

“Leading the Transformation to Zero-Carbon Economy and Society”

An Update to the Dean’s Advisory Board of CECS

Presented by

Jay Kapat
Pegasus Professor and Trustee Chair
Director of CATER
University of Central Florida

April 23rd, 2022

Overview

UNIVERSITY OF CENTRAL FLORIDA

Office of the Provost and Academic Affairs

4365 Andromeda Loop, North
Millican Hall, Suite 331
Orlando, Florida 32816

February 17, 2022

Dr. Jayanta Kapat
Center for Advanced Turbomachinery and
Energy Research
College of Engineering and Computer
Science

Dr. Zhihua Qu
Resilient, Intelligent and Sustainable
Energy Systems
College of Engineering and Computer
Science

Dear Drs. Kapat and Qu:

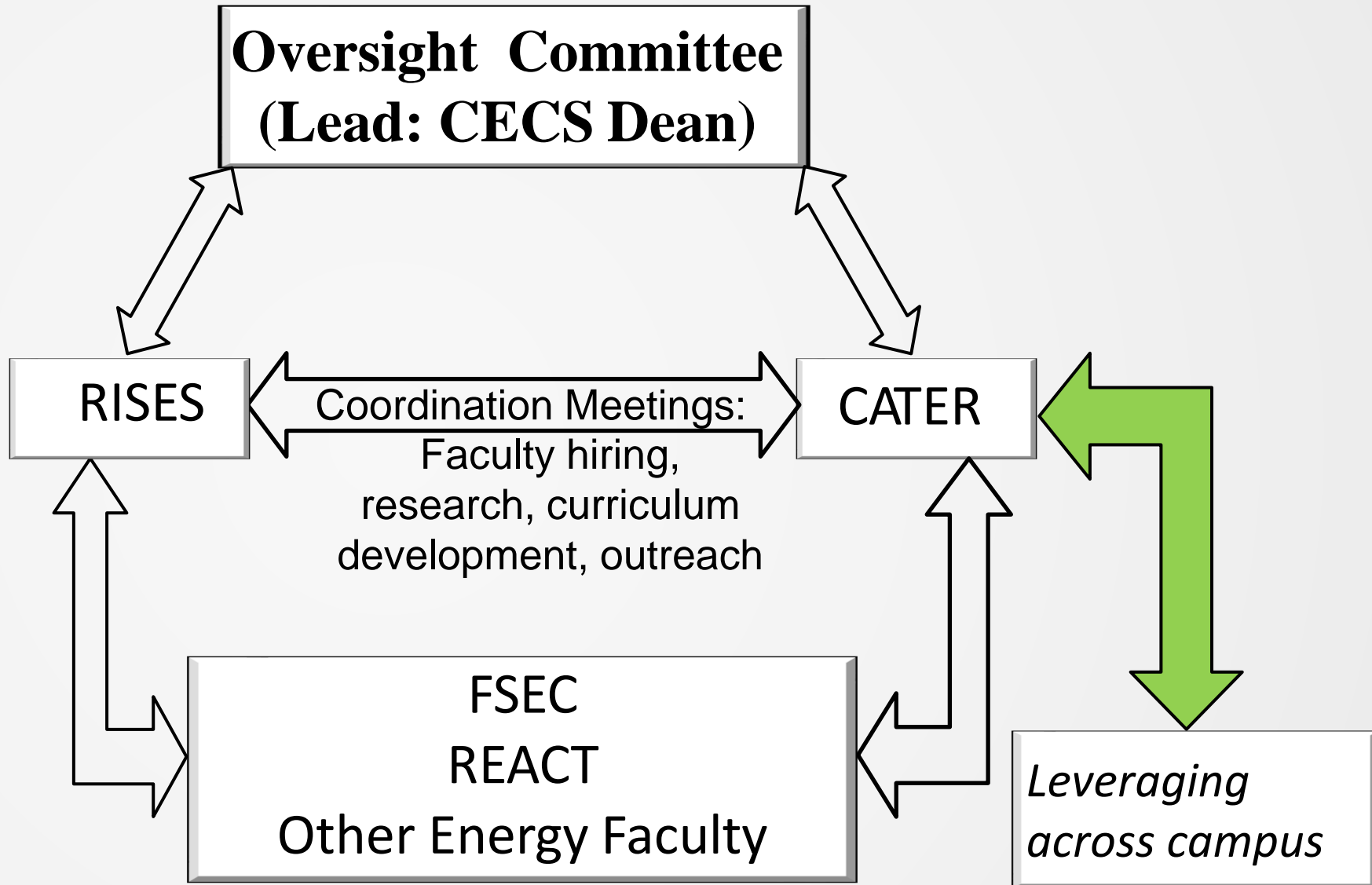
Congratulations! I am pleased to inform you that the focus area in your proposal, *Leading the Transformation to Zero-Carbon Economy and Society*, has been selected for investment as part of the Academic Excellence Fund under the 2021-22 President's Strategic Investment Program. We will provide \$1 million in recurring funds and \$5 million in non-recurring funds. This requires fulfillment of the match commitments in your final proposal. You will receive another communication soon with information on how the funds will be distributed, plus additional information.

Faculty Hiring

Faculty numbers	Home Colleges	Targeted Areas
1 & 2	FCI, CECS/COS	energy storage, non-combustion reaction, decarbonization
3 & 4	CECS	data driven optimization, control, and machine learning for energy systems
5 & 6	COS/CECS	data science, physics-based artificial intelligence
7 & 8	SMST	<i>modeling and large scale simulation, digital twin</i>
9 & 10	CECS	<i>hydrogen, alternative fuel and propulsion</i>

Overall Governance Structure for

“Leading the Transformation to Zero-Carbon Economy and Society”



Specific Research Topics of Immediate Interest

NASA University Leadership Initiative: Strategic Thrust – Zero Emission Aviation

“Zero-Carbon Engine Core with Supercritical Carbon Dioxide Power Cycle for Onboard Power”

J. Kapat (Overall PI): University of Central Florida

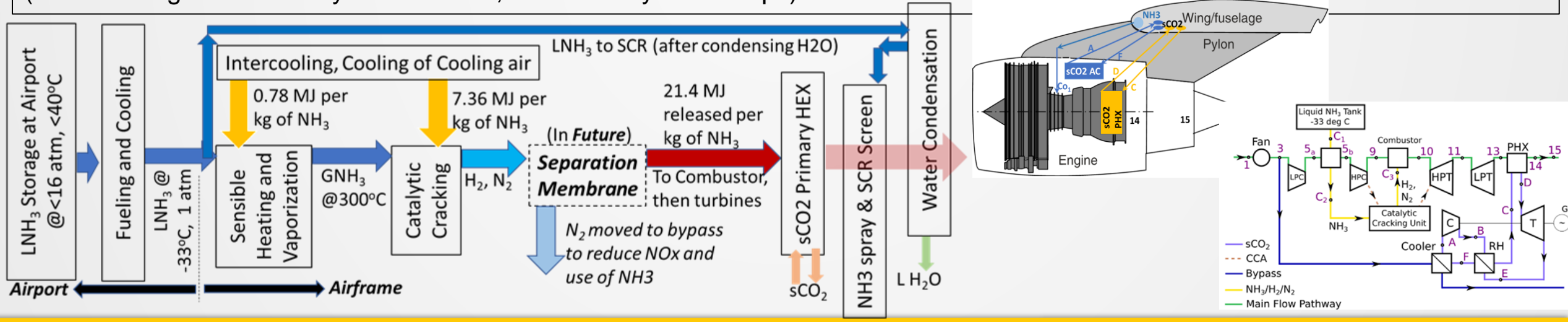
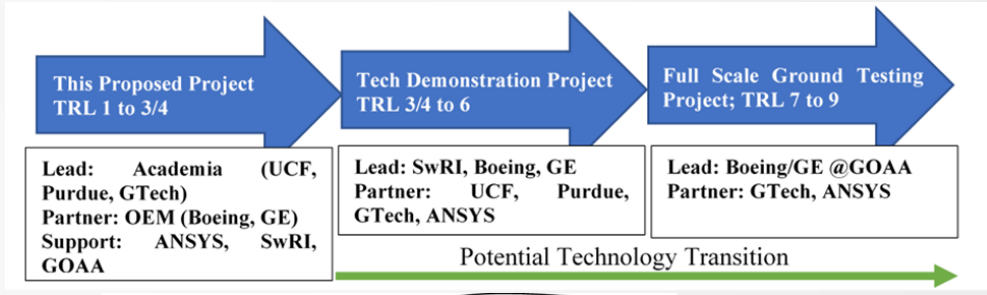
J. Kapat, S. Vasu, R Blair, S. Hick, H-J. Kiesow, E. Fernandez, L. Vesely, M. Otto – *University of Central Florida (MSI)*
 T. Meyer, G. Paniagua – *Purdue University*
 G. Natsui, K. McManus – *GE*
 S. Saxena – *ANSYS*
 J. Schmitt, T. Allison, G. Musgrove – *Southwest Research Institute*
 K. Thompson – *Greater Orlando Aviation Authority*

D. Mavris, J. Gladin – *Georgia Institute of Technology*
 M. Stoia, K. Jui, N. Applegate – *Boeing*

Total Budget: \$9,978,816 (August 1, 2022 – July 31, 2027)

Total Cost Share: \$486,761

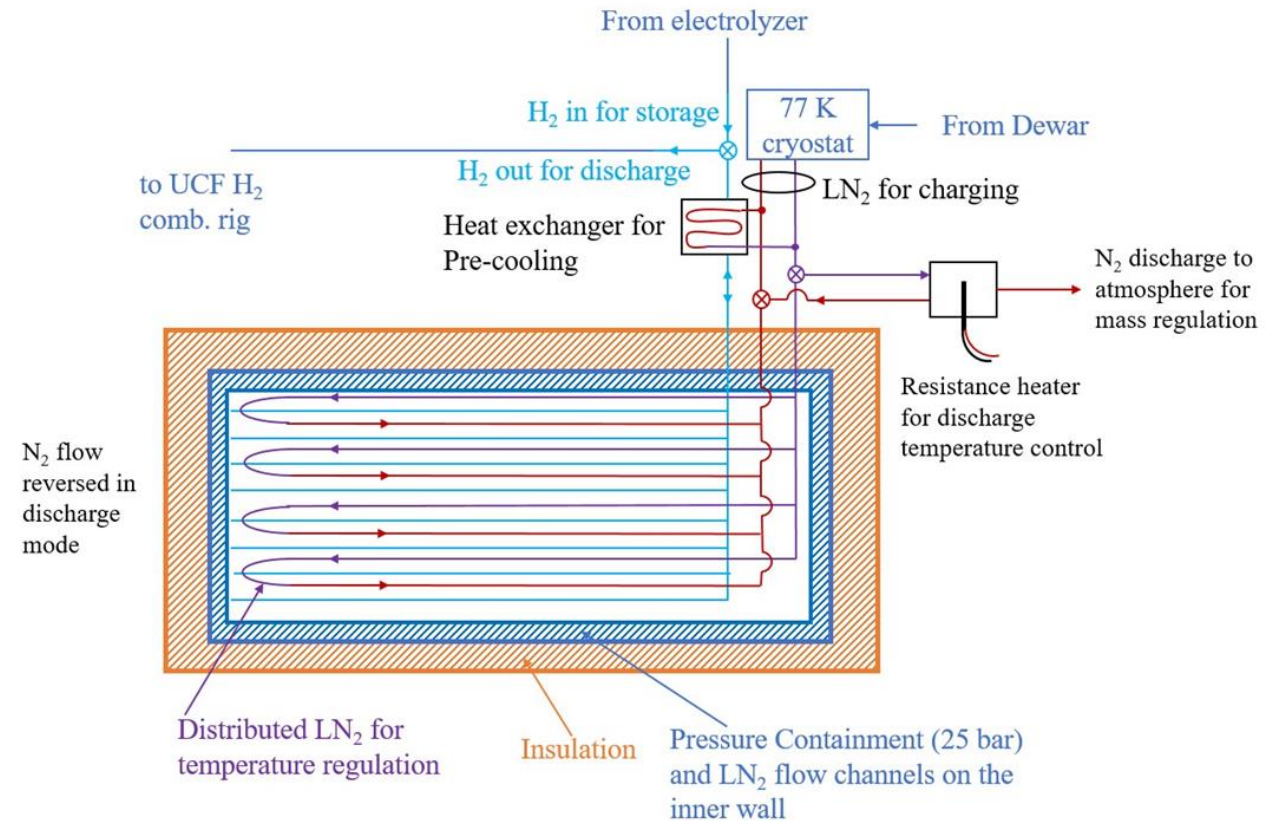
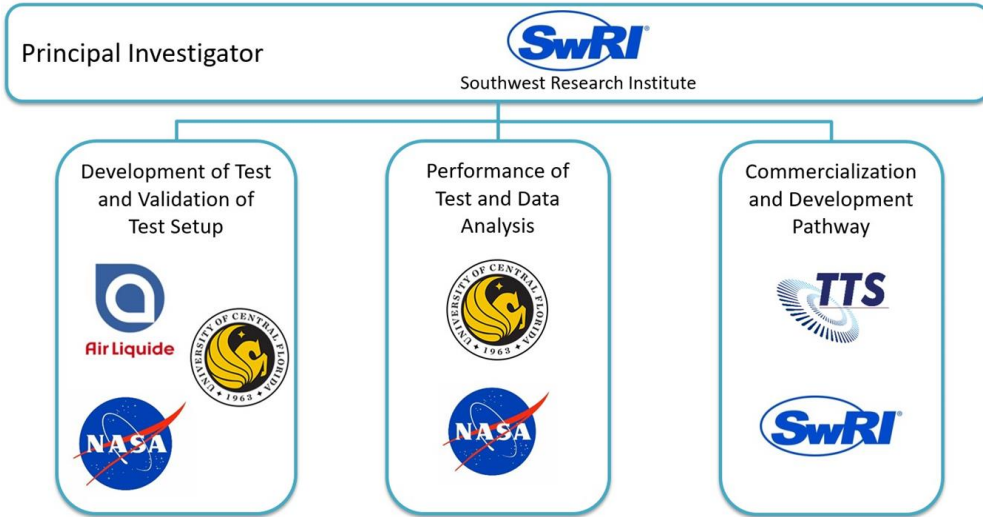
(not including some Faculty release time, and industry internships)



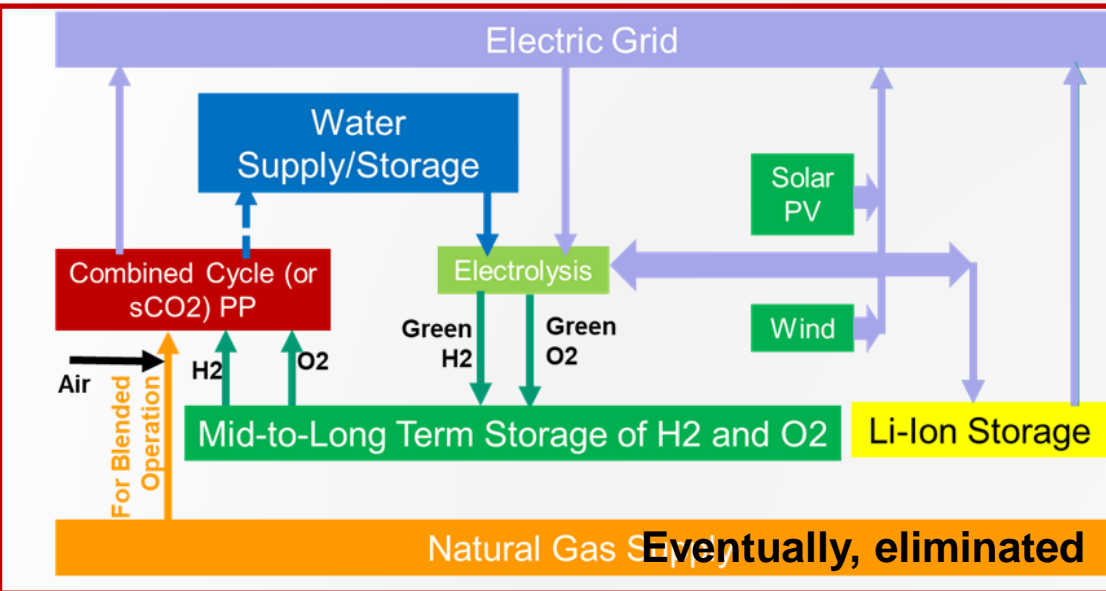
Development of an Advanced Hydrogen Energy Storage System using Aerogel in a Cryogenic Flux Capacitor

Award: DE-FE0032003

Team Organization

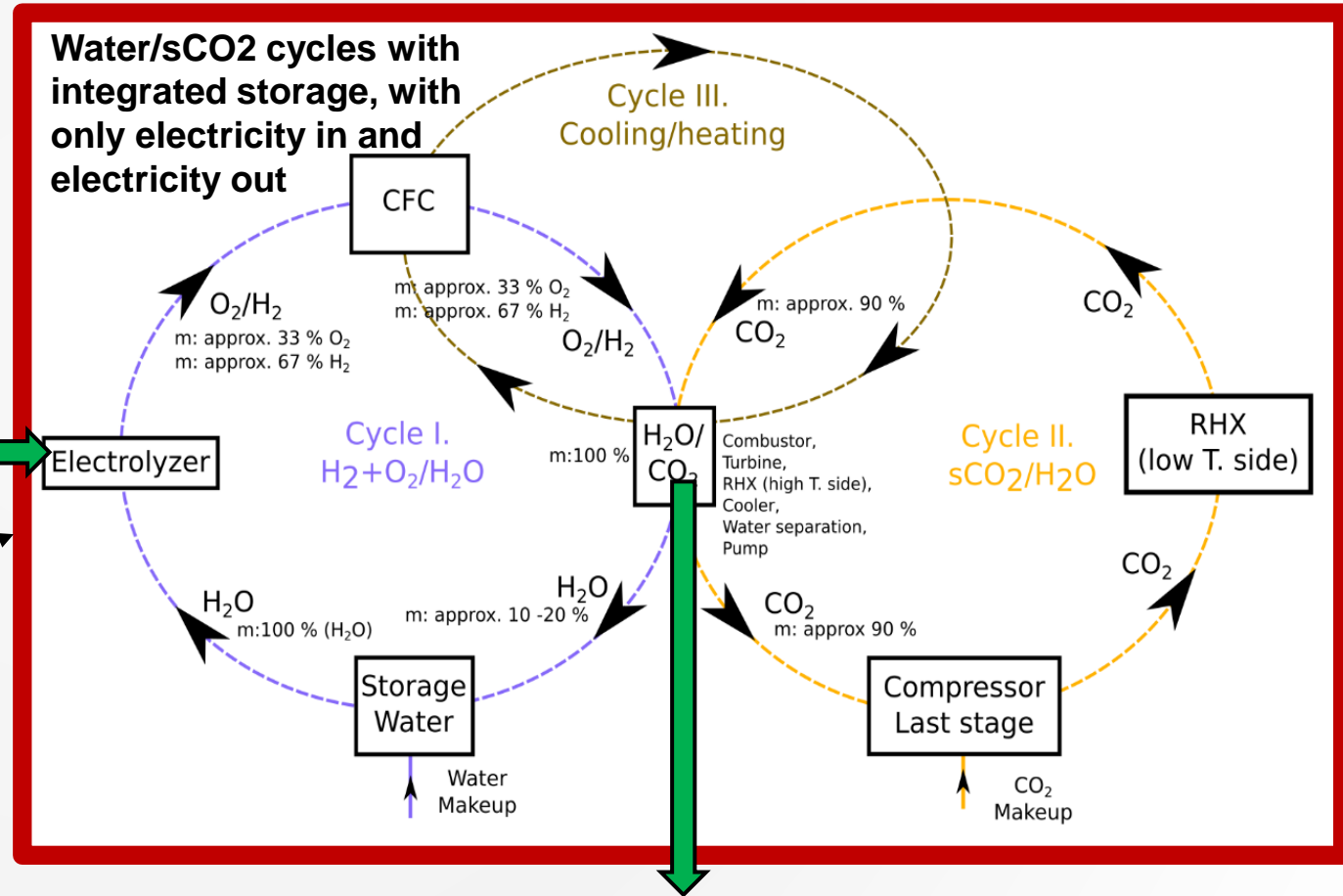


Hydrogen as a storage for Renewables for Power Generation



Digital Plant Model is a lot more involved.

What if we reuse the water, since combustion process produces water!! ***This poster received the best poster award*** for its innovative idea, in the sCO₂ symposium, 2022.

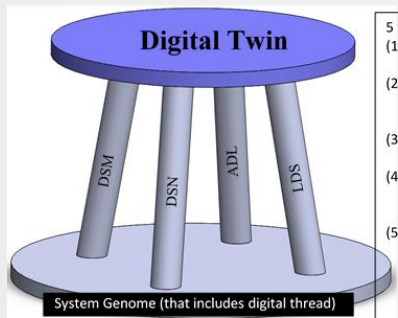


Digital Twin: Cyber-Physical model:

Because of renewable integration, Future Power Plants will become more complex with, Power-to-X, Electrolysis to green hydrogen, onsite storage of hydrogen, and use of pure or blended hydrogen, etc. Such power plants will require Digital Twin architecture, such as the proposed here, to achieve high RAM at lower cost.

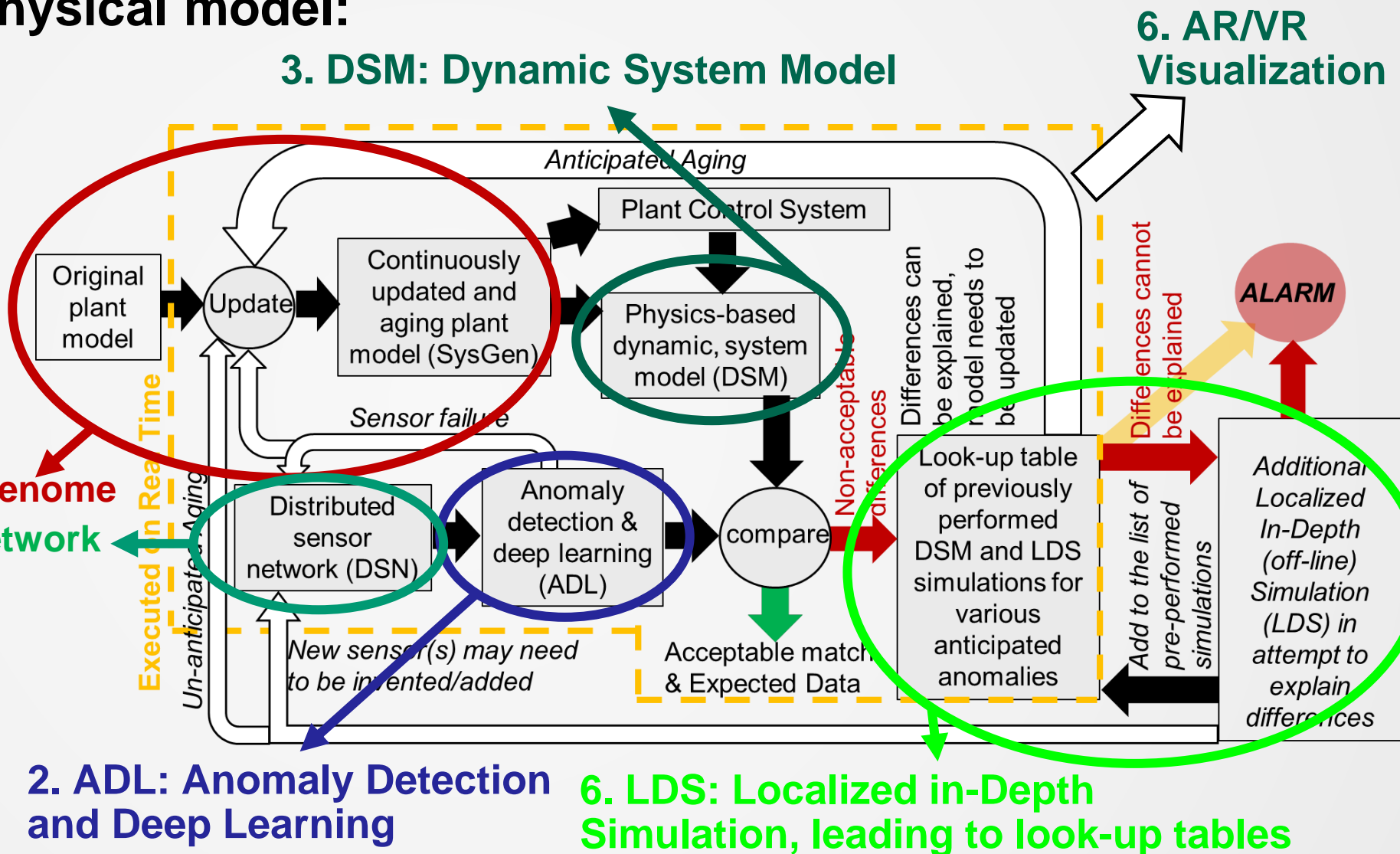
1. Digital Thread or System Genome

5. DSN: Distributed Sensor Network

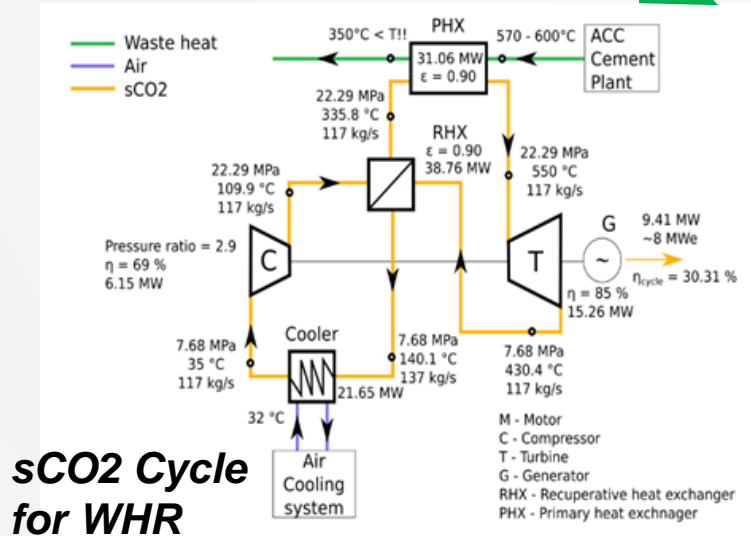
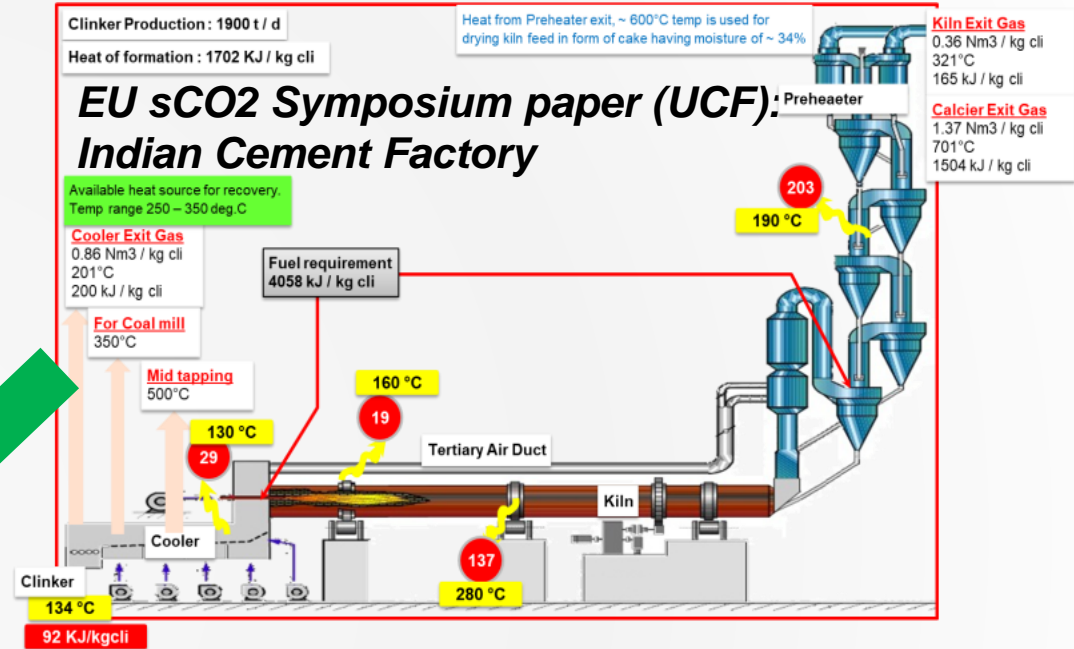
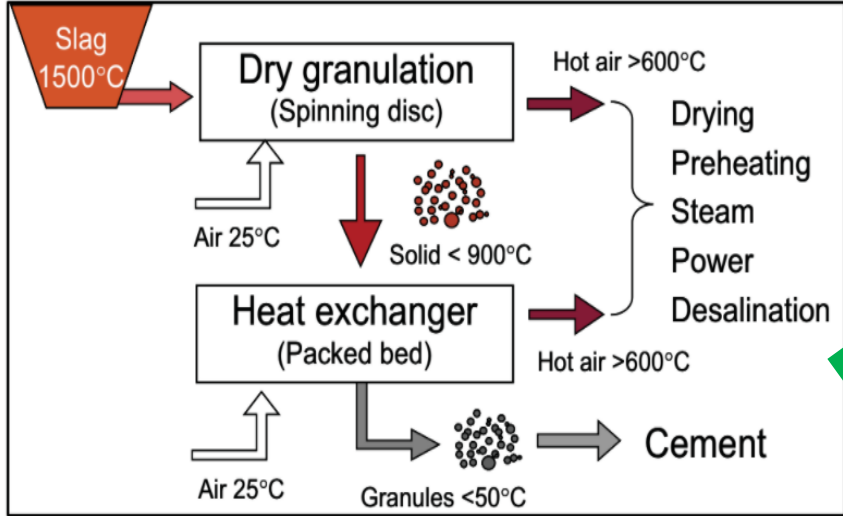


- 5 Primary Components:
- (1) System Genome that includes digital thread
 - (2) DSM (Dynamic System Model) – A low-order, physics-based model of the entire system
 - (3) DSN (Distributed Sensor Network), providing real-time data
 - (4) ADL (Anomaly Detection / Deep Learning), continuously analyzing the data
 - (5) LDS (Localized in-Depth Simulation), performed as needed to explain findings of ADL, that is differences between DSM prediction and DSN observation.

Figure 1. Components of Digital Twin with System Genome (DT-SysGen) as Proposed Here



Decarbonization of Cement and Steel Industry



sCO₂ Cycle for WHR

Sandia Lab funded Project (Steel/Cement Waste Heat Recovery)

FL-HEAT (Florida Consortium on Hydrogen for Energy, Aerospace, and Transportation)

The objective of this proposal is to create a FL-centric/FL-led H2-hub for aviation, power generation, marine and land transportation, and select industries, based on the combined strengths of key Florida universities and infrastructure related business to position Florida as a key partner in the creation of a southeast H2 hub.

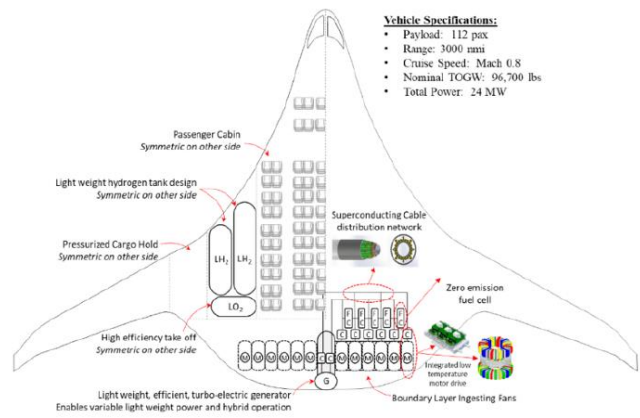
The consortium leverages recent *NASA awards led by FSU-FAMU and UCF (>\$20M, 2022-2027)* that recognize decades of research and development efforts to realize zero-emission hydrogen-fueled aviation, along with their ongoing DOE-funded efforts in hydrogen. It should be noted that FAMU is HBCU and UCF is HSI. The consortium also leverages significant institutional commitment and support provided by UCF.

Highlights of Capabilities:

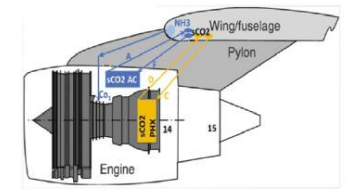
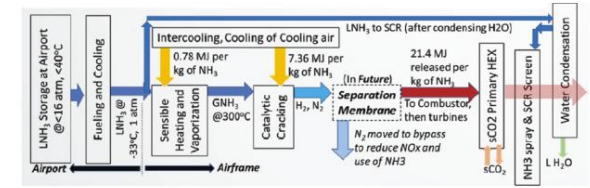
<p>Transportation (ULI-UCF, ULI-FSU):</p> <ul style="list-style-type: none"> Aircraft: funded concepts for zero-emission aviation. Ships: System-level ship electro-thermal co-simulations; Hardware-in-the-loop experiments to de-risk H2/NH3 concepts (collaboration with FSU/CAPS). Buses/trucks: Fuel cell power train concepts and demonstrations (Disney/ University Buses). <p>Ammonia as a Hydrogen Carrier (ULI-UCF+):</p> <ul style="list-style-type: none"> Storage: LNH3 storage at < 16 atm Fueling and cooling at -33°C NH3 thermal management for sensible heat Catalytic <p>Magnets</p> <ul style="list-style-type: none"> superconducting magnets. new H2 liquefaction technologies (ASC/NHMFL). 	<p>Hydrogen (ULI-FSU):</p> <ul style="list-style-type: none"> Cryogenic systems to store LH2 at <20K. Alternative H2 storage, including cryogenic flux capacitor and pressurized LH2 thermal management Superconducting <p>System level (ULI-UCF, ULI-FSU, FAMU):</p> <ul style="list-style-type: none"> Frameworks for evaluation and optimization of system level CO2 emissions, energy usage, and water footprint covering the H2 value chain (production, storage, transportation, use). Fuel cells systems integration (heat recovery/ cooling). Airport/airframe integration – economics. upgrade
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Excellent Topic for LBR and Federal Priorities.

Additional Synergistic Activities under Discussion: (1) Orlando-based, local H2-hub, centered around Disney and local transportation (existing and planned), including city/Disney buses, cruises, urban air/road mobility, in partnership with local OEM's and utility companies/cooperatives. (2) MCO (Orlando International Airport)-based consortium/testbed for "Towards Zero-Emission Aviation" that will involve airframers, airlines, aviation fuel supplier, GOAA (Greater Orlando Airport Authority) and FL-based suppliers and producers, with focus on exploring SAF (sustainable aviation fuel) in the near-term and potentially H2/NH3 for longer-term solutions.



- Vehicle Specifications:**
- Payload: 112 pax
 - Range: 3000 mi
 - Cruise Speed: Mach 0.8
 - Nominal TOGW: 96,700 lbs
 - Total Power: 24 MW



Examples of Ammonia and H2 concepts by the team towards Zero-emission Aviation.

FAMU/FSU: Dr. Juan Ordonez, ordonez@eng.famu.fsu.edu

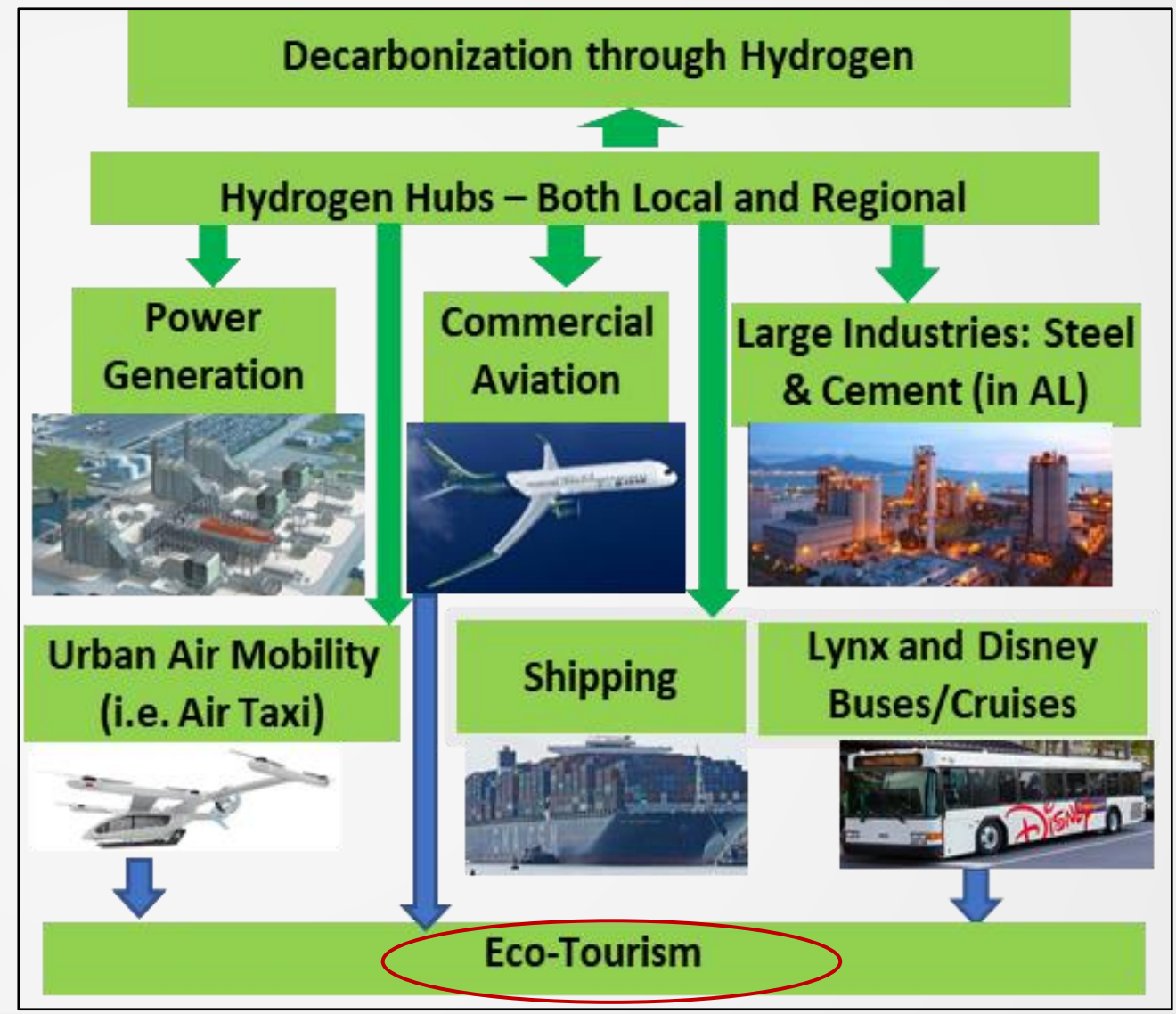
UCF: Dr. Jay Kapat, jayanta.kapat@ucf.edu
Dr. Grace Bochenek grace.bochenek@ucf.edu

In partnership with
Rosen College of Hospitality Management,
 to create a

Local Hydrogen Hub

around Orlando and Florida

that focuses on
 Tourism Industry.

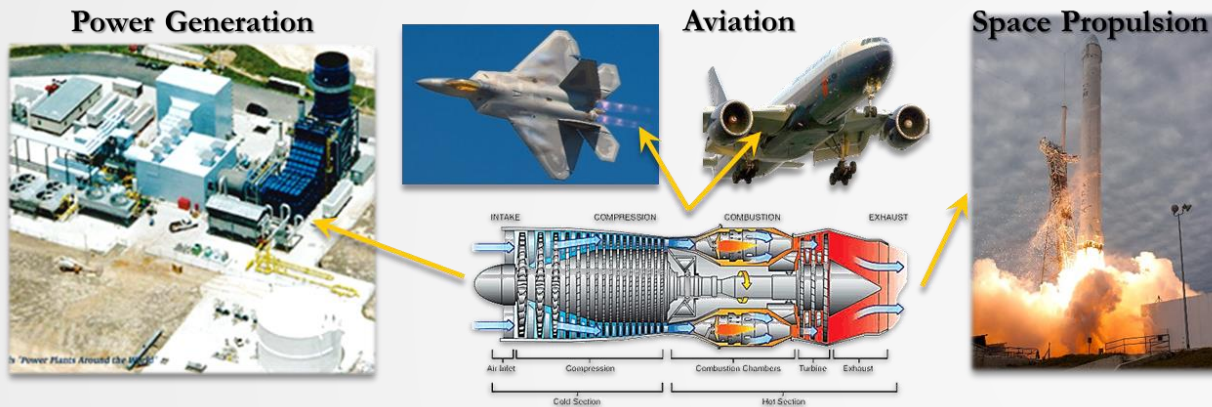


A Few Final Thoughts

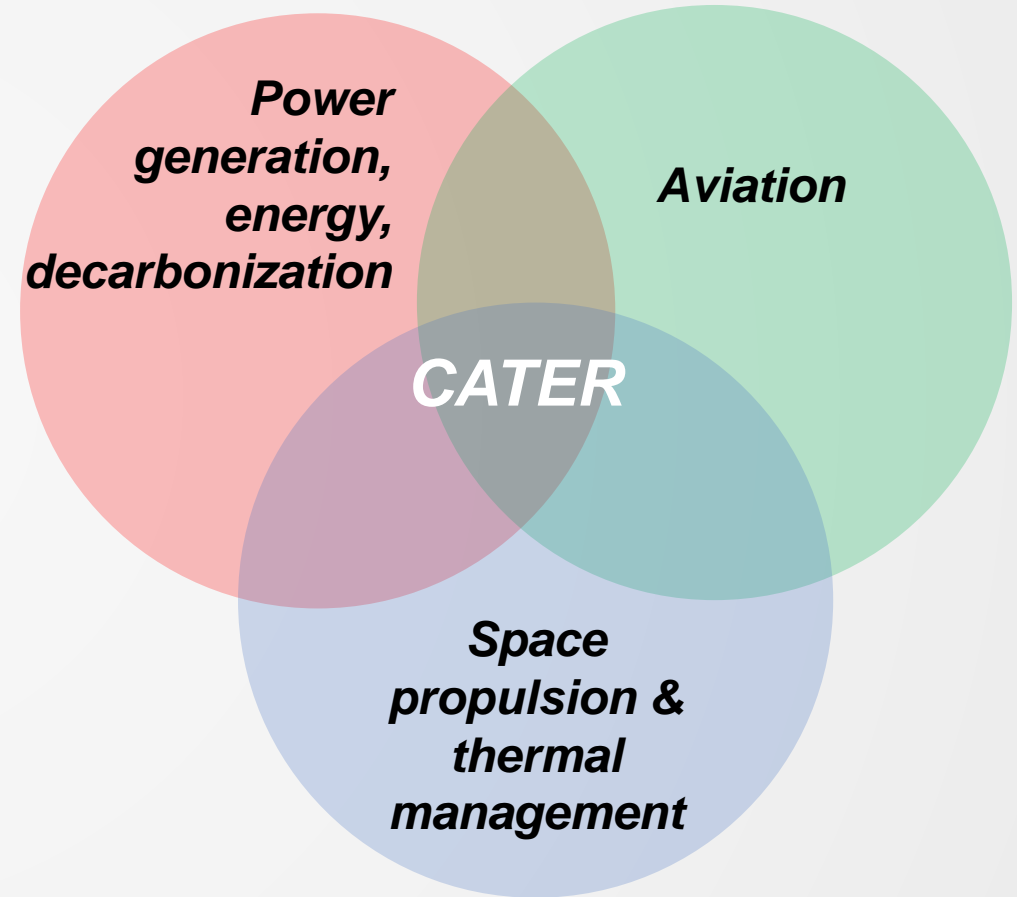
Return on Investment:

1. **Branding/Naming:** From departments under DOE to international partners such as ITA in Brazil, and among our US peers, **CATER** has created a significant name recognition. To strengthen and enhance that name recognition, we will launch CATER 2.0, so that we become the desired destination of the best of the best across the globe.
2. **Metrics:** (a) In the first 7 years of existence, CATER experienced an average of ~20% Y-on-Y growth in external funding. We will maintain a minimum of 10% growth rate for the coming years. (b) Each **CORE member** of CATER 2.0 must meet minimum performance metrics (e.g. Ph.D. graduation and mentoring, external funding, etc.), tied to the respective of college average.
3. **Sustained Activity w/ succession plans and strong mentoring**
4. **Leveraging across the University ...**

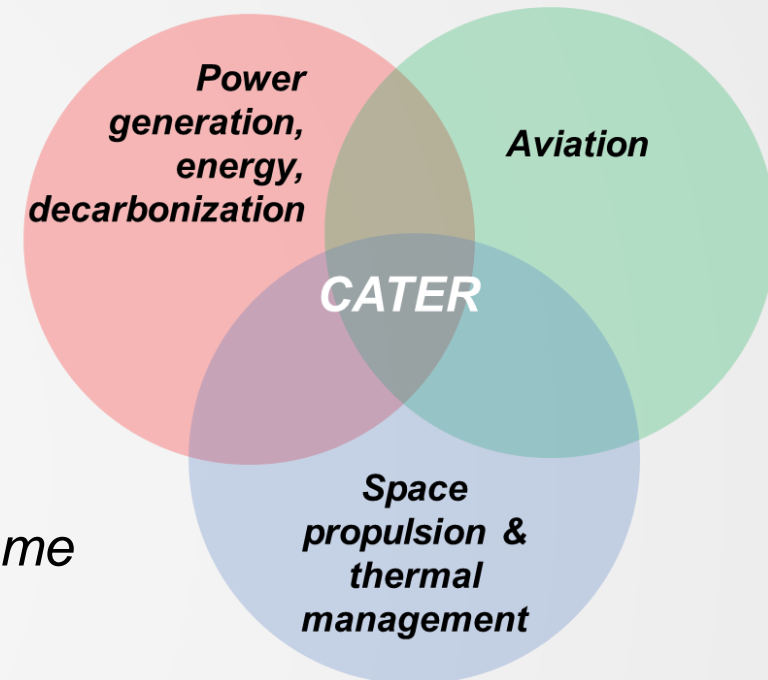
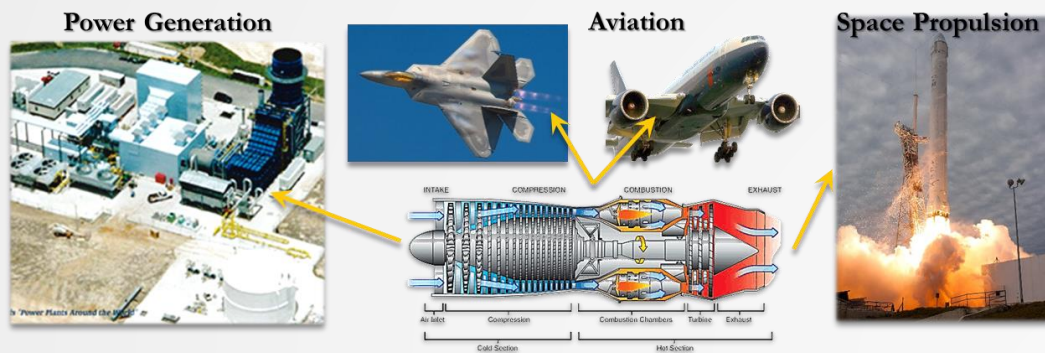
*Laws of Science do not care how we differentiate applications!
e.g. NASA ULI*



All these applications face very similar technical challenges and the same laws of science and engineering relations.



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This Academic Excellence Award directly invests in CATER (CECS+COS) + RISES, SMST, REACT, FSEC, as stated earlier.

However, activities under this award will lead to better collaboration with RCHM, VARLab, FSI, and even Policy.

Thank You

Presented by

Jay Kapat

Pegasus Professor and Trustee Chair

Director of CATER

University of Central Florida

email: Jayanta.kapat@ucf.edu; text: (407) 617-1201

April 23rd, 2022