Aero

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Aircraft Systems Overview

Greening of Secondary Power Systems

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SWAFEA – Sustainable Way for Alternative Fuels and Energy for Aviation

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Content

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- **Secondary Power Systems**
- **Fuel Cells in Aviation (example: Airbus)**
- **Greening of Secondary Power Systems**

Secondary Power Systems

1.) **Propulsive power**: aircraft engines

2.) **Secondary power**: onboard power

- for technical loads

  consumed by equipment required to operate the aircraft safely

- for commercial loads

  consumed by equipment required to increase passenger comfort and satisfaction

Consumption of secondary power systems:

about 5 % of fuel consumed for the total flight

Energy types of secondary power systems:

- electric
- hydraulic (special hydraulic fluid under pressure)
  - 3000 psi = 206 hPa
  - 5000 psi = 343 hPa
- pneumatic (air under pressure)
  - at about 4 hPa and 200 °C

Onboard systems and their type of secondary power

identifier	name of system	secondary power
21	air conditioning	pneumatic => future: **electric**
22	auto flight	electric
23	communications	electric
24	electrical power	**generation**: electric
25	equipment / furnishings	electric
26	fire protection	–
27	flight controls	hydraulic => future: **electric**
28	fuel	electric
29	hydraulic power	**generation**: hydraulic
30	ice & rain protection	pneumatic / electric => future: **electric** / electric
31	indicating / recording systems	electric
32	landing gear	hydraulic => future: **electric**
33	lights	electric
34	navigation	electric
35	oxygen	–
36	pneumatic	**generation**: pneumatic
38	water / waste	pneumatic => future: **electric**
49	airborne auxiliary power	**generation**: electric / pneumatic

Original sources of aircraft secondary power:

- Aircraft engines normally (e. i. during taxiing and in flight) provide all energy needs onboard
- Other power sources needed only

  a) on the ground

  (to make the aircraft self sufficient)

  b) for additional redundancy

Aircraft engines deliver ...

- mechanical energy (shaft power) for:
  - electric (generator)
  - hydraulic (engine driven pump)
- pneumatic (bleed air)

Other power sources are ...

- Auxiliary Power Unit (APU)
- Ram Air Turbine (RAT)
- Batteries (BAT)
- Future => Fuel Cell (FC)
- Airport equipment. Delivery of:
  - electrical power
  - hydraulic power
  - pressurized air
  - air for air conditioning

Other power sources and their application ...

- **Auxiliary Power Unit** (APU)
  - on ground
  - in flight for added redundancy
    - additional redundancy (non essential APU)
    - necessary redundancy (essential APU, e.g. ETOPS flights)
- **Ram Air Turbine** (RAT)
  - electrical RAT: electric power => also converted into hydraulic power
  - hydraulic RAT: hydraulic power => also converted into electrical power
- **Batteries** (BAT)
  - DC => also converted into AC
- **Fuel Cell** (FC)
  - DC => also converted into AC
- **Airport Equipment**
  - Electricity
  - Hydraulic Power
  - Pressurized Air
  - Air for Air Conditioning

Energy conversion on board (1/2):

- **electric => hydraulic**: electric motor driven hydraulic pump (electric motor driven pump, EMDP)
- **electric => pneumatic**: electric motor driven compressor

- **hydraulic => electric**: hydraulic motor driven generator (constant speed motor / generator – CSM/G)
- **hydraulic => pneumatic**: hydraulic motor driven compressor

Energy conversion on board (2/2):

- **pneumatic => electric**: pneumatic motor driven generator
- **pneumatic => hydraulic**: pneumatic motor driven compressor

- **hydraulic => hydraulic**: hydraulic motor drives hydraulic pump

  (power transfer unit – PTU)

Energy conversion ...

should be avoided to save energy (conversion

Reasons for energy consumption due to **onboard systems**:

- direct consumption of shaft power from the engine
  - electric
  - hydraulic
- bleed air (air taken from different compressor stages in the engine)
- system mass => induced drag => increased thrust demand
- ram air => added drag => increased thrust demand
- additional drag

Fuel Cells in Aviation (example: Airbus)

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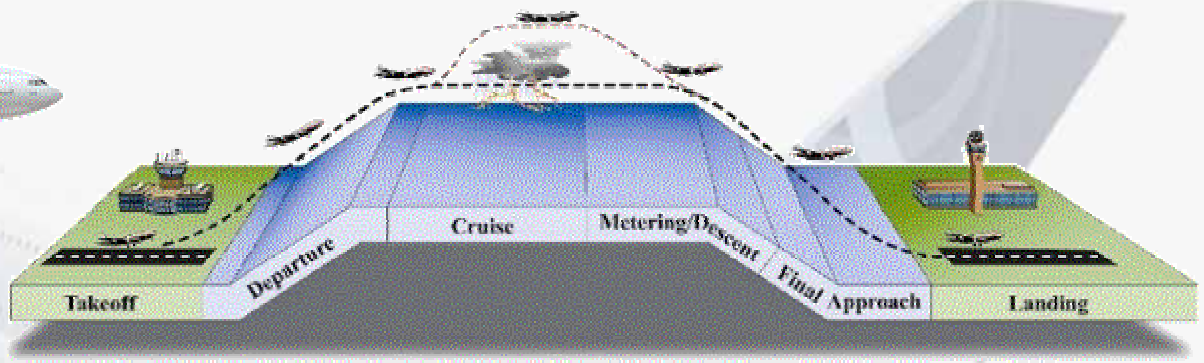
Greening of secondary power systems ...
... with Fuel Cells (FC)

- See Airbus public presentation at HAW Hamburg:

  http://www.fzt.haw-hamburg.de/pers/Scholz/dglr/hh/text_2007_05_10_Brennstoffzelle.pdf

Motivation for Fuel Cell System Application

Aircraft Mission



Example: A330-300:

- ~100 000 L per flight of ~10 000 km (Average Fuel Consumption)
- Fuel Use: up to 5 %* Aircraft Systems
  95 - 97% Propulsion

up to 5000 L per flight for Aircraft Systems operation

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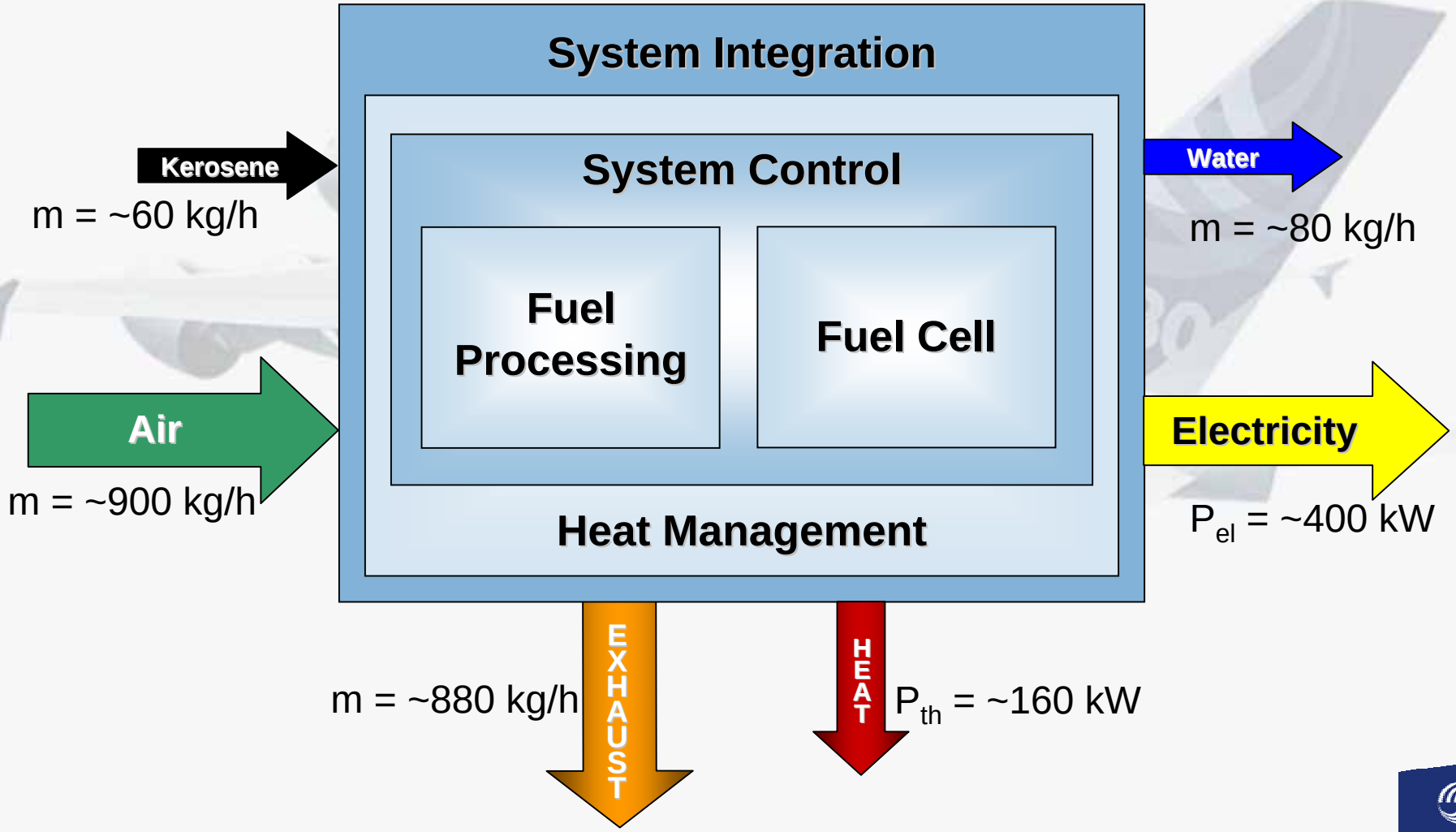
Fuel Cell Systems Architecture

System Architecture Overview



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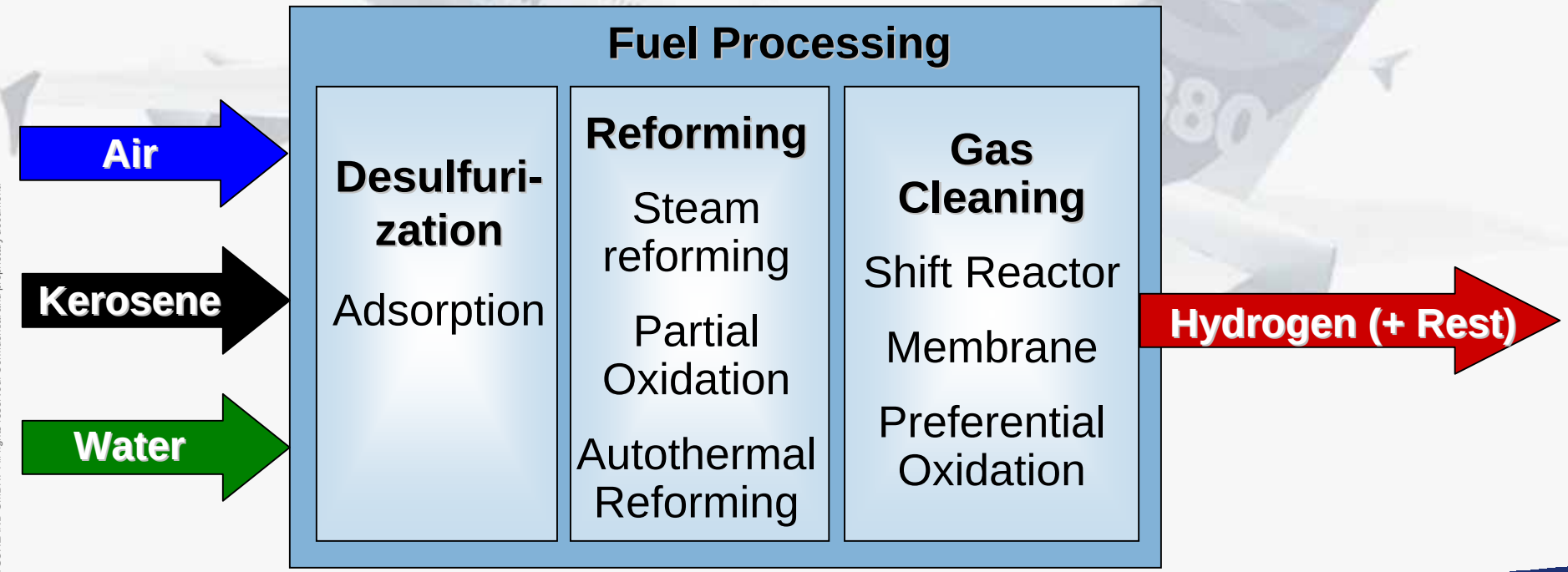
Fuel Cell Systems Architecture

Key Challenge Fuel Processing

Fuel Processing is the Conversion of Kerosene into a hydrogen rich gas. Three Parts are normally necessary:

Desulfurization: Removal of sulfur from kerosene.
Reforming: Conversion of kerosene into a hydrogen rich gas (Reformat).
Gas Cleaning: Cleaning of the reformat (depending on fuel cell).



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Airbus Fuel Cell System Strategy

Step by Step Approach

Step 1

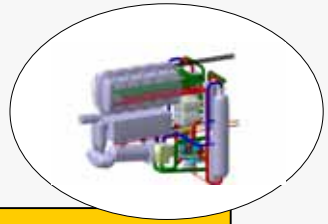
H_2 Vessel

Flying Test Bed

Step 2

H_2 Vessel

Fuel Cell Emergency Power System



Step 3

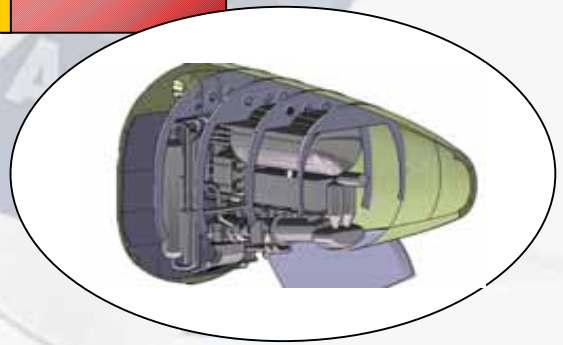
Kerosene

Fuel Cell Power Unit

Step 4

Kerosene

Primary Power Supply



Step 5

?

Alternative Fuels

2007

mid of next decade

end of next decade

20XX

Time

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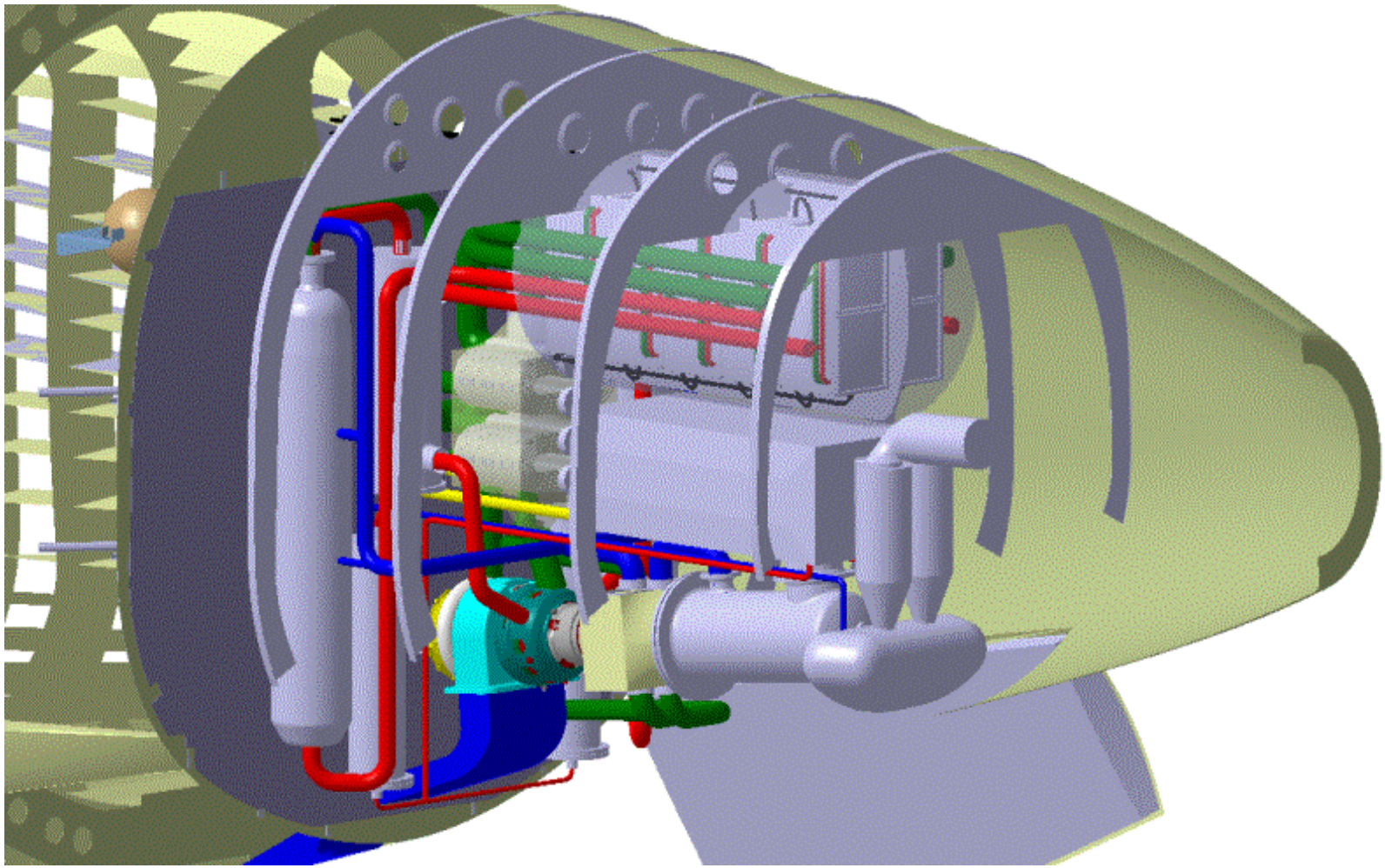
Step 3: Fuel Cell Power Unit

Tail Cone Integration Concept



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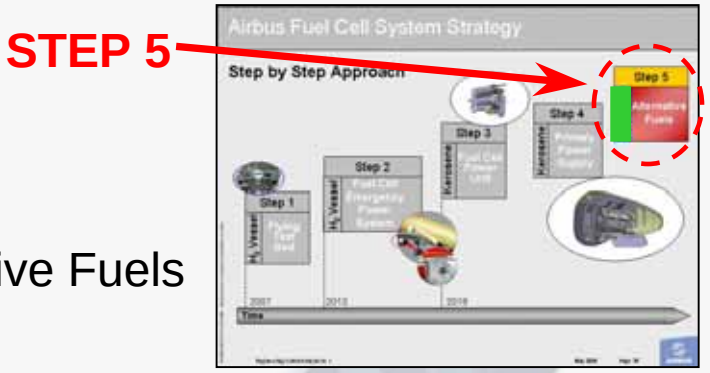
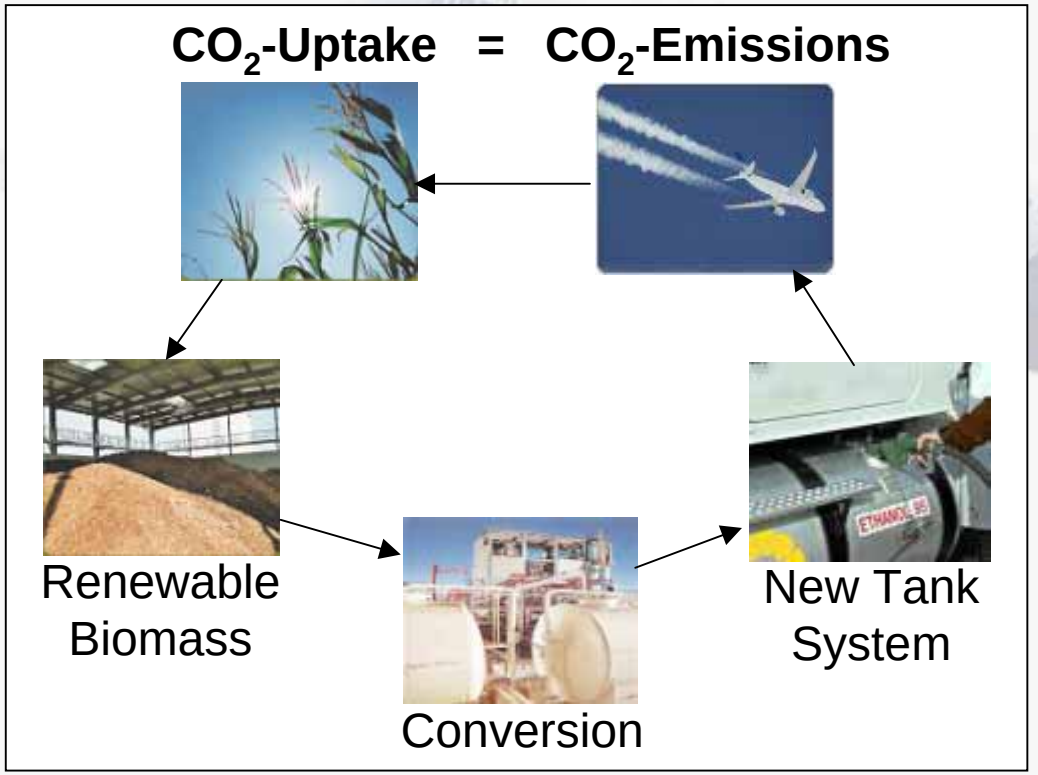
Alternative Fuels

Overview

Target (20XX)

Power Generation by Fuel Cell System with Alternative Fuels





Alternative Fuels:

- Desulfurized Kerosene
- Hydrogen
- Ethanol/Methanol
- Biofuels

New Aircraft Generation

- Hydrogen Fuelled Aircraft
- New Tank System
- Fuel Cell System without Fuel Processing

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Greening of secondary power systems (1/2) ...

... with todays technology we have these options:

- reduced direct consumption of shaft power (electric / hydraulic) due to:
  - **better efficiency** of **consumers**
  - **fewer steps** of **energy conversions**
  - **better efficiency** in **power generation**
- **improved / less / no bleed air usage**
- **reduced system mass**
- **reduced ram air**
- **reduced amount of added drag**

Greening of secondary power systems (2/2) ...

... with tomorrows technology we have these options:

simple but important thought

1. keep system technology principles as is, but **change to a sustainable type of fuel** (e.g. bio fuel or LH2 for engines and/or APU)
2. **change system technology principles** (e.g. fuel cell) but operate with conventional fuel (kerosene)
3. **change both**

=> consumption of secondary power systems can be:

1. sustainable
2. about 20 % less (4 % instead of 5 % from total)

Summary

simple but important thought

- Since all power comes from the aircraft engines, **onboard systems are "green" if the engines are "green"** (e.g. with bio fuel).

- The fuel cell is a new secondary power generator:
  - with high efficiency
  - especially useful if LH2 is already on board for the aircraft engines

- "Greening" secondary power systems may involve:
  - **evolution**: being more efficient in every little detail (accepting related costs)
  - **revolution**: looking for optimized system configurations (less conversions, more electric, new secondary power generators, ...)