KTH ROYAL INSTITUTE
OF TECHNOLOGY

CCGEx 2018-2021:

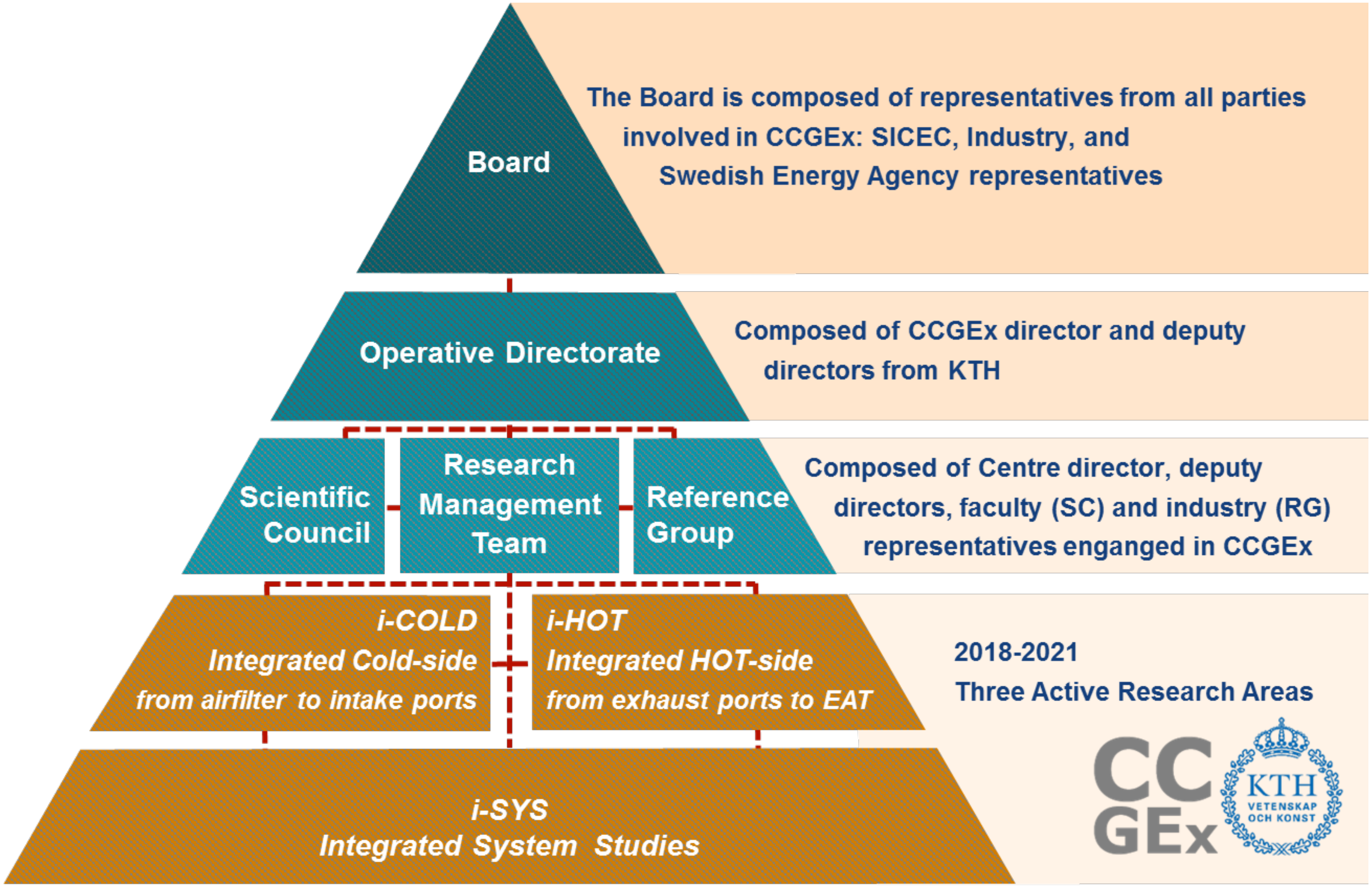
Goals, Focus areas & Research questions

7th - 8th of September, 2017, CCGEx – Research Days

CCGEx Targets & Goals

- Higher power train efficiency through:
  - Increased gas exchange and turbocharging efficiency
  - Higher charge pressure enabling efficient thermodynamic cycles (e.g. Miller)
  - Lower aerothermodynamic losses
  - Efficient and smarter EGR systems for optimized, diluted & cold combustion: smart EGR-turbocharger-Intercooling integration
  - Integrated waste heat recovery (WHR)
- Enhance hybridization potential for a better response & efficiency under transients
- Better methods for thermal handling and regulation of after-treatment systems
- Zero emissions during real use (RDE)
- Increased inlet pressure during transients for better response
- Enable transition to 100% renewable fuels in SI and CI engines

CCGEx Organization



CCGEx Research Areas 2018-2021

- i-COLD: Integrated COLD-side
- i-HOT: Integrated HOT-side
- i-SYS: Integrated System Studies

i-COLD: Integrated Cold-side

Research Questions: 2018-2021

Research Questions - iCOLD

- Which are the mechanisms & key factors leading to stall onset in centrifugal compressors?
  - Impact of upstream / downstream perturbations and installation effects on compressor stability and performance
  - Assess & mitigate flow phenomena leading to stall/surge

R1

- Understand compressor system's components, their interactions, for an optimal, variable boosting system
  - Impact of hybridization; El-booster/power-boost system integration; Two stage/sequential system integration
  - Optimised component interaction/connections

R2

- Which are the mechanisms for the aerodynamically generated noise in compressor systems?
  - Assess & mitigate the dominant acoustic sources

R3

Which are the mechanisms & key factors leading to stall onset in centrifugal compressors?

- Quantify and understand the flow instabilities, the process of their generation, their impact on compressor operability range
  - asses sensitivity to the upstream / downstream perturbations (e.g. pressure pulses caused by engine breathing);
  - impact on the onset of instabilities
  - understand the role of the flow-acoustics coupling and impact on compressor stability
  - mitigation of flow instabilities in centrifugal compressors for a wider operating map and improved performance at off-design.

- Provide knowledge to the System Study area
  - retain key phenomena for reduce modeling of compressor's performance and onset of instabilities

R1

Understand compressor system's components & interactions, for an optimal, variable boosting system

- Understand the air boosting system response under transients
  - Optimal integration: bended pipes & intercooler & compressor & EGR & resonators
  - Hybridization: El-booster integration; Two stage/sequential system integration; asses interaction between compressors;
  - Asses interaction between components; Optimised component interaction/connections
  - Assess the air boosting system under transients
  - Develop an efficient and accurate method for modelling charging system's stability and performance
- Provide knowledge and reduced models to Sys. Stud.

R2

Which are the mechanisms for the aerodynamically generated noise in compressor systems?

- Understand the driving factors and parameters governing the noise generation process
  - quantification of the dominant acoustic sources;
  - establish correlations between the acoustic sources and the propagating noise
  - take advantage of this knowledge and identify efficient noise suppression technologies at source
  - understand the impact of upstream and downstream instalation effects on aeroacoustics
  - characterisation of the flow-acoustics coupling in the system
- How to develop flow control technologies for suppressing acoustic sources in the system

R3

i-HOT: Integrated HOT-side

Research Questions: 2018-2021

Research Questions: i-HOT

- Understand the impact of pulsating hot flows on component & connections (interaction between components) R1
  - Identify and mitigate aero- and thermal losses
  - Identify the available enthalpy (exergy)

- How to take advantage of the pulsating conditions to maximize the average turbine power output? R2

- Understand the heat-harvesting mechanisms from pulsating hot gas R3
  - Pressure drop penalties vs. heat transferred
  - Fluctuations impact on performance
  - New concepts for WHR

Understand the impact of pulsating hot flows on component and connections

- Understand the pulse propagation (pressure, flow, enthalpy) through the ports, EGR valve, turbine, EAT, heat-recovery.
  - Understand exhaust port flow impact on the turbine
  - Understand impact of the EGR valve/ exhaust gas split on e.g. exhaust flow, turbine, EAT
  - Understand the impact of turbine exhaust unsteadiness (e.g. instabilities, flow intermittence) on EAT
  - Understand the impact of EAT exit unsteadiness on heat-recovery

- How to provide knowledge and reduced models to the System Study area.

R1

How to take advantage of the pulsating conditions to maximise the average turbine output?

- Understand the influence of the pulse characteristics on the
  - Aero-thermodynamic losses
  - Turbine performance/Design

- Understand the sensitivity to the onset of instabilities
  - Exhaust valve strategies; effect of the pulse shape and general transient operation
  - Effect of the manifold and casing geometry/shape

- Identify and retain the key phenomena for reduce modeling of turbine performance and onset of instabilities

R2

Understanding the heat-harvesting mechanisms from pulsating/intermittent hot-gas

- Understand heat-exchanger transient response
  - Mechanisms for losses and transfer (pressure drop vs. Nu)
  - Simulation, reduced models
- Understand and predict Heat-Exchanger fouling (method dev.)
- Investigation of new concepts for minimal pressure drop and maximum heat-transfer at low ΔT (simulations & concept validation)
- How to predict available heat for WHR during pulsating conditions.
- Thermoacoustic WHR
- Metamaterials with combined acoustic and heat transfer properties

R3

i-SYS: Integrated System Studies

Research Questions: 2018-2021

Research Questions: i-SYS

- Understand the characteristics of gas exchange systems for effective, highly boosted, diluted (EGR) cold combustion with renewable fuels & near zero emissions. R1
- How to leverage the potential of hybridization to increase efficiency, transient response, and integrate waste heat recovery. R2
- How to simulate real drive emissions (RDE) in laboratory and virtual real time environments to achieve near zero emissions. R3
- Understand particle characterization and treatment R4
- Urea SCR revisited – from fundamental understanding to system view R5

Characteristics of gas exchange systems for effective, highly boosted, diluted (EGR), cold combustion with renewable fuels & near zero emissions.

- Understand potential and limitations of two stage turbocharging – high inlet pressure, efficiency, inter-stage losses, transient response.
- Explore new concepts for efficient, controllable EGR systems integrated with waste heat recovery.
- Propose and evaluate concepts with the highest potential for efficiency and emission.
- Investigation of the potential for high efficiency and practically zero emissions for heavy duty DISI stoichiometric engine concepts with renewable liquid fuels.

R1

How to leverage the potential of hybridization to increase efficiency, transient response and integrate waste heat recovery whilst minimizing real drive emissions?

- Understand the potential and limitations of hybridization in combination with e-boost/power pulse and its implication for RDE over typical operating cycles.

- Understand hybrid/WHR system topology and its consequence on transient response.

- Methods for optimization of energy harvesting, system topology layout for transient conditions.

R2

How to simulate real drive emissions (RDE) in laboratory and generate virtual real time environments to achieve near zero emissions?

- Understand the how to predict RDE based on engine testing in laboratory and models in virtual environments.
- Understand hybrid/WHR system topology and its consequence on transient response with corresponding RDE.
- Explore novel methods for emission control & thermal management during transients and cold starts.
- Methods for aggregation of reduced order models from other research areas to system topology layout for transient conditions.

R3

Particle characterization and treatment

- Experimental characterization of particles in the exhaust line
  - Actual measurement techniques
  - Understand evolution along exhaust line
- Numerical methods for exhaust flows with particles
  - from 1D to high fidelity
- Methods for removing/reducing particle mass/number in the exhaust flow
  - Agglomeration – change size distribution
  - Improved filtration concepts
- Influence of different fuels

R4

Urea SCR revisited – from fundamental understanding to system view

- Experimental data base for urea-sprays in mean flow
  - Understand evaporation and mixing
  - Needed for development of numerical methods

- Improved numerical models for the introduction of sprays

- System view:
  - Mixer concepts
  - System design

R5

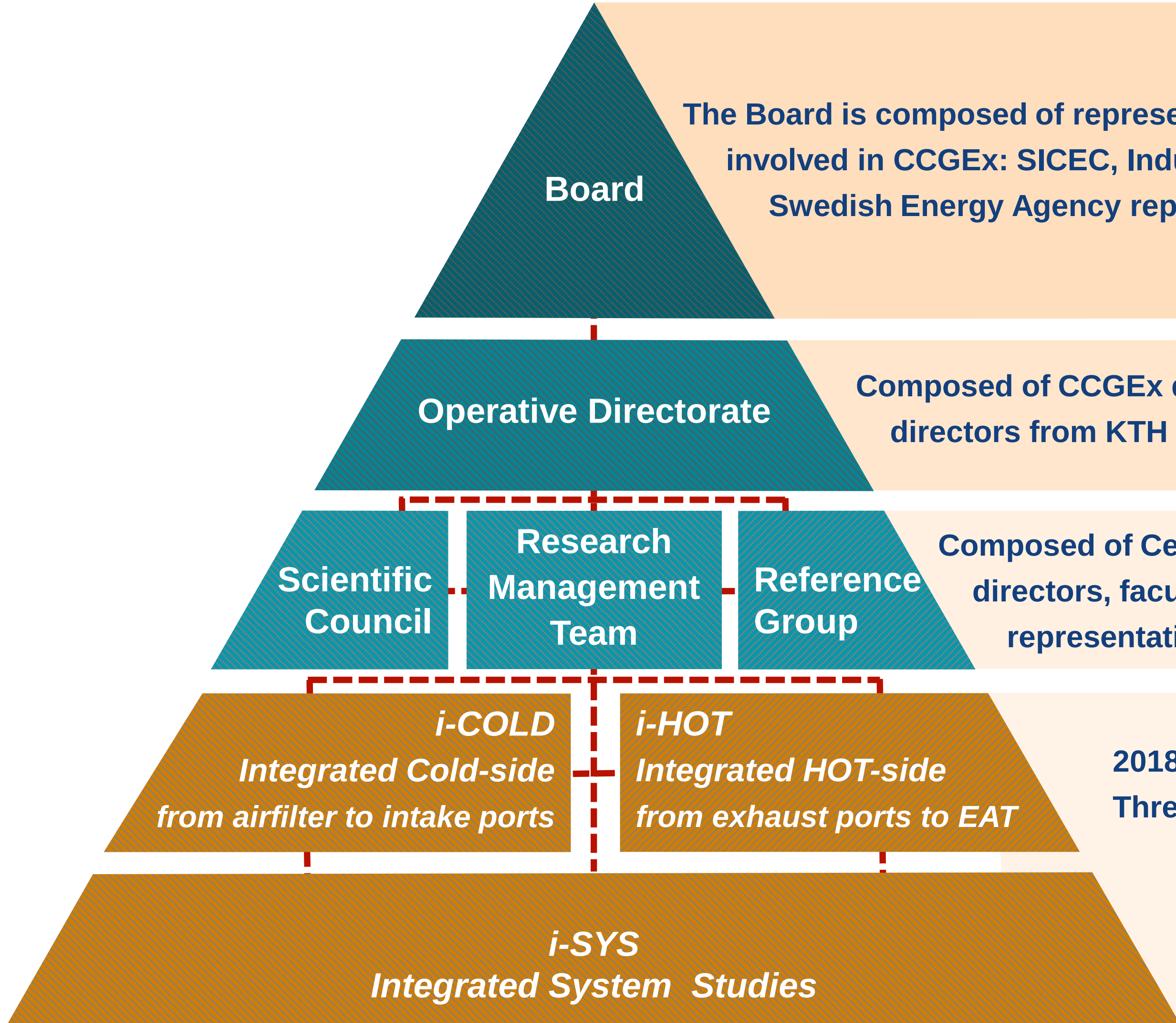
Competence Center for Gas Exchange

CCGEx

"Charging for the future"

Energimyndigheten SCANIA VOLVO VOLVO BorgWarner

CCGEx Research Areas



The Board is composed of representatives from all parties involved in CCGEx: SICEC, Industry, and Swedish Energy Agency representatives

Composed of CCGEx director and deputy directors from KTH

Composed of Centre director, deputy directors, faculty (SC) and industry (RG) representatives enganged in CCGEx

2018-2021
Three Active Research Areas