Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institute for Dynamic Systems and Control
IDSC
Institut für Dynamische Systeme und Regelungstechnik

New Demands on Engineers of the Automotive Industry

Mechanical Engineering Education at ETH Zurich

Chris Onder
onder@ethz.ch

Content of presentation

- **Demands of automotive industry**
- **Education at ETH Zurich, Mechanical Engineering**
- **Focus Projects**
- **Lessons learned**

- Demands of Automotive Industry
  Intitial position

  - Many single components still to develop and to optimize

  BUT

  - Break-throughs often take place at borders between disciplines

Demands of Automotive Industry

- normal engineering knowledge (math, fluid dynamics, thermo dynamics, mechanics, ...)
- Capable to work self-responsible and with enough self-motivation (→grades!)
- soft skills (team spirit, organisation, management, ...)

- systems oriented knowledge (system modelling of complex systems, control oriented models, optimization oriented models, optimization techniques, ...)

onder@ethz.ch

- Example for complex System:
  Hybrid (Electric) Powertrain
  - Given configuration can deliver demanded behaviour with various input combinations
  - Size of individual components is not definded a-priori

Bachelor im M.E. At ETH Zurich

1. Semester (28 ECTS)	2. Semester (29 ECTS)	3. Semester (30 ECTS)	4. Semester (30 ECTS)	5. Semester (30 ECTS)	6. Semester (26 ECTS)
Analysis I	Analysis II	Analysis III	Physics II	Fluid Dynamics II	Bachelor Thesis
Mechanics I	Mechanics II	Mechanics III	Fluid Dynamics I	Thermodynamics III	
Linear Algebra	Chemistry	Dimensioning I	Thermodynamics II	3 Elective Courses	
Engineering Materials & Production I	Engineering Materials & Production II	Electrical Engineering I	4 Elective Courses		
		Thermodynamics I			
Product Design: - CAD - Technical Drawings - Machine Elements	Informatics I	Control Systems I		Focus	
	Product Design: - Innovation Project - Innovation Process	Physics I		Laboratory Practice	
		Engineering Tool II	Engineering Tool III	Engineering Tool IV	
					Focus
	Engineering Tool I				Engineering Tool V

GESS: Courses in Humanities, Social and Political Sciences (6 ECTS)

Workshop Training, 5 Weeks (5 ECTS)

- Compulsory Courses: 108 ECTS
- Elective Courses: 21 ECTS (distributed in 4. and 5. Semester)
- Workshop Training: 5 ECTS
- Focus: 20 ECTS (distributed in 5. and 6. Semester)
- GESS: 6 ECTS
- Bachelor Thesis: 15 ECTS
- Engineering Tool: 5 ECTS
- Laboratory Practice: 4 ECTS

onder@ethz.ch

- Focus
  - „normal focus“: Choose lectures from a list according to a certain topic (i.e. Mechatronics, Biomedical Engineering, Energy flows & Processes, Manufacturing Science,...)
  - „focus project“: Choose a project and get the necessary knowledge to succeed in various lectures

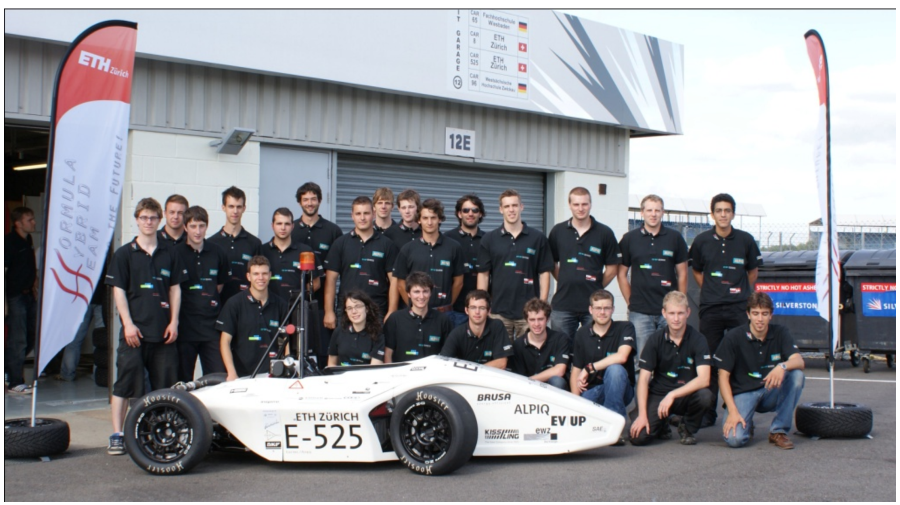
- Focus Project
  - Focus project provides an opportunity for project-based learning. Students work in teams to conceptualize, design, develop, and construct an object. The necessary knowledge is acquired through self-study, course attendance and consultation.
  - 20 CP ECTS

- Master requirements:
  - **Credits required**
    - Core courses 36 CP
    - Multidisciplinary courses 6 CP
    - GESS courses in Humanities, Social and Political Science 2 CP
    - Semester project 8 CP
    - Internship 8 CP
    - Master thesis 30 CP
    - **Total** 90 CP

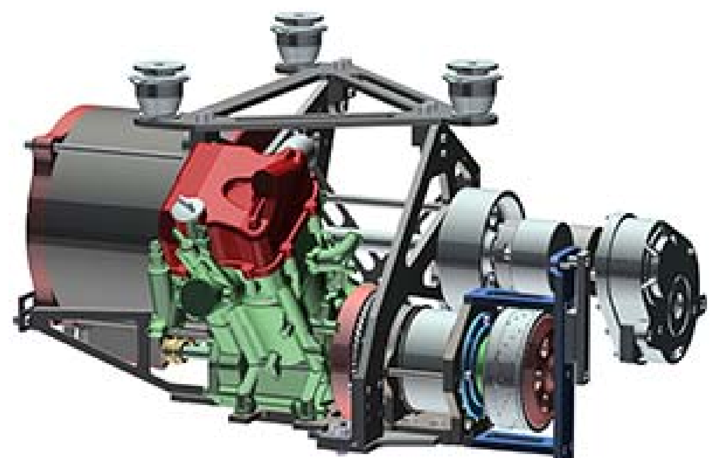
Some past focus projects at IDSC

PAC-Car (www.paccar.ethz.ch)

Hyb-α (www.formula-hybrid.ethz.ch/HS08)



Pegasus (www.formula-hybrid.ethz.ch/HS09)



Hermes (www.formula-hybrid.ethz.ch)

Master: Tutor based, example curriculum

- **Autumn Semester**
  - Dynamic Programming and Optimal Control
  - Embedded Control Systems
  - Engine Systems
  - Vehicle Propulsion Systems
- **Spring Semester**
  - Introduction to Recursive Filtering and Estimation
  - Model Predictive Control
  - Bio-Inspired Optimization and Design
  - Energy Systems and Power Engineering

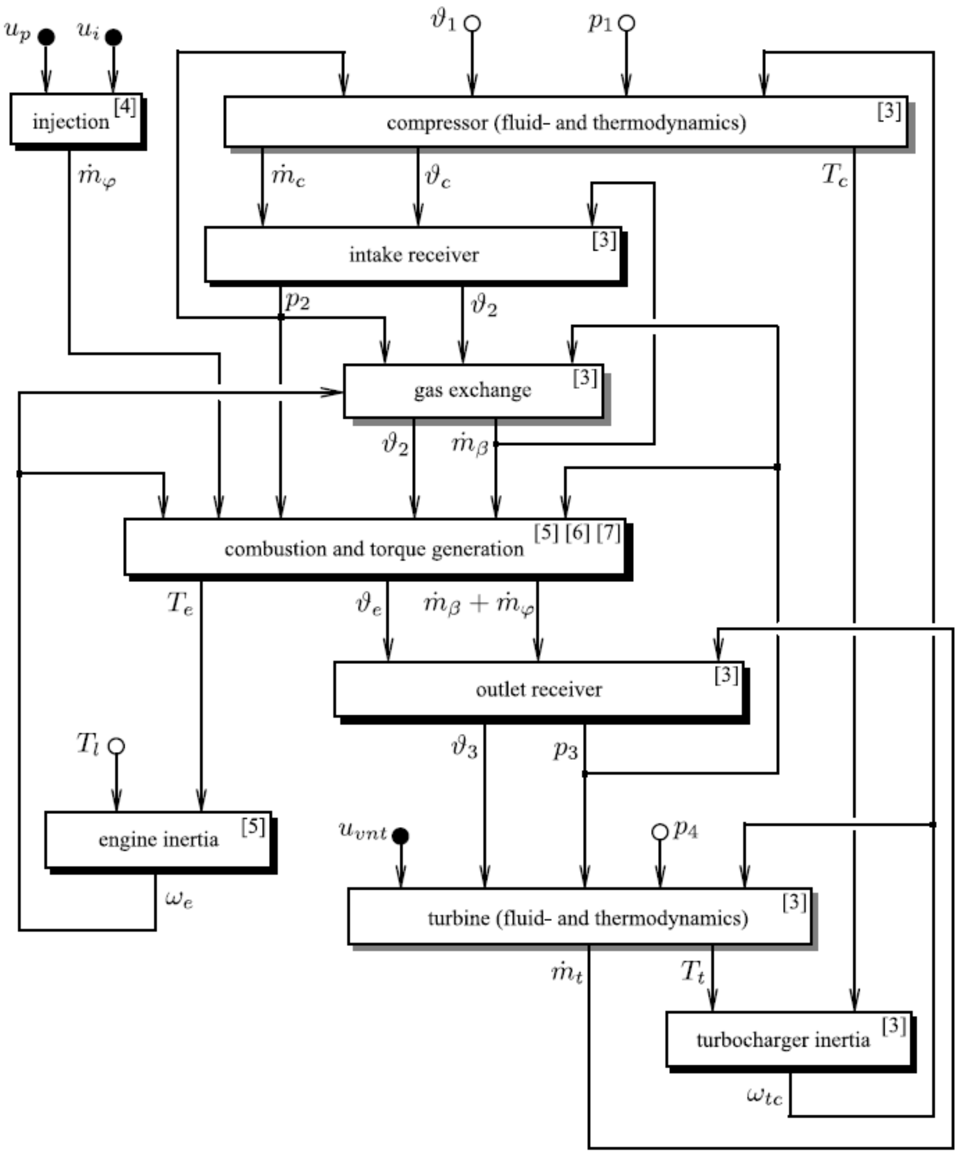
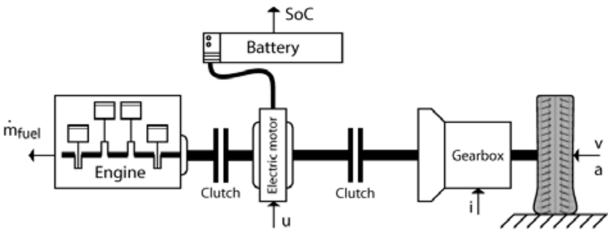


Fig. 2.6. Cause and effect diagram of a Diesel engine (EGR and intercooler not included).

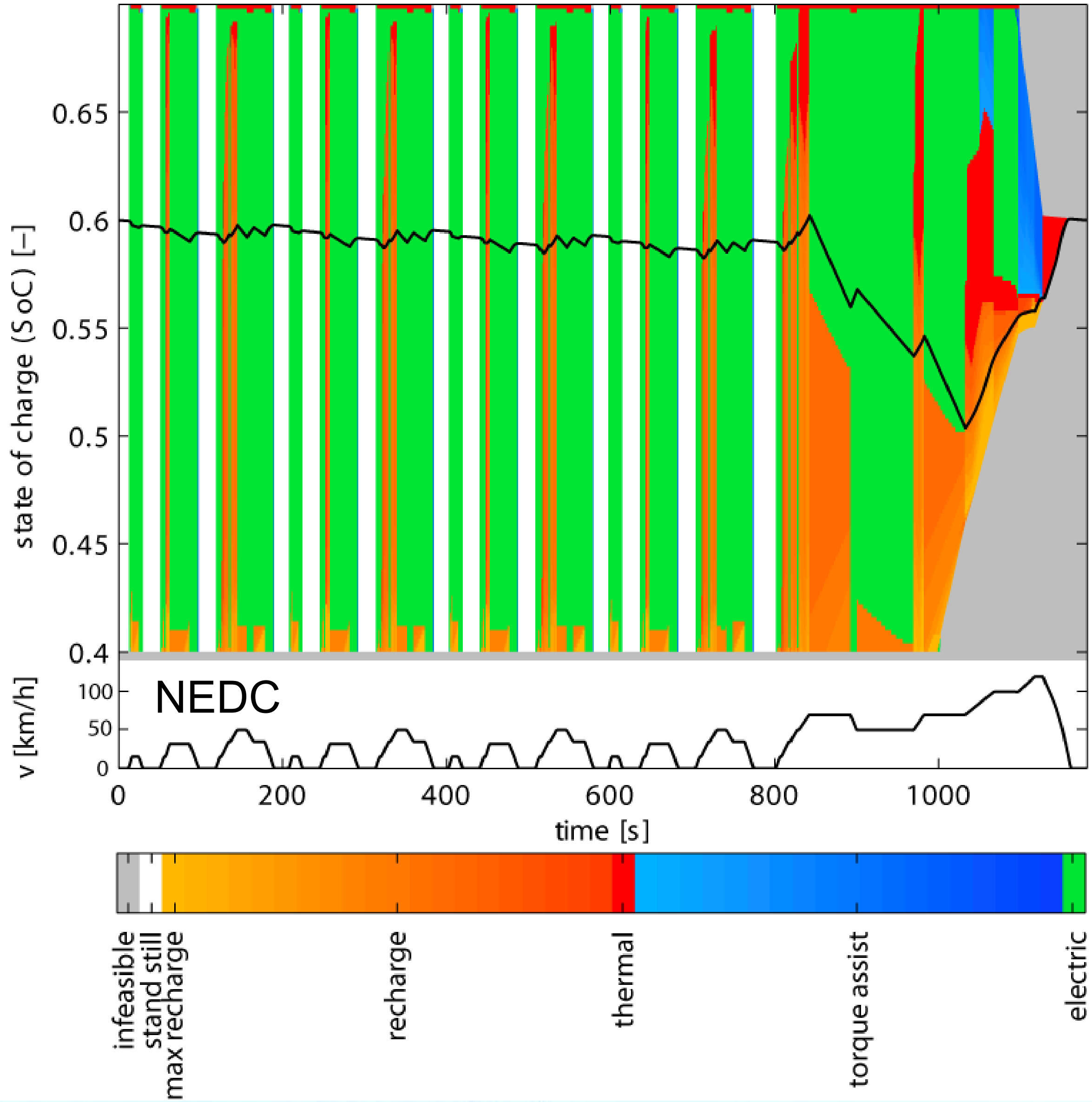
Cause-Effect Diagrams help to understand interconnections and to build simplified models

 onder@ethz.ch

Optimal Control with Dynamic Programming

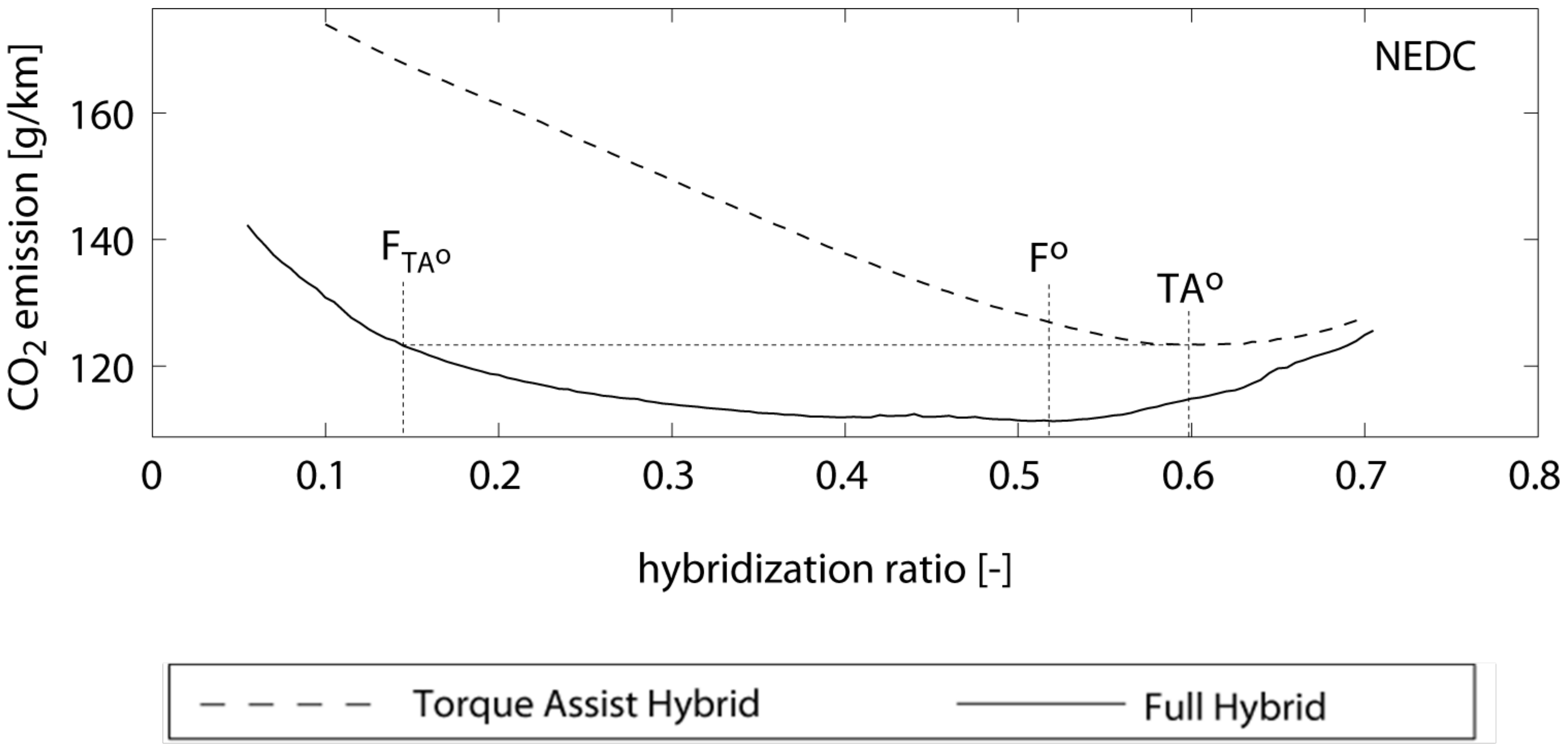


- Optimal strategy
  - Mainly pure electric operation
  - Recharging using engine
  - Rarely boosting



Decoupling of Sizing Problem from Optimal Control Problem

Results (NEDC)



- Lessons learned
  - Offer student projects which are relevant to society, environment, economy
  - Choose the students (grades)
  - First simulate, then build (avoid tinkering of students, i.e. in end phase)
  - Bachelor thesis should have scientific content
  - Provide enough consulting manpower
  - 1 year duration of ETH Focus Project is very short for Formula Student Projects, thus the Bologna process does not favor these projects
  - Formula Student Projects are NOT a recruiting tool for phd students

onder@ethz.ch