ethane Compression/ Cracking



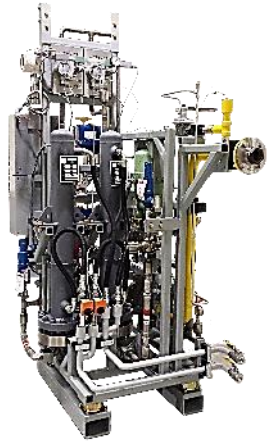
Gas – Turbomachinery

Gas – Natural Gas Compression

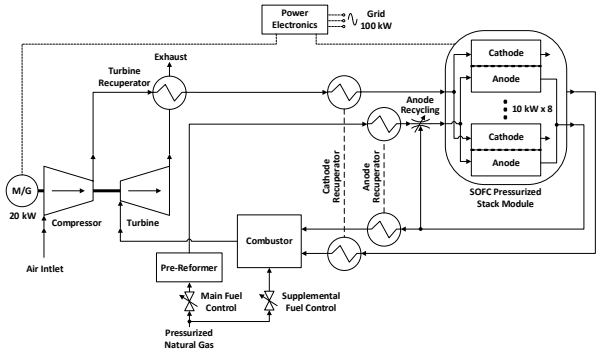
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Gas – Hydrogen Compression

Gas – Compressed Air Energy Storage



Gas – Natural Gas Skid



Gas – Pressurized SOFC/PEM Fuel Cells and Reforming

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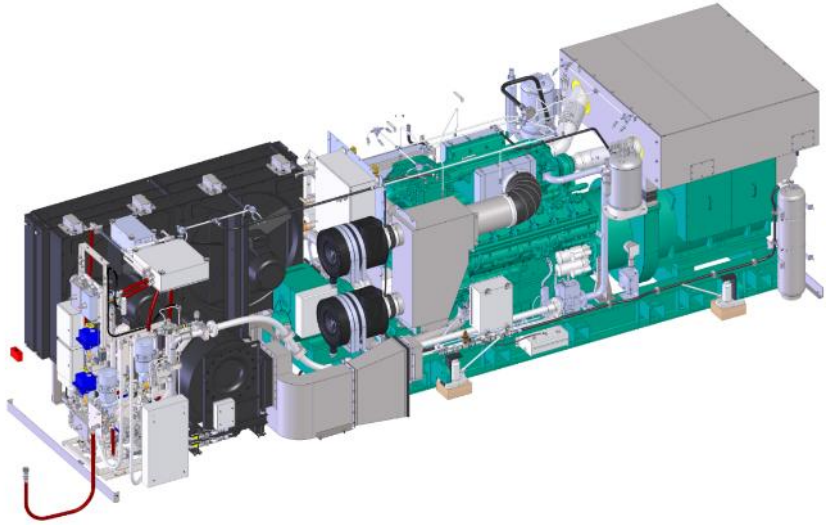
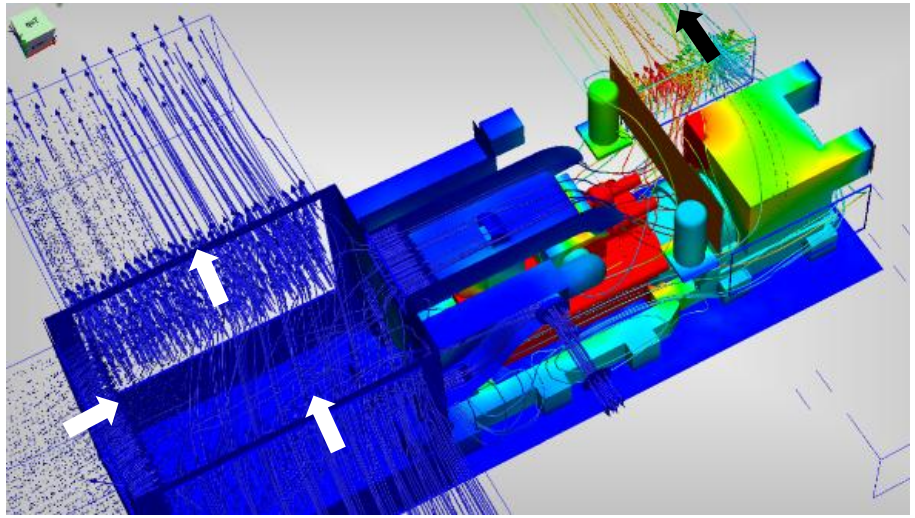
Natural Gas Genset

Czero designed a novel tender car based system that burned CNG to generate high voltage DC power that is exported to a minimally modified diesel electric locomotive.

- Full system design that utilized a Cummins QSK60 (1.5MW) engine, Kato generator, CNG tanks and BOP
- Designed and analyzed thermal management system
- Complex systems integration and packaging of custom
- genset and all ancillary systems into 30’ ISO container
- Successfully operating in field tests with Bright Rail Energy





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Natural Gas Fuel Skid

The Bright Rail Energy system required a custom fuel skid to accommodate a wide range of temperatures and flow requirements.

Czero was responsible for design and build of the entire skid:

- Fuel Inlet Conditions:
  - Gas temperature: -30°C to 40°C
  - Gas pressure: 300psi to 3,250psi
- Fuel Outlet Requirement:
  - Fuel Flow: 2,210SCFH to 14,500SCFH
  - Fuel Pressure: 4.8psi to 6psi
  - Fuel temperature: 5°C to 50°C

BRIGHT RAIL ENERGY™
NATURAL GAS LOCOMOTIVE POWER

Parametric Table

Valve Sizing | HX Design | Table 2

1..4	Q [ft3/hr]	$Perc_{open1}$	$Perc_{open2}$	$Perc_{open3}$	$Perc_{open4}$	$T1_{Ci}$ [C]
Run 1	14500	5.439	10.58	32.1	85.61	-15
Run 2	8170	3.065	5.964	18.08	48.24	-15
Run 3	4420	1.658	3.226	9.784	26.1	-15
Run 4	2210	0.829	1.613	4.892	13.05	-15

Equations Window

```
PROCEDURE Valve_Fun(P1,P2,T1_C,Q,Cv_valve:T2_C,C_v,Perc_open,P2_cr)
    "Define the variables called from the main function"
    $Common C_f, Fluid$

    "Preliminary calcs"
    DELTAP = P1-P2

    "Calculate y"
    IF (1.63/C_f*sqrt(DELTAP/P1) < 1.5) THEN
                                        y := 1.63/C_f*sqrt(DELTAP/P1)
    ELSE
                                        y := 1.5
    "Choked flow case"
    ENDIF

    "Calculate temperatures"
    T1 = ConvertTEMP(C,R,T1_C)
    h = Enthalpy(Fluid$,T=T1,P=P1)
    T2 = Temperature(Fluid$,P=P2,h=h)
    T_ave = (T1+T2)/2
    T2_C := ConvertTEMP(R,C,T2)

    "Calculate gas specific gravities"
    rho = Density(Fluid$,T=419.67[R],P=14.7[psia])
    rho_air = Density(Air_ha,T=419.67[R],P=14.7[psia])
    SG = rho/rho_air
    {SG = 0.8}
    mw = MolarMass(Fluid$)
    mw_air = MolarMass(Air_ha)
    SG2 = mw/mw_air

    "Calculate the flow coefficient for the valve in the current state of flow"
    C_v := Q*sqrt(SG*T1)/(834[ft^3*R^0.5/hr*psia]*C_f*P1*(y-0.148*y^3))
                                        "Q [SCFH]"
                                        "T [R]"
                                        "P [psia]"
```

Detailed analysis of gas flow and temp across a wide operating range

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Machine Design, Build, and Test

Rhizosphere Observations Optimizing Terrestrial Sequestration (ROOTS)

ROOTS supports development of new technologies and crop cultivars to improve soil, increase water productivity, and reduce atmospheric buildup of the greenhouse gases carbon dioxide (CO2) and nitrous oxide (N20), an ozone precursor

Its ambitions goals for the technology and cultivar development ROOTS funds include:

- 50% increase in soil carbon accumulation
- 50% reduction in N2O emissions
- 25% increase in water productivity

Czero contracted by Colorado State University to design and develop an automated system for agricultural field research. A tractor mounted system, the first of its kind, will automate the process of collecting data to characterize the root systems of individual plants and below-ground soil conditions

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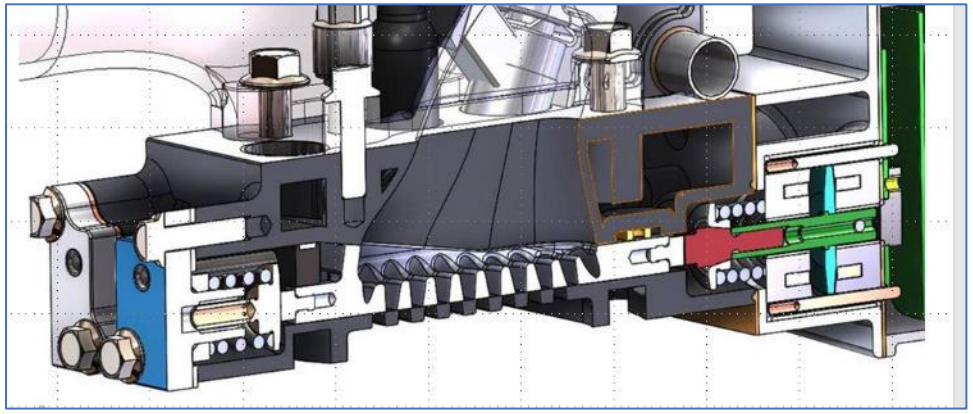
Fully Variable Valve Actuation System for Four Cylinder Test Engine Head

Full Analysis led Mechanical and Industrial Design

- CAD, FEA, mechanical and thermal stress/distortion, thermal modeling
- Dynamic and magnetic modeling of the actuator
- CFD and engine performance modeling
- Capable of sub 2 millisecond travel times
- Upwards of 7000 RPM operation



Project Included Custom Engine Dyno Capable of 8,000 RPM, 100 HP

- ABB PLC SCADA for supervisory control and management
- SCADA responsible for control and management of all dyno subsystems
- LabView based front end for operator control
- Integrated NI hardware for data acquisition

Babbitt et al / SAE Int. J. Engines / Volume 10, Issue 3 (June 2017)

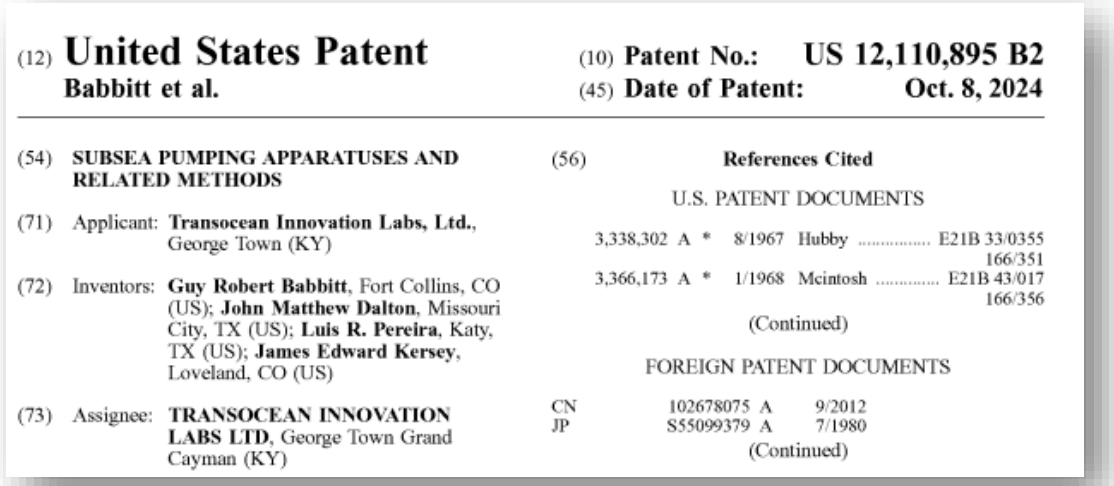
© Czero 2026

Subsea Hydraulic System

Czero was enlisted to develop new architectures for subsea well control and design and build prototypes.

Integrated pumps, valves, and regulators with control system:

- Subsea environment
- Extremely high-pressure demands
- Redundant system for fail-safe operation



(12) **United States Patent**
Babbitt et al.

(10) **Patent No.: US 12,110,895 B2**
(45) **Date of Patent: Oct. 8, 2024**

(54) **SUBSEA PUMPING APPARATUSES AND RELATED METHODS**

(71) Applicant: **Transocean Innovation Labs, Ltd.**, George Town (KY)

(72) Inventors: **Guy Robert Babbitt**, Fort Collins, CO (US); **John Matthew Dalton**, Missouri City, TX (US); **Luis R. Pereira**, Katy, TX (US); **James Edward Kersey**, Loveland, CO (US)

(73) Assignee: **TRANSOCEAN INNOVATION LABS LTD**, George Town Grand Cayman (KY)

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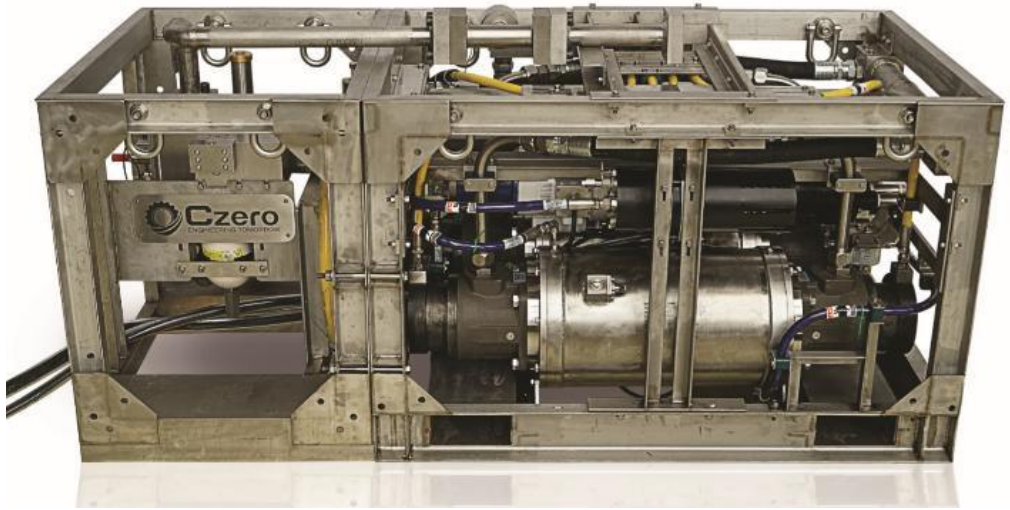

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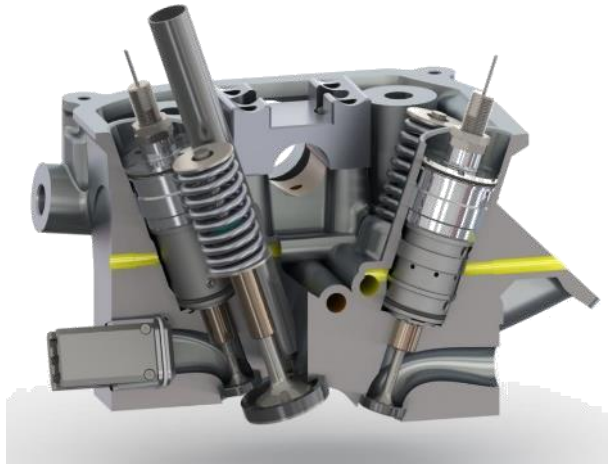
Dual-mode CNG Engine

This dual-mode CNG engine can propel the vehicle as well as refuel the onboard tank using commonly available low-pressure natural gas supplies.

- Redesign the cylinder head for natural gas compression in addition to normal combustion mode:
  - CNG porting design
  - Custom check valve for CNG metering
  - Deactivation system for the standard valvetrain
  - Revised PFI intake and exhaust ports
  - Simulation of check valves and combustion system
  - Control system for fueling and pumping modes

- From production cylinder head to assembled prototype in 4 months

Onboard Dynamics, Inc.
Self-refueling anywhere.



arpa·e U.S. DEPARTMENT OF ENERGY

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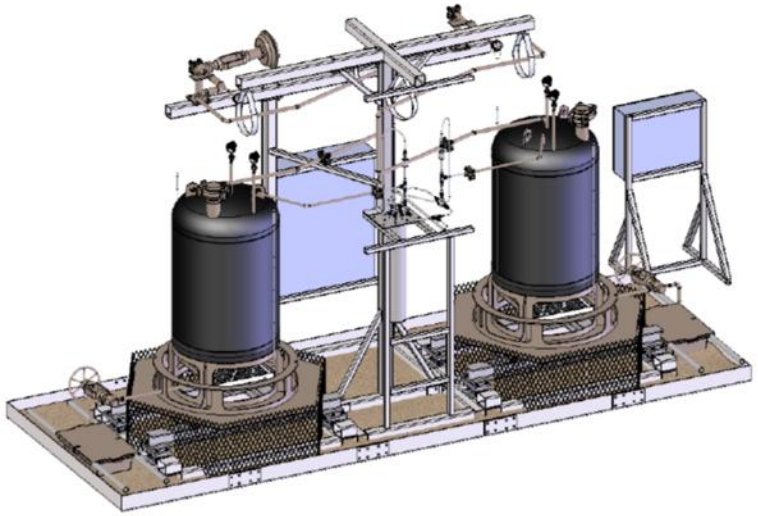
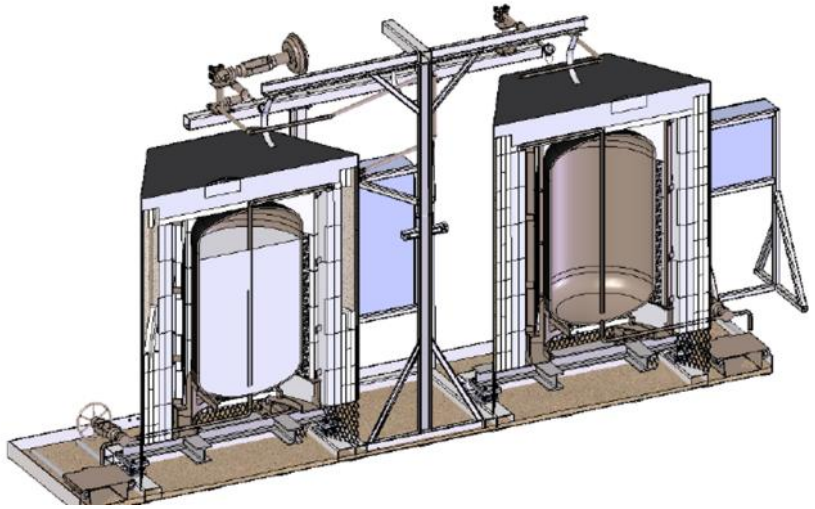
Test Rig for 800º C Molten Salts

- Springs Fab and Czero won a competitive research project with the NREL SunShot program to push the boundaries of energy storage for solar power concentration.
- Czero designed the test rig to evaluate thermal energy storage components for higher-temperature molten salt systems.
- The system components needed to withstand sustained temperatures of 1,500 °F (815°C) created by an array of mirrors concentrating sunlight on a heliostat that heats salt to a molten state to store the sun's energy.





NREL
NATIONAL RENEWABLE ENERGY LABORATORY

SPRINGS FABRICATION

This technology represents an important step in making solar-powered energy plants more competitive with those powered by fossil fuels.

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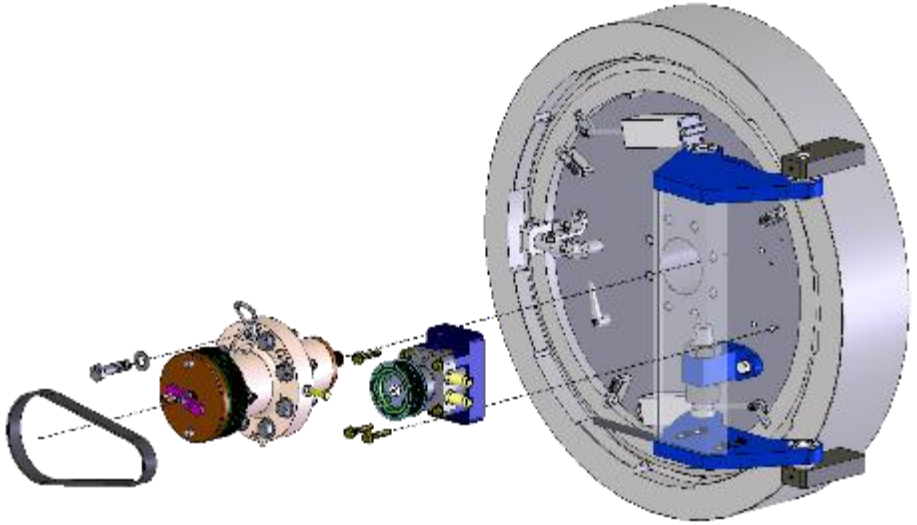
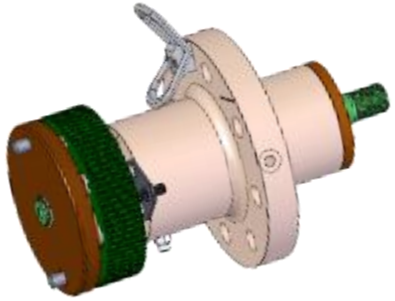
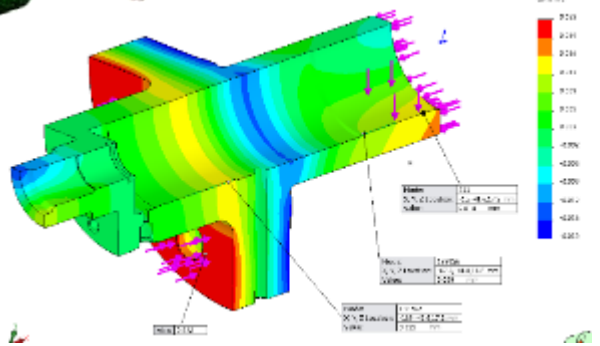
CO2 Based Cleaning Machines

Czero supported the design and development of a novel CO2 based garment cleaning system

- Designed and built first double door commercial laundry system (2011) as virtual Engineering team
- Responsible for full drum design and development as well as closed loop process system for CO2
- Czero continues to support CO2Nexus Engineering
- Multiple patent applications filed







TERSUS SOLUTIONS

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Subterranean Compressed Air Energy Storage

Bright Energy Storage Technologies (BEST), working with Czero engineers, has developed new technology for compressed air energy storage that will help wind and solar energy become more stable, profitable sources of clean power for the global electricity grid. This advanced positive-displacement compressor/expander and storage system has poised BEST to enter the market with a low-cost, scalable solution, at a time when renewable energy production is growing by more than 30% each year.

BRIGHT ENERGY
STORAGE TECHNOLOGIES

Czero has been an invaluable and integral part of our program. From component and subsystem design to detailed system performance analysis, Czero's integrated engineering approach has allowed us to develop elements quickly to meet the very ambitious schedule challenges imposed by our U.S Department of Defense contract.

- Scott Frazier, Co-founder and CEO
Bright Energy Storage Technologies

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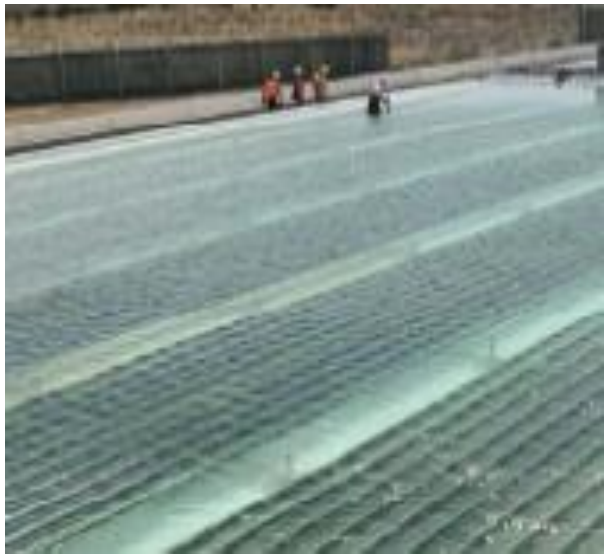
Algae bioreactors for Solix Biofuels / Solix Biosystems

Czero work with Solix Biosystems

- Started by augmenting their small engineering team (2007)
- Took on Engineering Director role and helped fill out engineering team
- Executed on project and helped secure A and B series funding
- Czero still doing work for Solix Biosystems and is currently on project
- Czero acted as virtual engineering team at first, they are bringing more in house
- Multiple patent applications filed



Pilot scale bioreactor designed by Czero

> Guy understands technology development from the back-of-the-napkin stage to the product launch stage. I've never met someone who is more capable of keeping the end-product vision in his mind during the early stages of engineering.
>
> —Sam Jaffe - CEO
> Panea Energy
> (Formerly Solix)

> Guy and Czero were an insightful and very technically proficient group that were instrumental in helping us develop our technology. They were very quick studies to understand the fundamental challenges we faced and design/build solutions around them. Top qualities: Great Results, Personable, Good Value.
>
> —Doug Henston - Former CEO, Solix Biofuels

Solix AGS 4000 portable bioreactor and support equipment designed by Czero

SOLIX
ALGAE TO ENERGY

© Czero 2026

Harvesting Title Power

Czero worked with Brown University and BlueSource Energy on developing new technology for harvesting energy from tidal currents in rivers near oceans

The engineers on the Czero team were proactive problem-solvers from our first introduction. They quickly applied the full breadth and depth of their engineering team's impressive intellect to determine the most efficient and cost effective system to maximize the energy-harvesting capabilities of Brown's concept. They were remarkably objective in their trade studies to find the best solution, favoring a simpler mechanical solution over their greatest strength: advanced hydraulics. They walked us through potential failure modes of each system, and educated the team about the pitfalls of component scalability. In addition to their technical solutions, Czero did an excellent job conveying their thought process and analysis to the Brown team with clear graphs, diagrams and presentations, which streamlined decision-making. Czero added tremendous value to the Brown project and was a pleasure to work with. We look forward to putting our heads together on future projects.

—Tom Derecktor, CEO, BluSource Energy

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Electrification/Hybridization of Heavy Equipment

Czero has electrified/hybridized several classes of mining/forestry machines for a client

- Czero developed and implemented control systems using MATLAB Simulink based embedded industrial control systems
- Field testing demonstrated substantial increases in fuel efficiency and productivity for these machines
- 350 and 750 VDC bus architectures were employed with electrical system design and component identification heavily supported by Czero

© Czero 2026

Sustainment Engineering

Czero provides reverse engineering services to the DOD through the Defense Logistics Agency (DLA)

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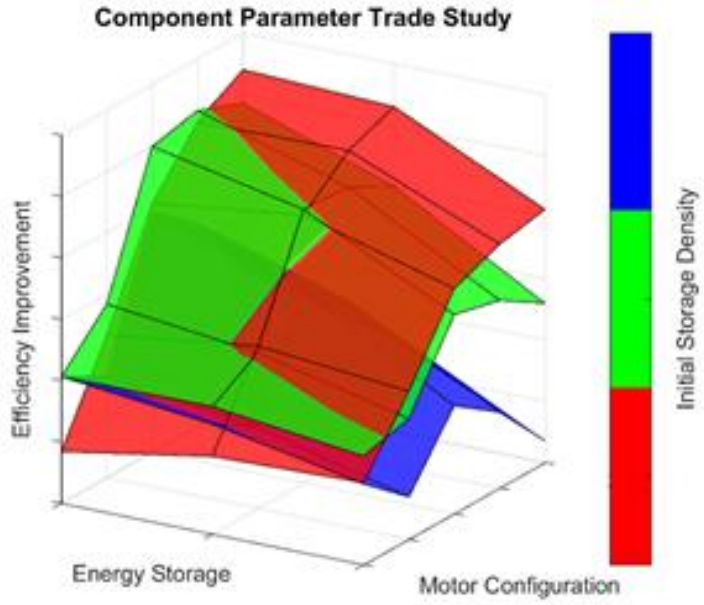
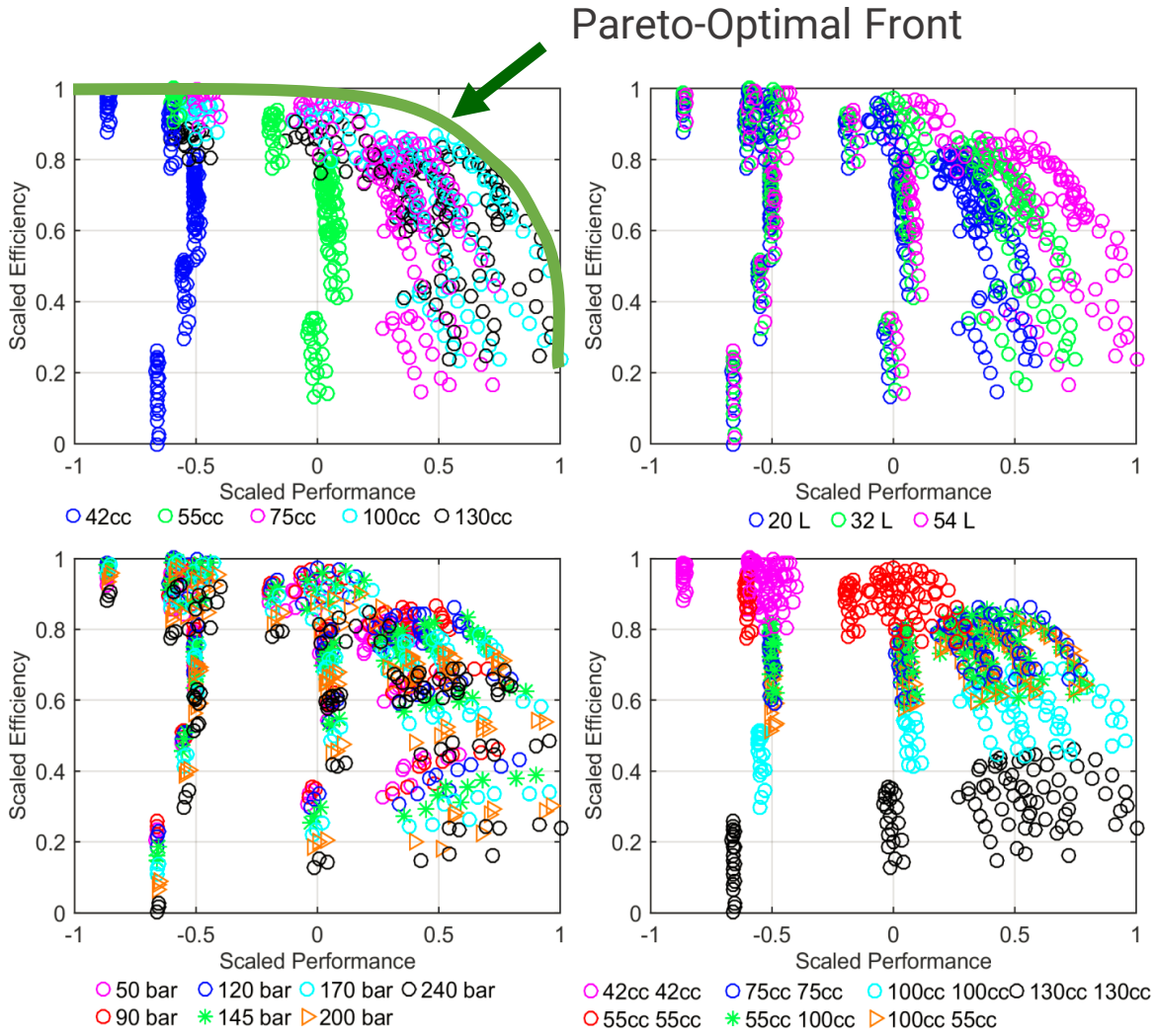
Trade Studies

Czero doesn't provide a single optimal solution, rather the tradeoffs between various system configurations and component sizing are presented graphically to provide a deeper understanding of the complex interactions between various systems





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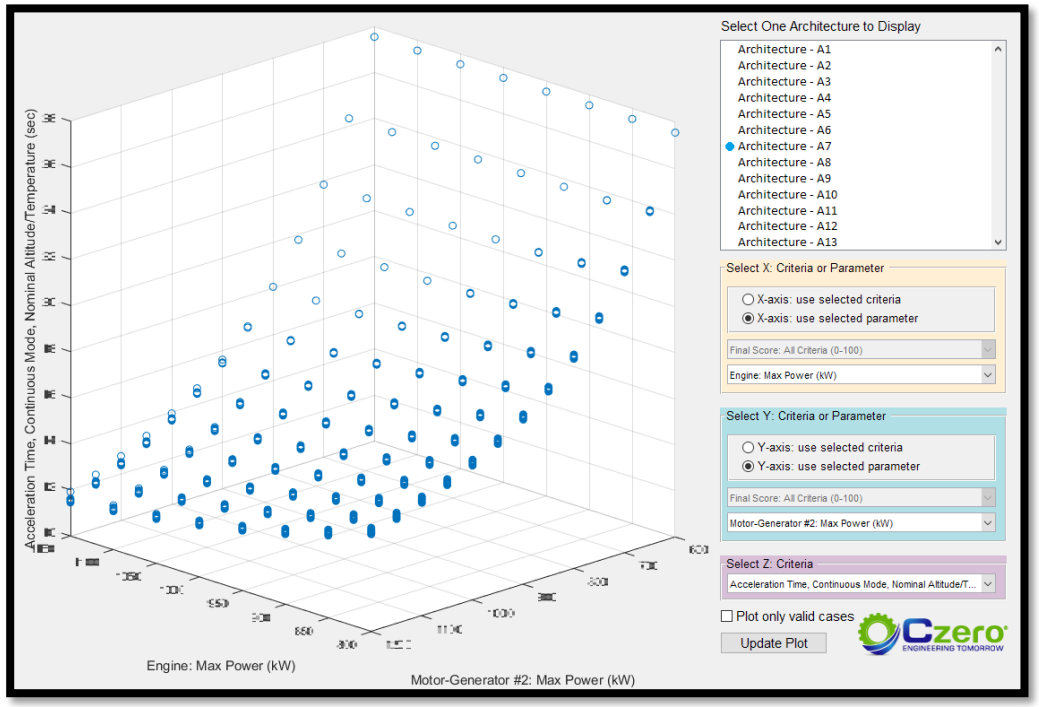
Powertrain Architecture Trade Tool for Heavy Tracked Vehicles

Czero developed a powertrain architecture trade tool to evaluate the next generation of hybrid powertrains for heavy tracked vehicles for GDLS (presented at SAE in 2019)

- Modular structure permitted rapid evaluation of 10+ powertrain topologies
- 50+ dynamic evaluations and 100+ weighted outputs
- Plant models developed in MATLAB Simulink
- All models controlled using instantaneous optimization algorithms
- Trade tool, data reduction, and visualization routines all developed in MATLAB



GENERAL DYNAMICS Land Systems

WCX APRIL 9-11 2019 DETROIT

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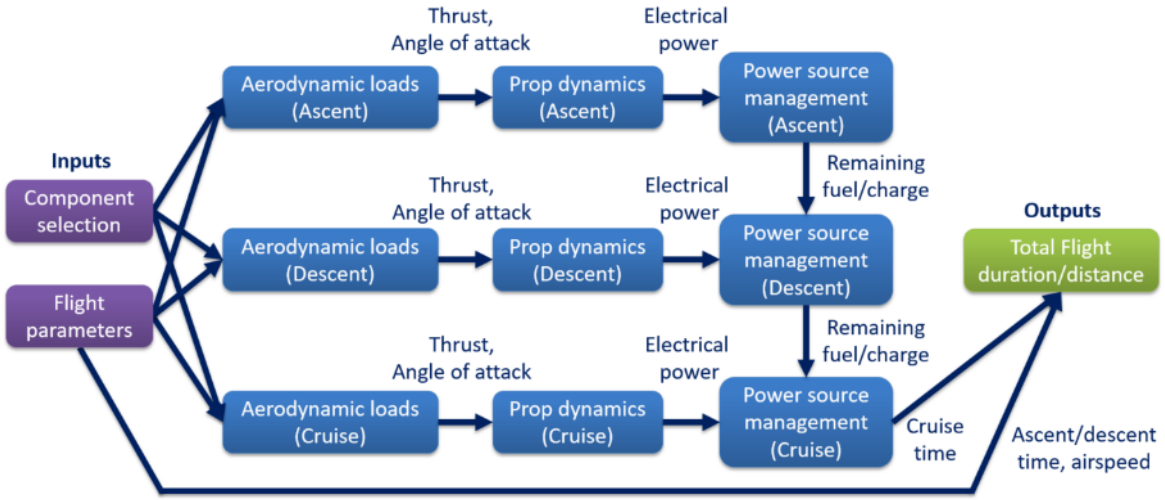
Joint Tactical Aerial Resupply Vehicle (JTARV) Range Extension Study

Czero performed study as a third-part subject matter expert for a prime contractor for Army Research Laboratory

Scope of Work:

- Industry COTS Powertrain Survey
- Aerodynamic Load Study
- Prop Dynamics Analysis
- Power Management Study and Algorithm Development
- Powertrain Evaluation

Result: Established performance benchmarks with respect to range and endurance and achieved other SOW objectives



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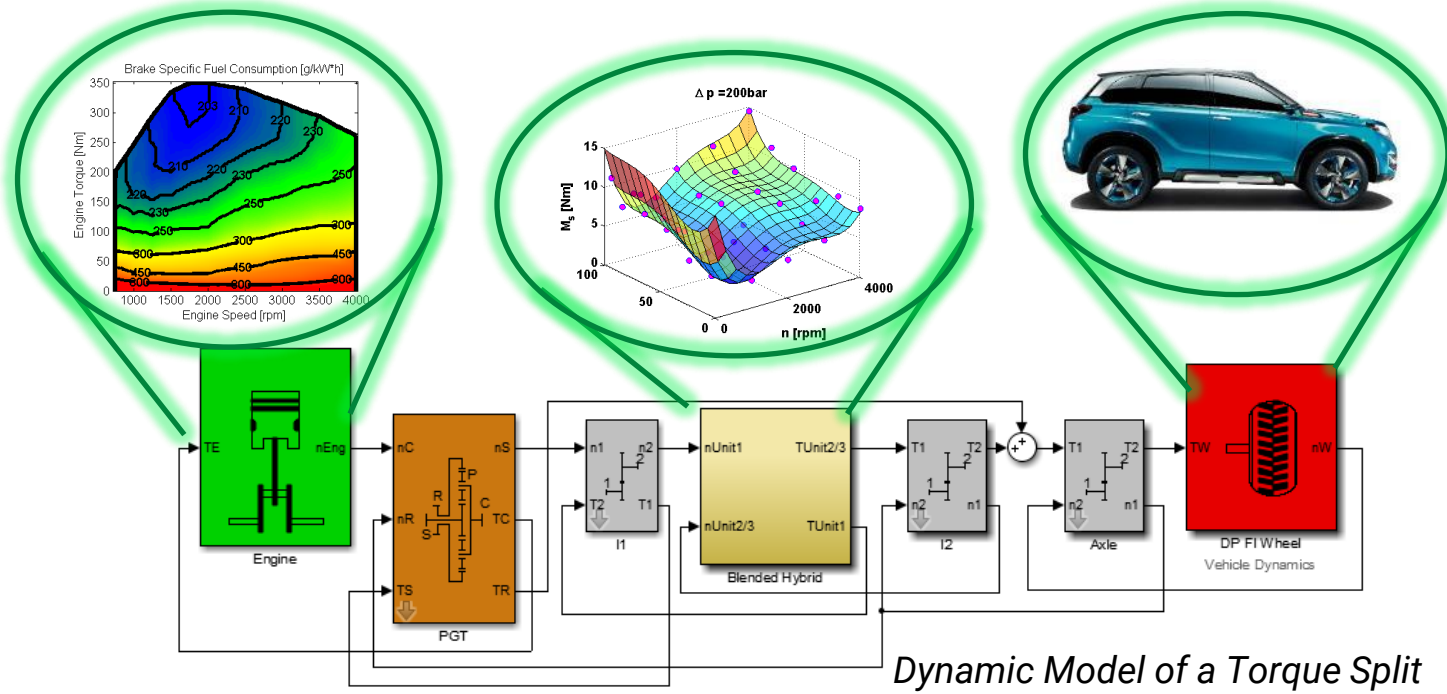
Dynamic Modeling of Hybrid Powertrains

Czero uses a suite of modeling tools, which have been customized and validated over many years, to analyze hybrid powertrains at all stages in the production cycle

Benefits of this dynamic modeling includes:

- Predicting performance and efficiency before any hardware is built
- Saving time and money by identifying problematic configurations and conditions before they occur in the field
- Optimizing system design and component sizing to maximize performance and efficiency
- Enabling the design and evaluation of more efficient control algorithms



Dynamic Model of a Torque Split Hydraulic Hybrid Transmission

Select modeling tools include:

MATLAB SIMULINK

GT Gamma Technologies

ANSYS

LMS ENGINEERING INNOVATION

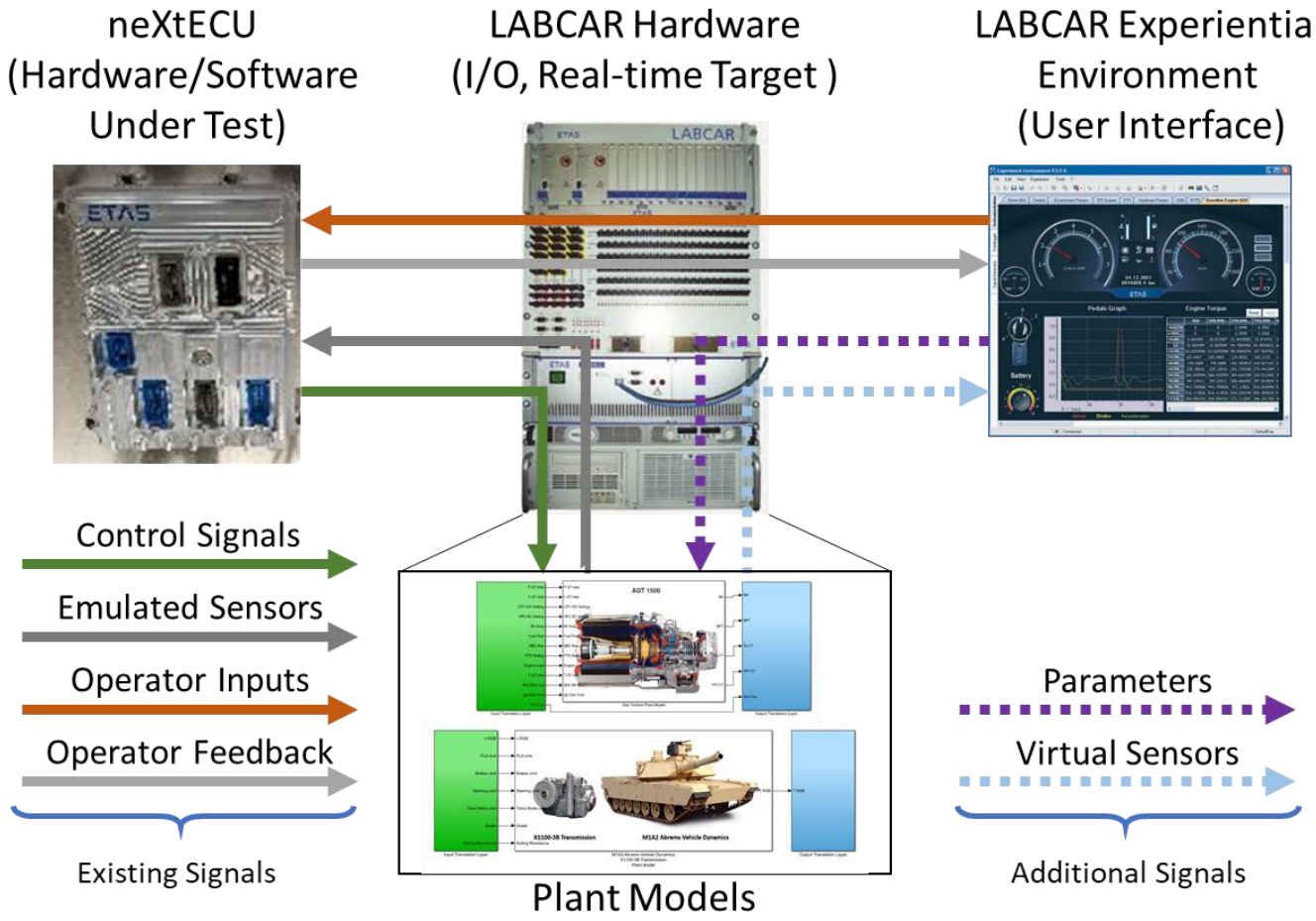
CONVERGENT SCIENCE

© Czero 2026

Dynamic Modeling for Hardware-in-the-Loop (HIL) Controls Validation of Gas Turbine and Drivetrain

Czero developed and validated a high-fidelity physics-based model of the Abrams gas turbine and powertrain to support DoD in validating a new controller (hardware/software) for the Abram's gas turbine.

Czero deployed this HIL model on multiple ETAS LABCAR test benches and used support controller (ECU) development and validation before moving to on-engine testing.

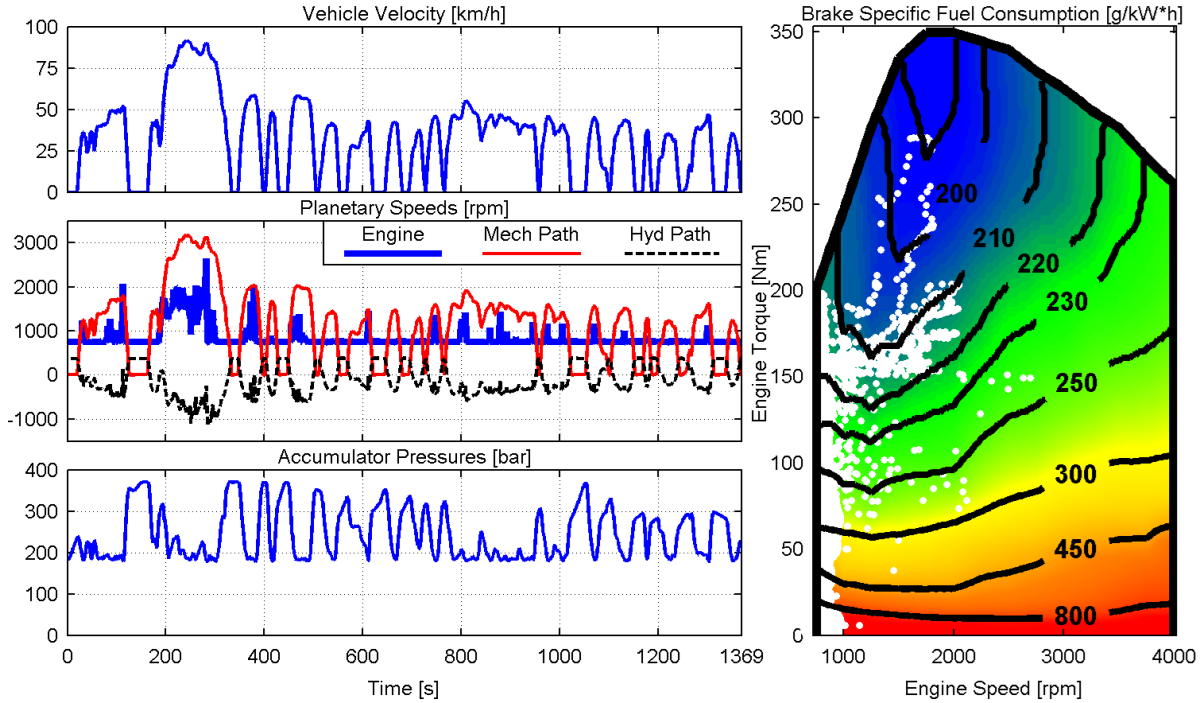


M. Sprengel, S. Raman, J. Rogers, P. Kruchko, D. Pace, "Hardware-in-the-Loop Plant Modeling in Support of the US Army's Common Powertrain Controller Development", In Proceedings of the Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), NDIA, Novi, MI, Aug. 11-13, 2020.

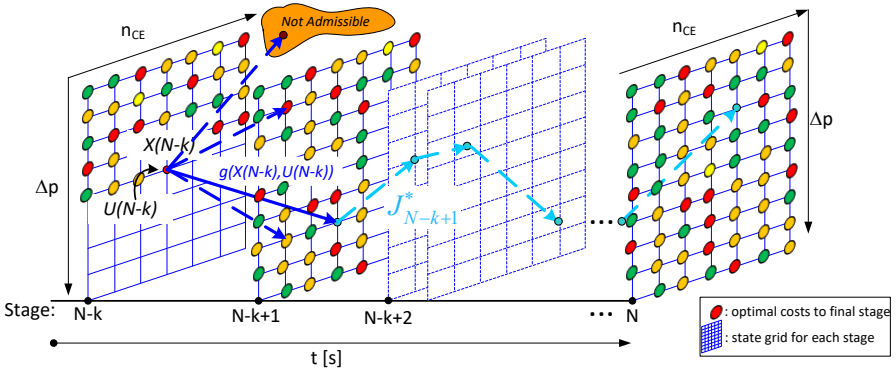
© Czero 2026

Globally Optimal System Control via Dynamic Programming

- Remove the influence of control on system performance enabling an unbiased comparison of multiple system architectures and component sizings
- Help ensure that the system with the greatest inherent potential is selected early in the design process
- Determine a system's maximum possible performance
- Discover effective, but perhaps counterintuitive, control schemes
- Provide a baseline for comparing implementable control strategies



Globally Optimal Control Trajectories generated by Dynamic Programming



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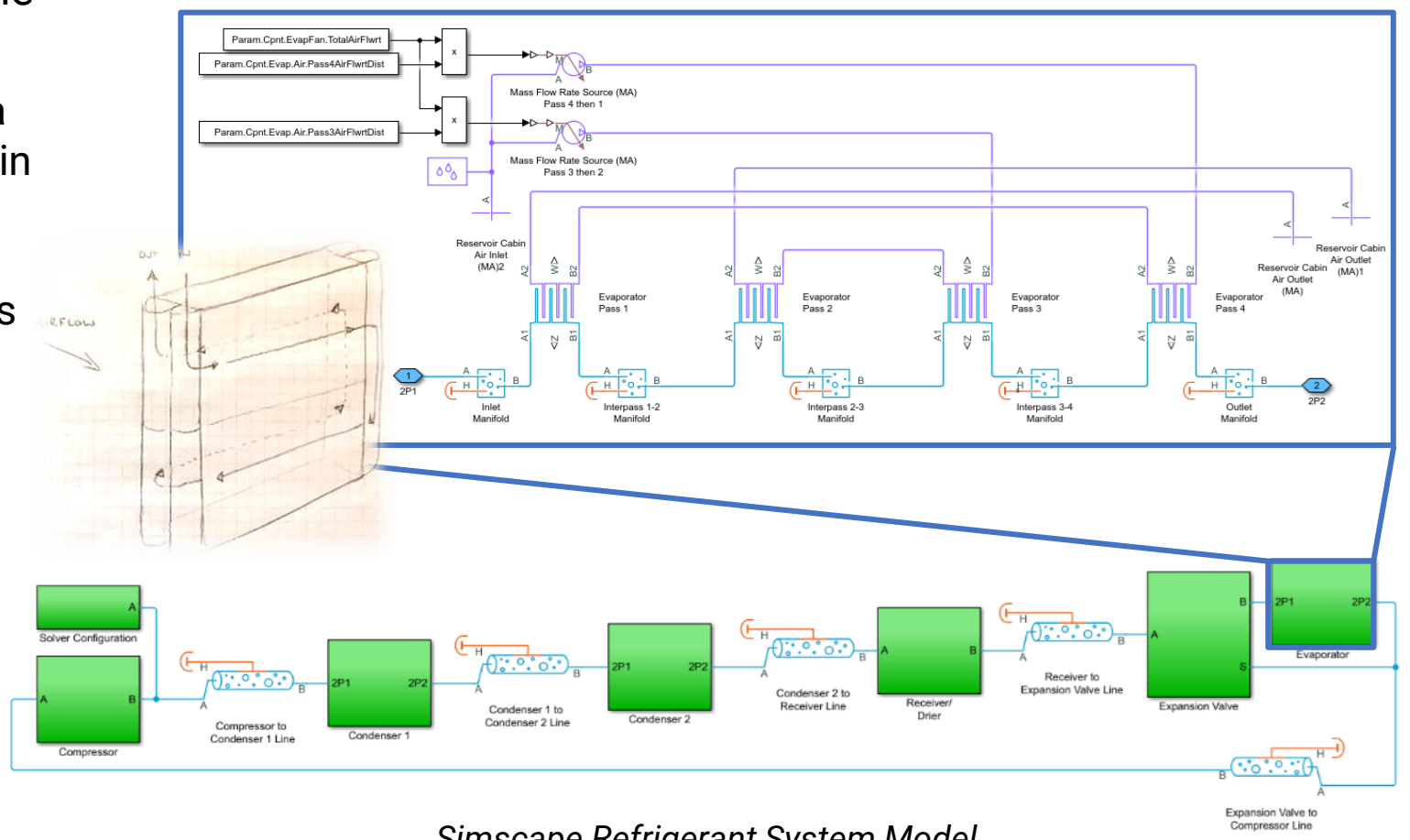
Multi-Species/ Multi-Phase System Modeling

Czero develops complex dynamic system models including those incorporating multi-species/ multi-phase compressible flow

- These models are built using either a custom Czero library developed within the base MATLAB Simulink environment, or leveraging MATLAB Simscape, depending on the project's scope and objectives
- Real+ideal gas properties (NIST REFPROP)
- Mixture modeling
- Individual species tracking
- Phase change (condensation / vaporization)
- Chemistry (rate limited and thermal equilibrium)



Simscape Refrigerant System Model

© Czero 2026

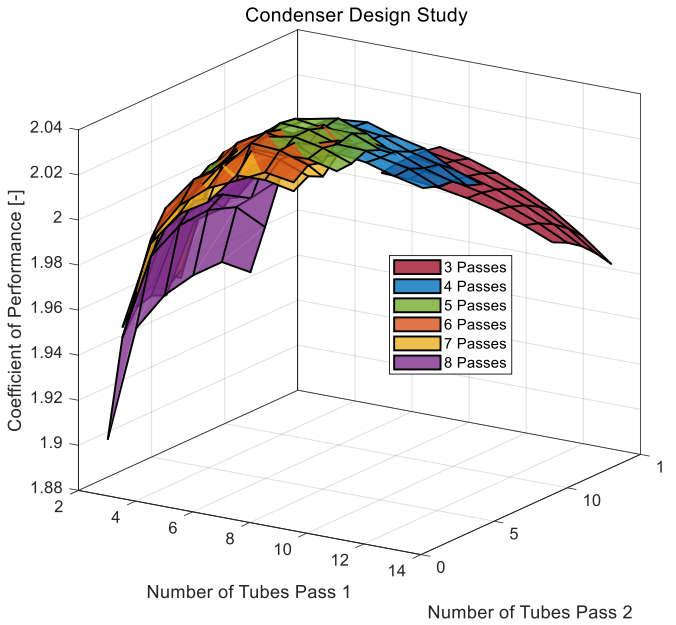
Refrigerant Systems – Dynamic System Modeling

Czero has completed multiple projects for clients designing and optimizing refrigerant systems, often for highly demanding mobile applications

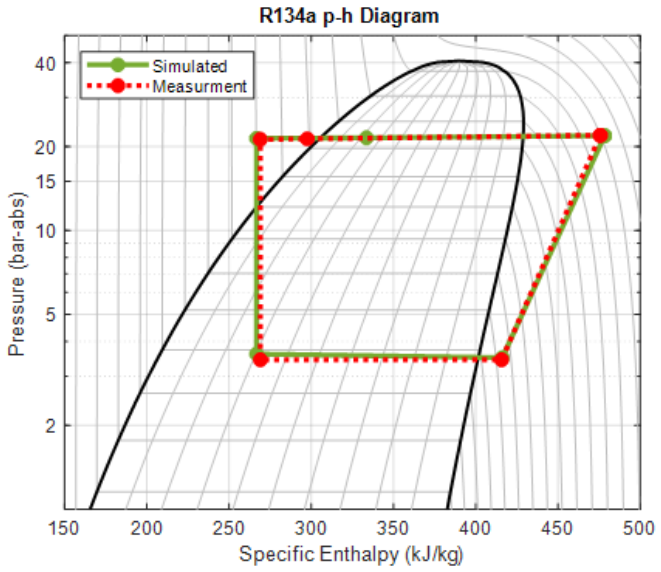
Dynamic models of the refrigerant systems are developed from base physics and calibrated, when available, using measurement data

The dynamic aspect of these models allow transient operations to be evaluated, however they are equally well suited for solving complex steady-state operations where reaching a stable operating point can be numerically challenging

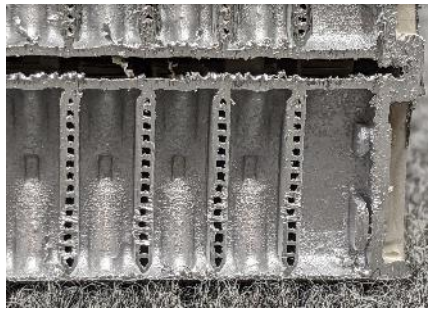
Often these models are coupled to additional dynamic system models, such as a battery pack with liquid cooling



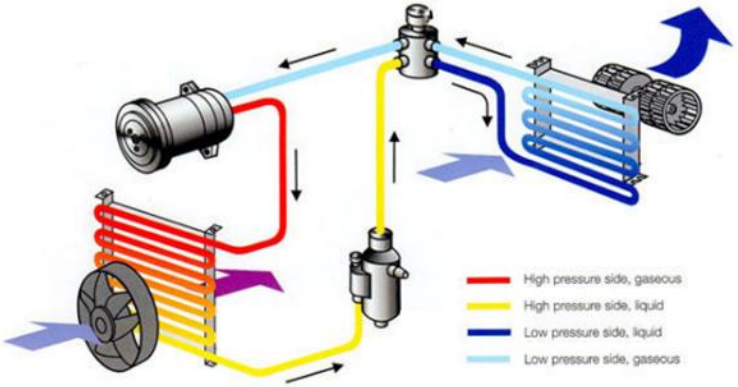
Condenser Design Optimization



Model Correlation



Evaporator Cross-section

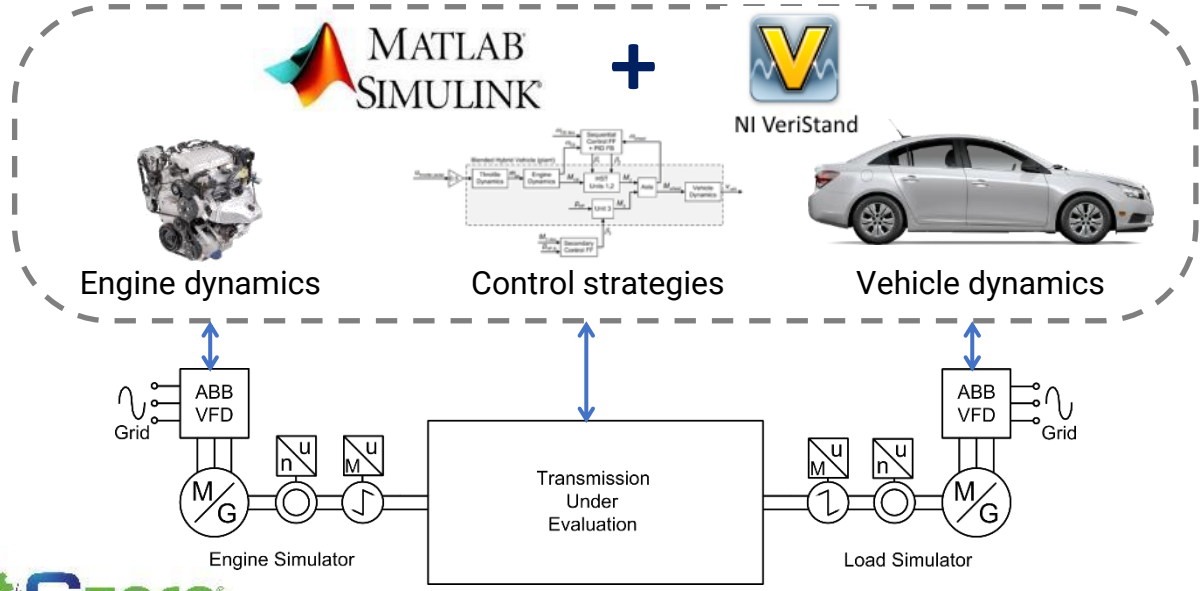


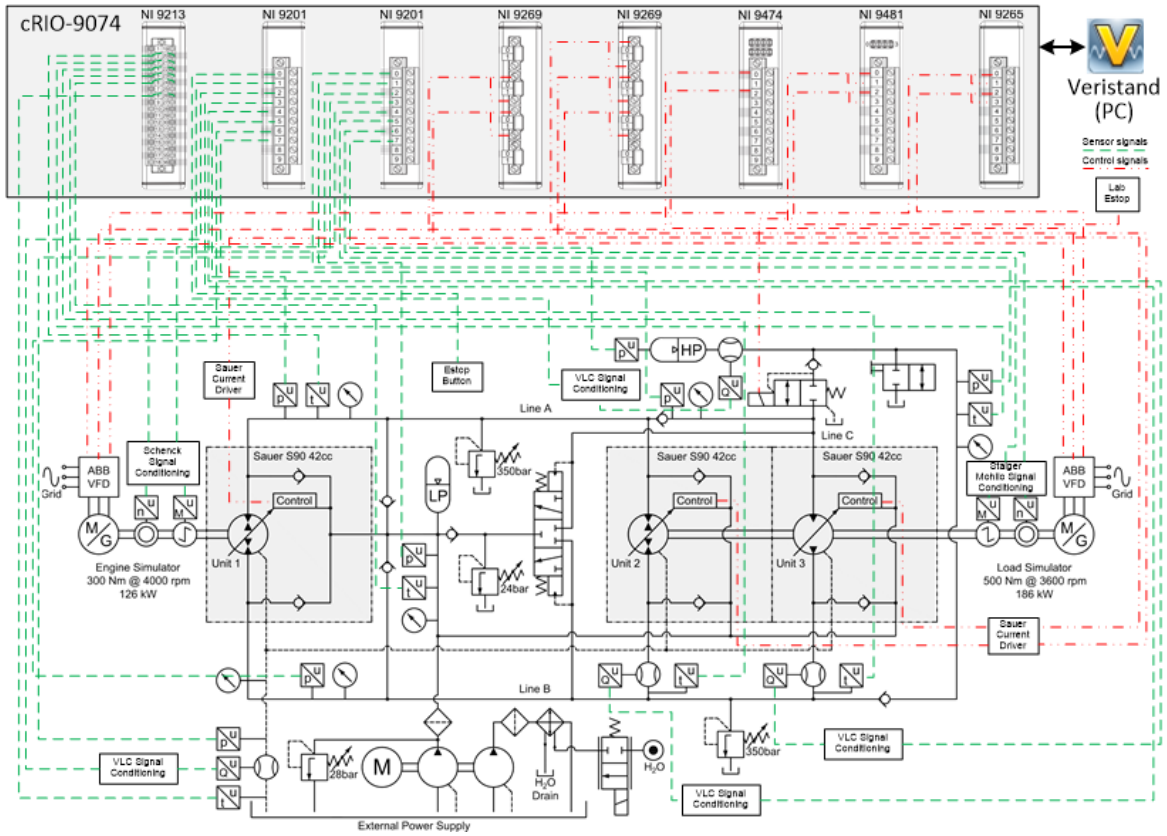
System Layout

© Czero 2026

Hardware-in-the-Loop Transmission Testing

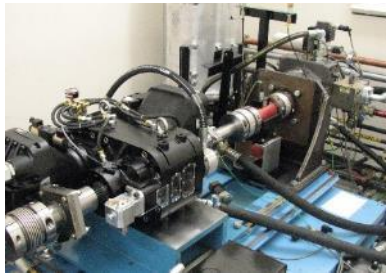
- Czero personnel have experience developing and implementing HIL based transmission test rigs using NI Veristand, xPC Target, and other real time control systems
- Control strategies originally developed and validated in MATLAB Simulink were transferred to HIL test rig and evaluated on hardware with minimal modification
- Full data acquisition systems were also implemented on each of these HIL test rig





Hydraulic Hybrid Transmission HIL Test Rig with **Electric** Engine and Vehicle Emulators

Hydraulic Hybrid Transmission HIL Test Rig with **Hydraulic** Engine and Vehicle Emulators



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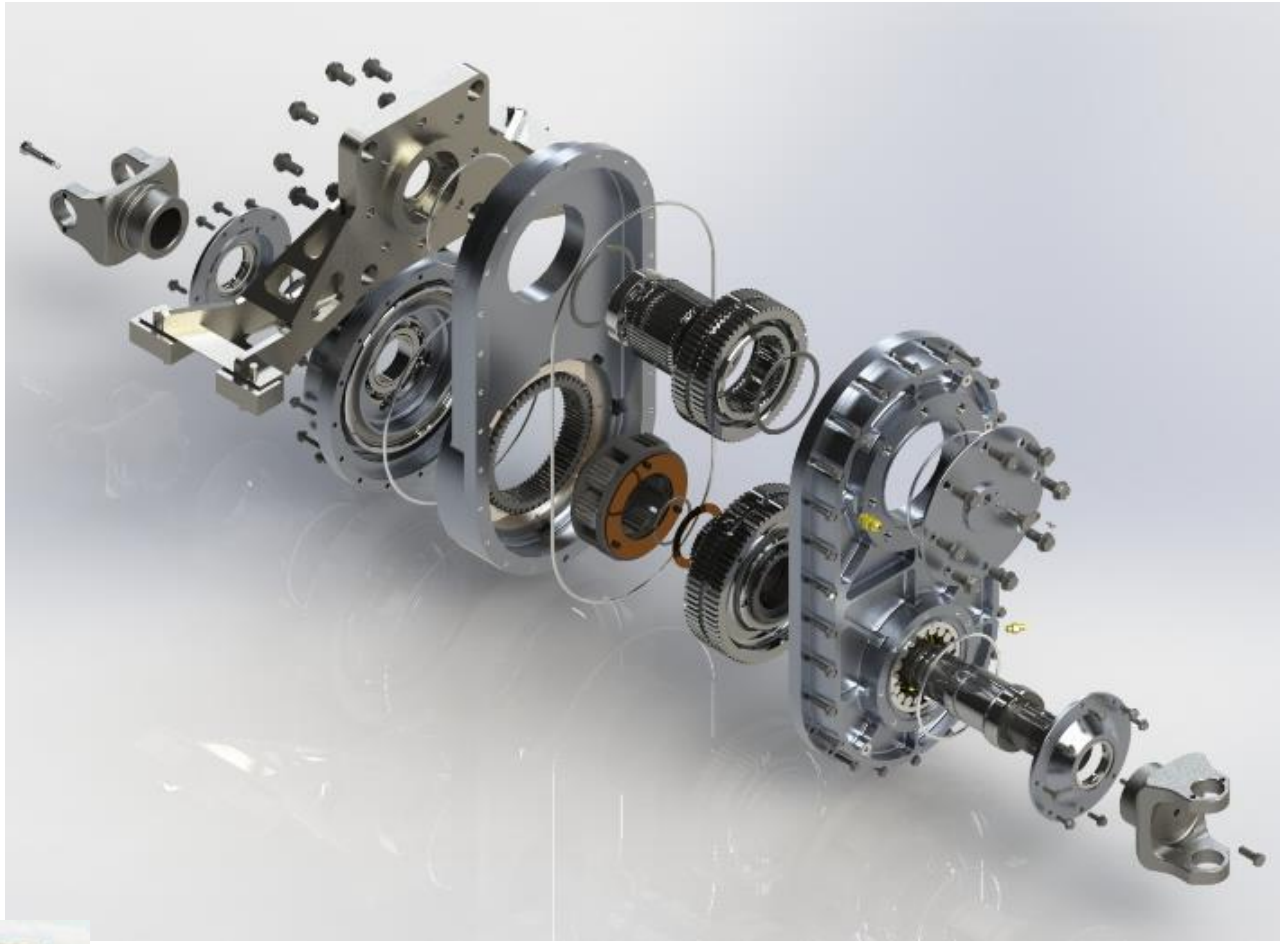
Hydraulic Hybrid

Czero completed an in-house project to design and develop a hydraulic hybrid retrofit system for medium duty trucks

- ~5 months from concept to installation
- Tested in Class 6 truck with only minor seal leak and no appreciable wear or degradation



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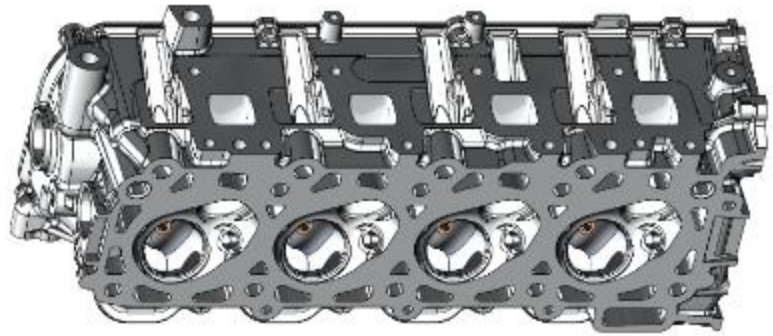
Custom Cast Cylinder Head

Baseline Part

Scanned Model



Detailed Model

Machined Part

Assembled Head

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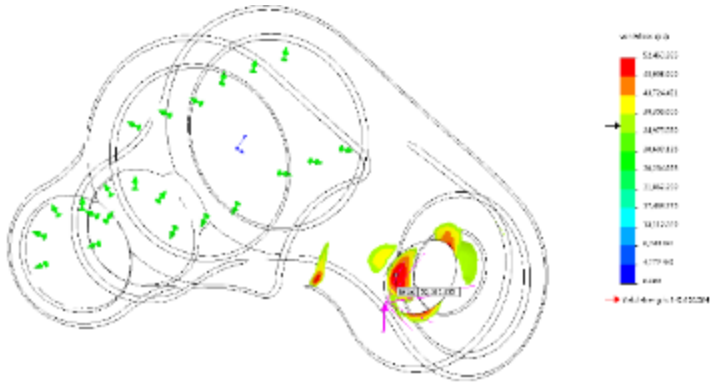
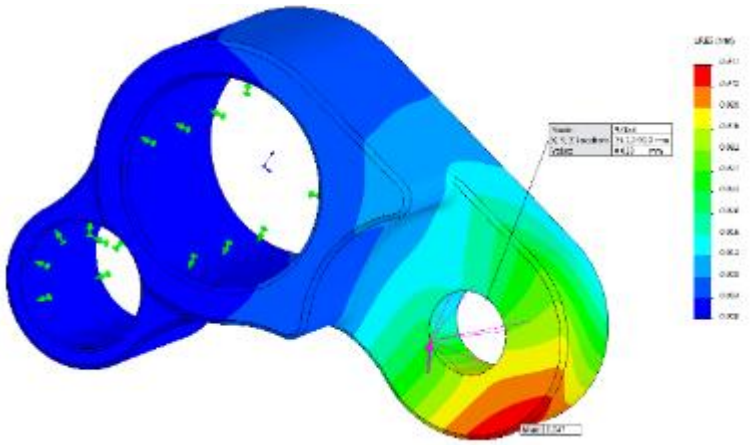
Custom Valve Deactivation System

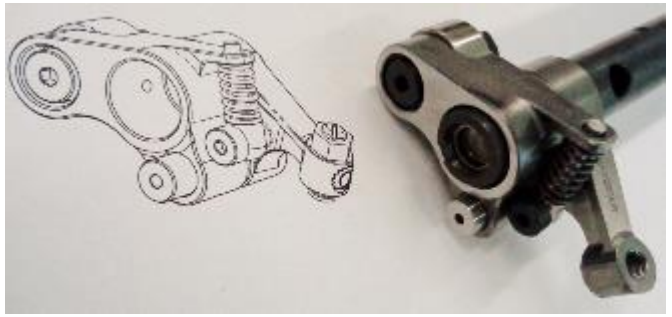
Design Challenge: Redesign the valve rockers to allow deactivation of the inlet and exhaust valves

- Rocker arm design
- Hydraulic actuation system
- Shaft mounting
- Integration into cylinder head

Result: Success demonstration of the system on the prototype Phase 2 engine, accumulating run time without failure







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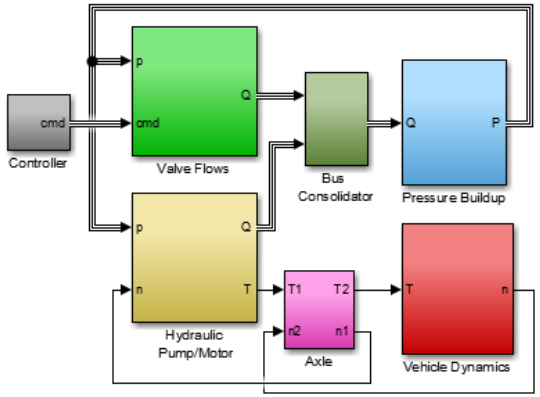
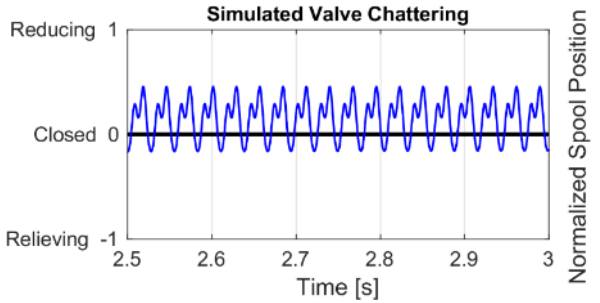
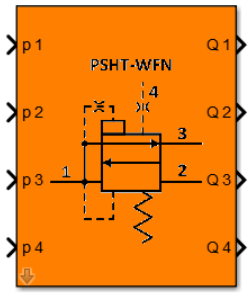
Valve Chatter Root Cause Investigation

Client was struggling with a valve chatter problem in their hydraulic system and asked Czero to analyze the issue and develop a solution.

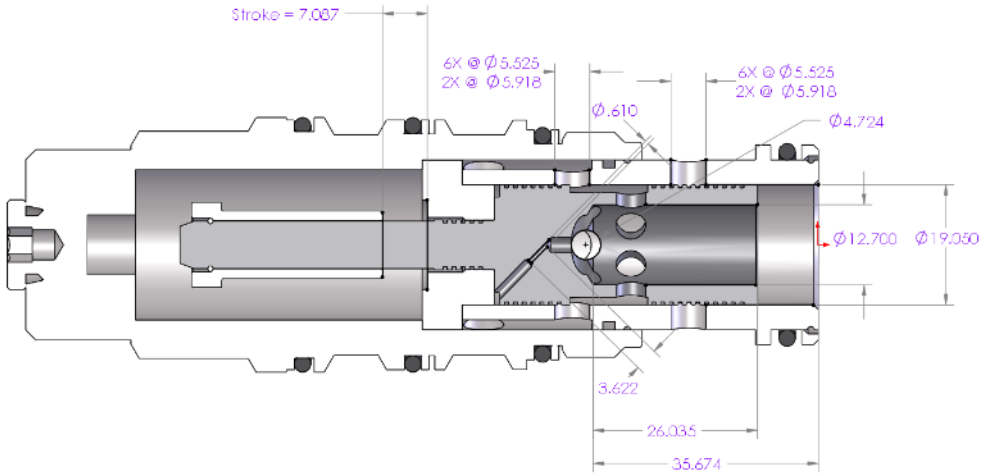
- **Approach**: A dynamic model of the system was build in MATLAB Simulink using custom blocks. Simulations were run with excellent correlation to real-world results.
- **Solution**: Simulation showed that the chatter was caused by an inability to fully vent pilot port and decreases in outlet pressure due to motor flow. The chatter was the valve cycling between reducing and relieving modes.
- **Result**: Czero determined necessary changes to the valve porting to eliminate the chatter condition. Prototypes were tested and confirmed successful resolution

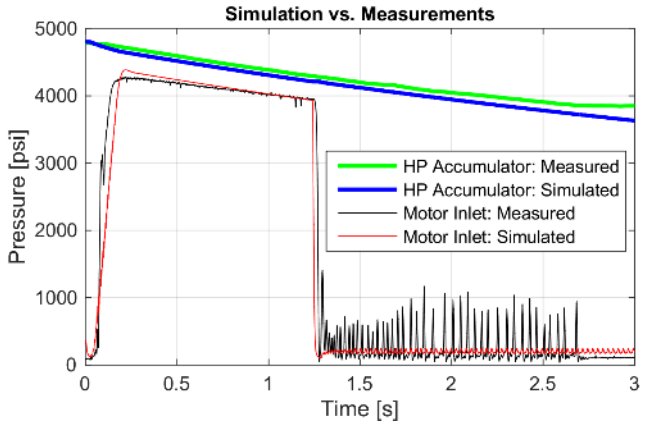






SUN PSHT-XFN
Reducing/Relieving Valve





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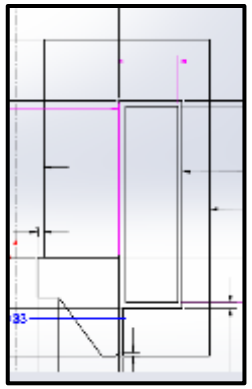
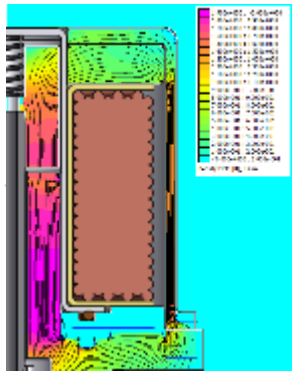
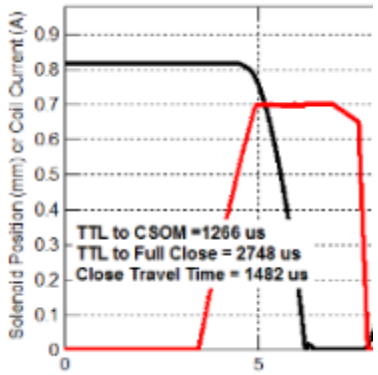
Solenoid & Injector Optimization



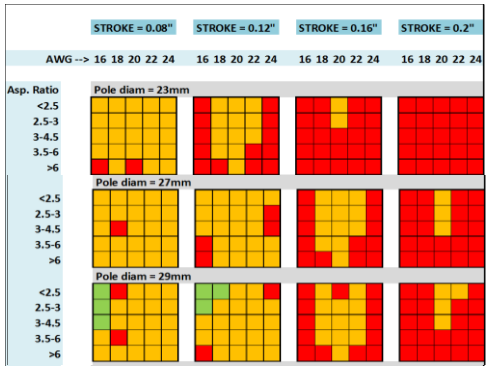
Generate large number of solid models from file of parameters automatically



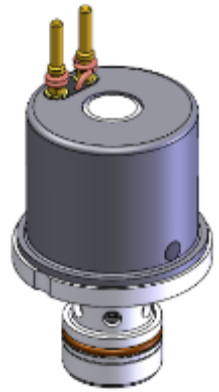
Data imported into magnetic analysis software. Force maps created for each case



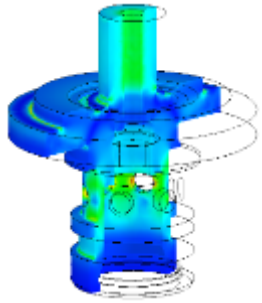
Magnetic data files used in simulation for each case to see how the actuator AND system perform



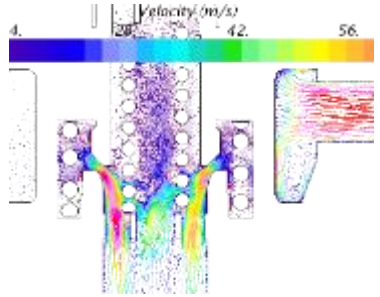
Performance metrics automatically plotted and rated allowing various trades to be quickly identified



Detail CAD Design

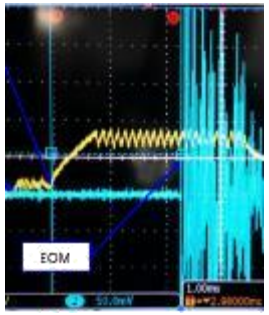


Structural Analysis



Fluid Forces and Internal Losses

Iteration as needed to get final design



Test

500-1000 design iterations day.

Optimal designs arrived at very quickly saving time and money

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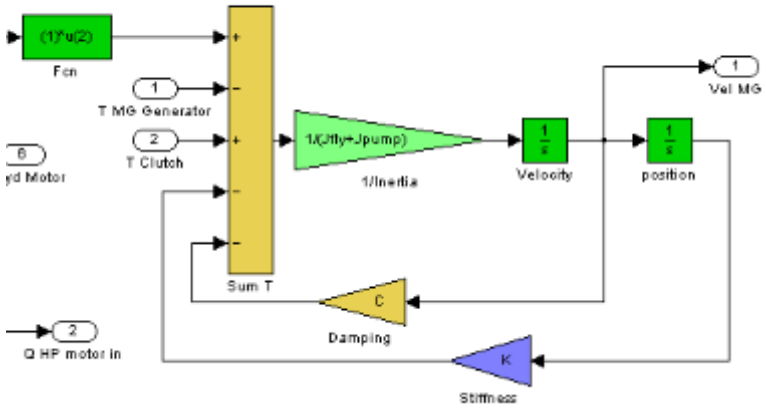
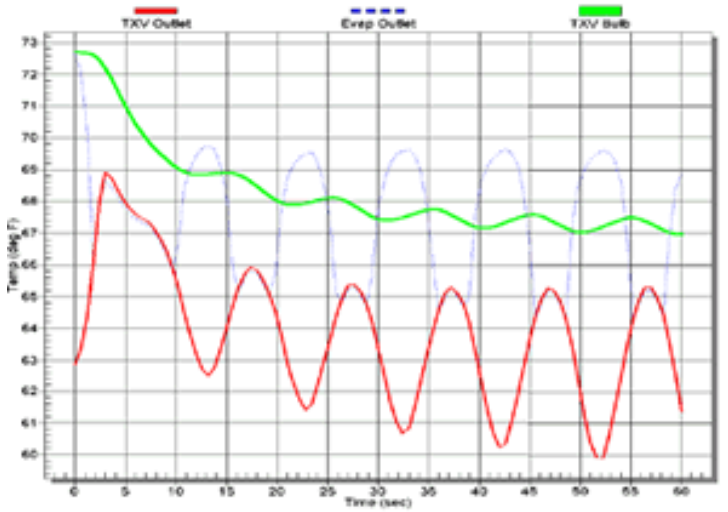
Outboard Engine Modeling & Simulation

Czero developed sophisticated simulation models for Bombardier Recreational Products that help make their Johnson and Evinrude outboard engines more efficient and reduce emissions

By using simulation models in place of testing Bombardier is able to reduce product development time and cost and provide their customers cleaner and more efficient products





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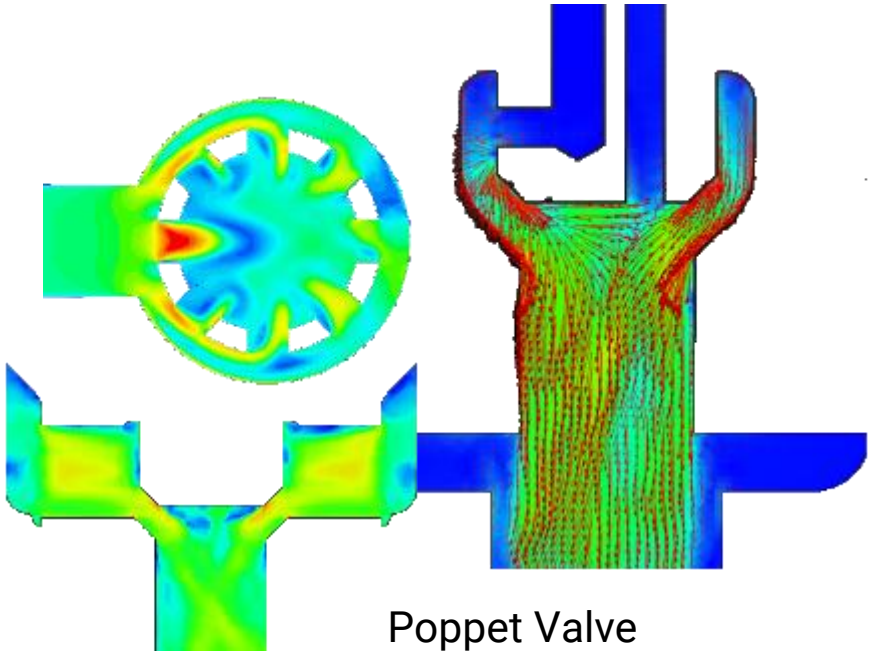
Hydraulic Valve CFD

Czero utilizes CFD to model flow characteristics/forces within hydraulic valves. Results are integrated into higher level dynamic models and used to inform the final valve design

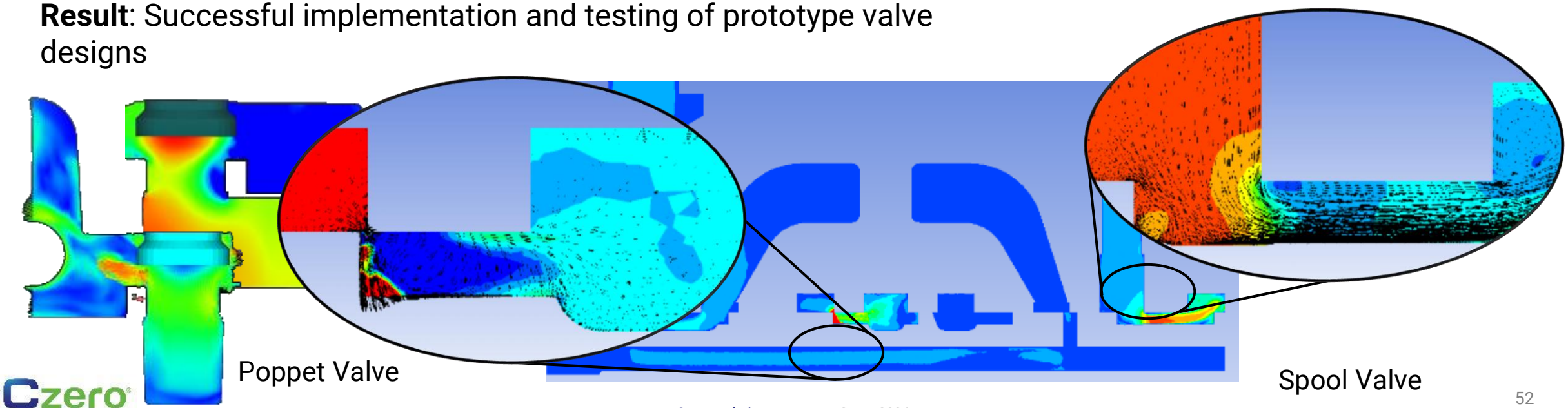
Design Challenges:

- Seek resolution of detrimental performance factors (oscillating/high flow forces, instabilities, cavitation, etc.)
- Provide modeling and test recommendations to correlate analytical and empirical data.

Result: Successful implementation and testing of prototype valve designs



Poppet Valve



Poppet Valve

Spool Valve

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LabVIEW and SCADA Panel Builds

- Czero frequency design and builds data acquisition and controls panels as part of many projects
- LabVIEW has been utilized for data acquisition and controls algorithm development on multiple hydraulic test stands which utilized National Instruments PXI hardware running Pharlap and Veristand
- Developed multiple engine dynamometer test systems which utilized Ni cDAQ and cRIO hardware platforms
- Multiple CLAD (Certified LabVIEW Associate Developer) certified engineers

Front Back

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Engineering with a Global Impact

Czero has provided engineering support and technical oversight during development of Envirofit's lighting products. This has included contributing to prototype design, refining technical specifications and tolerances, planning test protocols, and monitoring production quality

Czero has also helped design Envirofit's durable and lightweight free-standing plancha (metal griddle) cookstove. Known for fuel efficiency, Envirofit cookstoves significantly reduce smoke particulates and carbon dioxide emissions

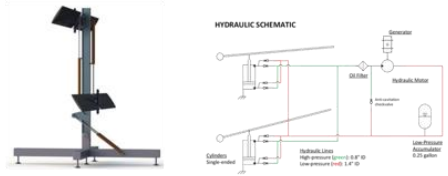
The Czero team was consistently precise, collected, and dedicated in management of our Empower Core 5 project, and Czero's consummate professionalism has made for a great working relationship with Envirofit. Our global users benefit greatly from Czero's engineering excellence and fantastic project management skills.

- Daniel Wald, Director of Sales and Operations
Envirofit

© Czero 2026

Czero's Active and Alumni Status ARPA-E Projects

Marine Hydrokinetic Energy Harvesting
ARPA-E Open 2012



BROWN · bluesource · Czero ENGINEERING TOMORROW

Natural Gas Vehicle Self-Contained Home Filling Station
ARPA-E MOVE – Phase I/II/SCALEUP

Oregon State University · Onboard Dynamics, Inc. Self-refueling anywhere. · Czero ENGINEERING TOMORROW

Monetizing By-products of Natural Gas Production
ARPA-E OPEN 2015

gti · Oregon State University · Ec Catalytic Technologies · Czero ENGINEERING TOMORROW

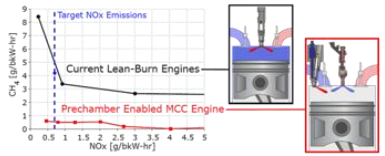
Test Facility and Proving Ground for ARPA-E MONITOR
ARPA-E MONITOR (Minor Role for Czero)

COLORADO STATE UNIVERSITY · Czero ENGINEERING TOMORROW

Root Genetics for Drought and Carbon Adaptation
ARPA-E ROOTS

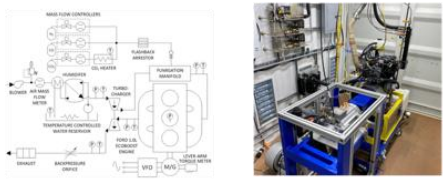
COLORADO STATE UNIVERSITY · Czero ENGINEERING TOMORROW

Prechamber Enabled Mixing Controlled Combustion of Natural Gas for Ultra-Low Methane Emissions from Lean-Burn Engines
ARPA-E REMEDY



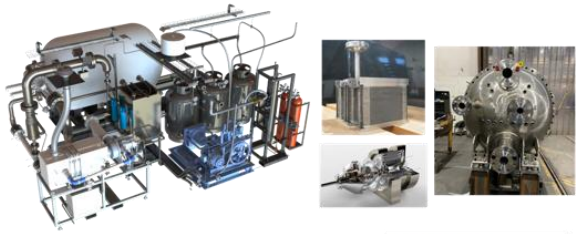
MARQUETTE UNIVERSITY · WISCONSIN · MAHLE · Czero ENGINEERING TOMORROW

Hybrid Electrochemistry–Advanced Combustion for High-Efficiency Distributed Power (HE-ACED)
ARPA-E INTEGRATE – Phase I



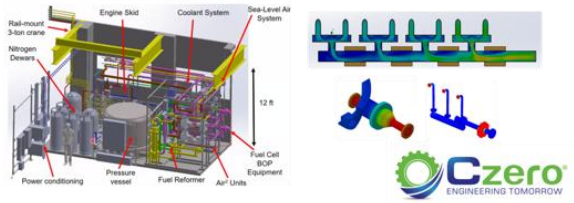
Stony Brook University · NEXCERIS · Czero ENGINEERING TOMORROW

High Efficiency SOFC/Turbine Hybrid Power System
ARPA-E INTEGRATE – Phase II



NEXCERIS · BraytonEnergy · Czero ENGINEERING TOMORROW

High Efficiency, Low Cost & Robust Hybrid SOFC/IC Engine Power Generator
ARPA-E INTEGRATE – Phase II (Minor Role for Czero)



MINES · COLORADO STATE UNIVERSITY · KOHLER. Power Systems · Air squared · Czero ENGINEERING TOMORROW

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Some of the Other Projects we have Worked On

pyrolysis reactors, hydrogen compressors, hybrid power trains, compressed air energy storage, vertical axis wind turbines, refrigeration cycle analysis, direct air carbon capture, combustion modeling, vapor emissions recovery system, natural gas locomotive conversion, agriculture machine electrification, tidal energy harvesting, thermochemical energy storage, hybrid vehicle modeling tools, gasifiers, off-grid refrigeration, desublimating carbon dioxide sequestration, turbocompounding, alkaline electrolyzers, vehicle and suspension dynamics, mobile natural gas compressor, liquid CO2 cleaning machines, e-fuels, wave energy harvester, subambient cooling systems, engine dynamometers, flare gas recovery, high speed valves for active suspension, machine-health monitoring devices, PEM fuel cells, air contactors, reactor controls, mobile EV charging systems, steam engines, woody biomass carbon sequestration, hydrogen electrolyzers, process modeling, waste heat to power, hydraulic hybrid vehicles, honey-bee overwintering equipment, highs speed electromagnetic actuators, automated soil sampling lab equipment, ceramic rotary valves, gas turbine modeling, methanol fuel injectors, truck frame stress analysis, ocean vessel anchoring systems, self-refueling natural gas vehicle, alkane conversion reactors, hydrogen fuel injectors, molten salt storage, algae biofuels, ultra-fast solenoids, briny water purification, LNG fuel injectors, turbochargers, compressed gas metering devices, amplification nozzles for rapid raft inflation, camless valve actuation systems, clean cookstoves, Solid Oxide Fuel Cells, hydraulically driven gas compression, subsea well control, transmission valves, wind turbine tower manufacturing, hydraulic power units, natural gas engine retrofit, hydraulic unit environmental testing, vehicle PTO-driven power generation, off-shore fish processing systems, methane leak detection sensors, rotary engine design, fire pit test unit, mobile diesel power generation, external combustion for biomass fuels, solar lighting, automated sampling tractor for carbon sequestration research, hardware-in-the-loop modeling, electric vehicle battery cooling, cryogenic carbon capture, crimper tool analysis, cylinder head fatigue failure analysis, methane oxidation heat exchanger, steam compressors, geothermal energy capture, biochar reactor, biosensors,, check valve chatter analysis, hybrid drone powertrains, hot gas filtration, cold temperature testing…

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Thank you for your time!

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