The effect of power cycles architectures at hydrogen production plants

First step of analysis

Petr Hájek

Hydrogen Days2014 , Prague. Czech republic, April 2 & 4, 2014

CONTENTS

1 The goal

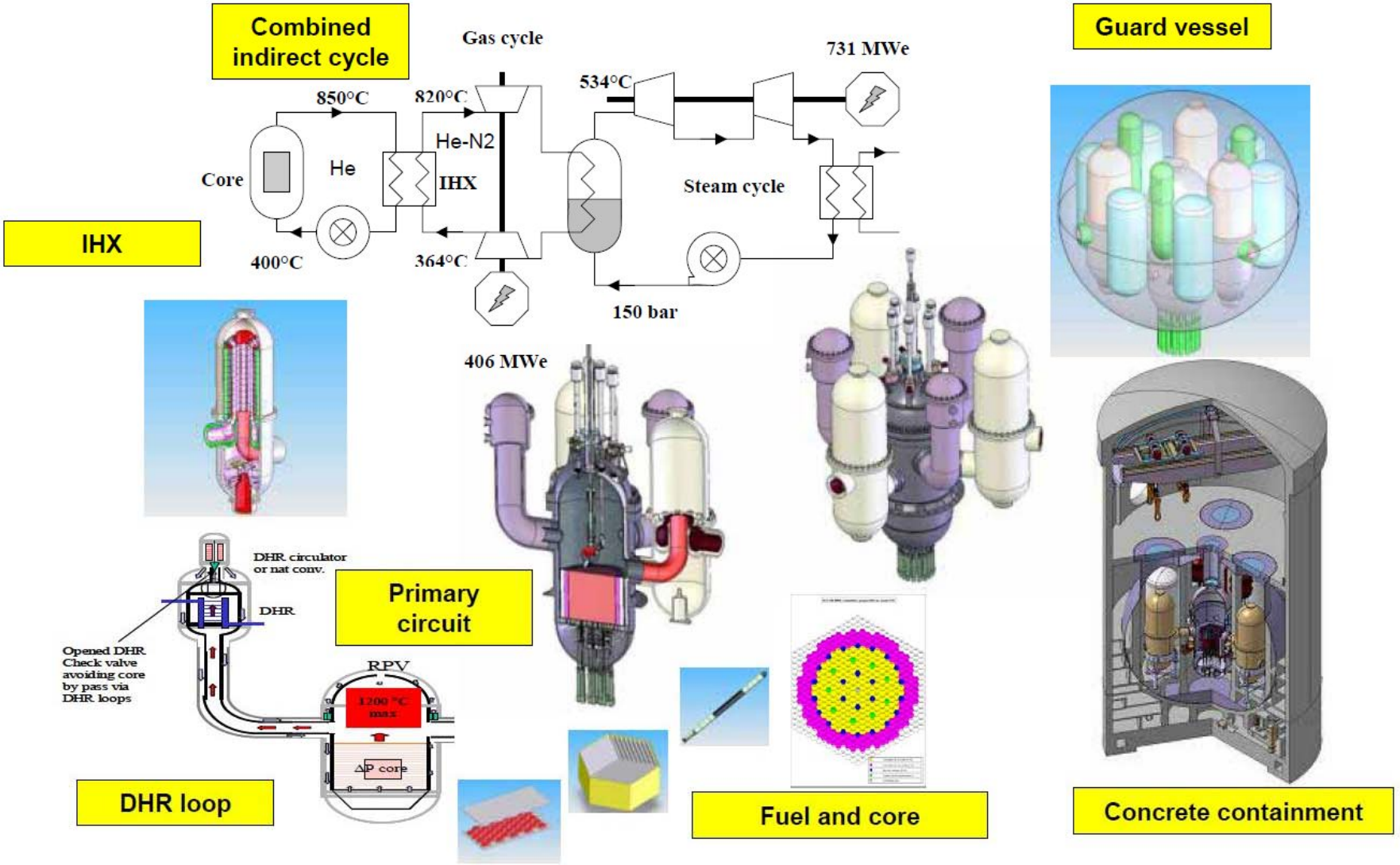
- **The main goal of this informaton is to prepare basis for opprimization of high temperature H2 production in connection with HTR and VHTR.**

- **It is also necessary to find the criteria for optimization .**

- **Short comments about CEA activites at the area of High temperature reactors**

2 Gas Fast Reactors

- **The CEA's 2007 GFR Reference Concept – 2400 MWth Reactor**



2 Gas Fast Reactors

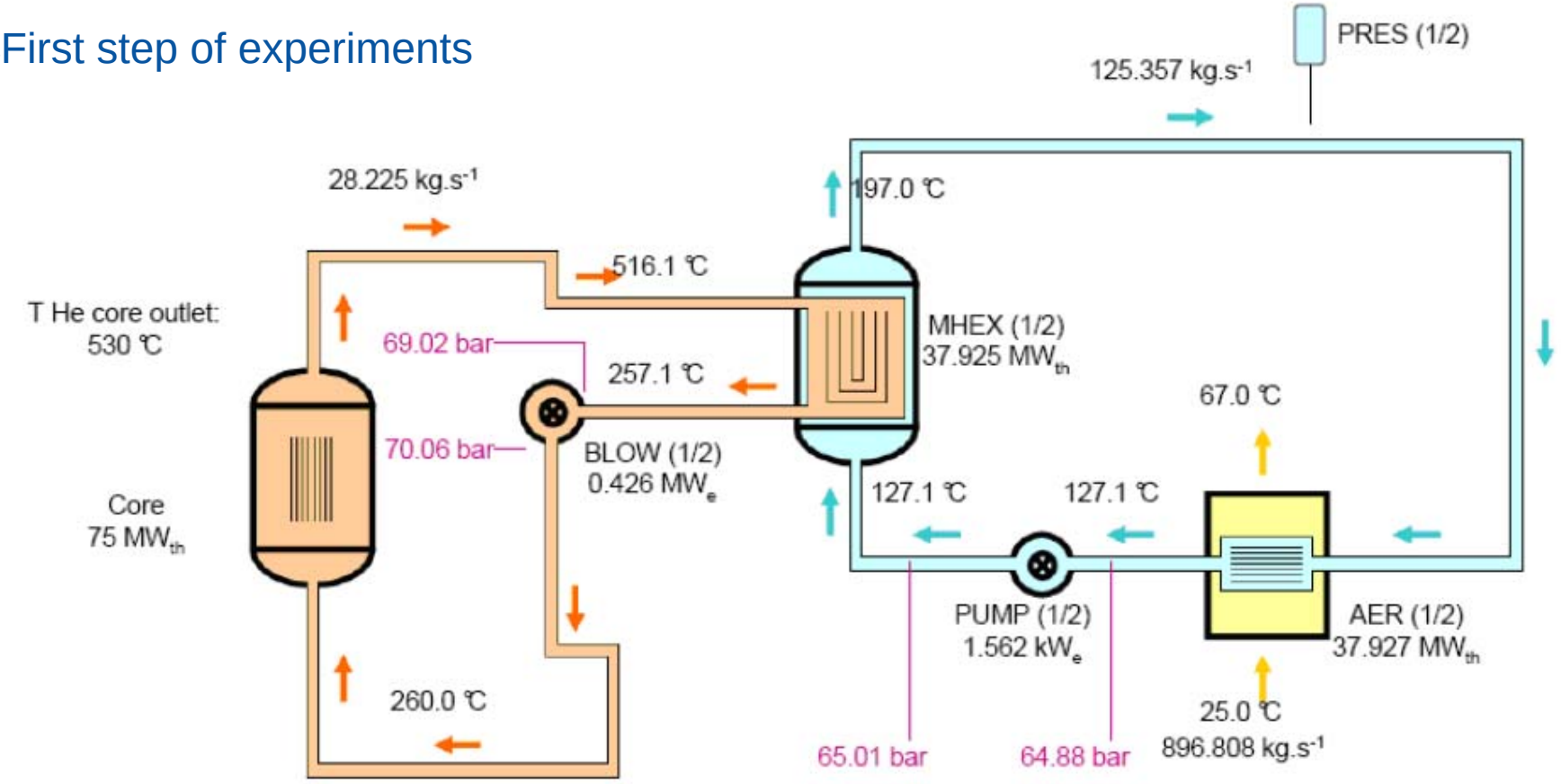
The CEA's 2007 GFR Reference Concept

COMMENTS:

- **Main supposed advantages:**
  - no activated coolant
  - appropriate efficiency more than 40%
- **Main supposed problems:**
  - very high temperatures
  - material problems
- - fuel, fuel manipulation
- - safety
  - He is very bad coolant (in comparison with water, liquids metals)
- **GFR concept has no connection to the hydrogen production**
- **CEA all activities at GFR stopped**

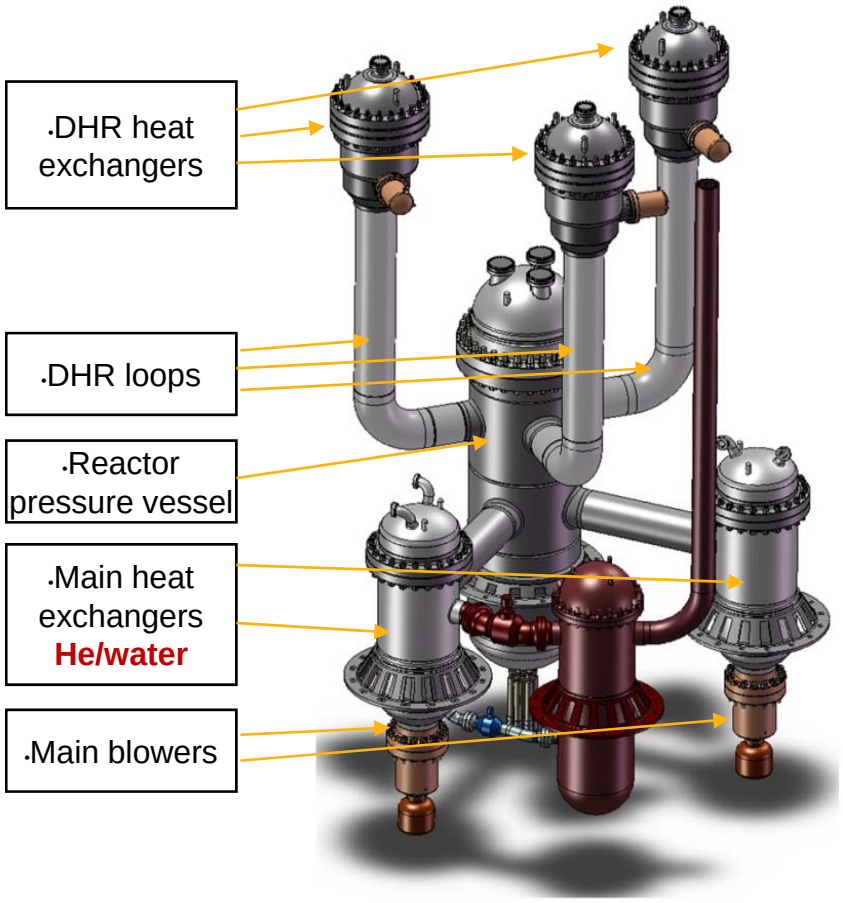
3 Allegro

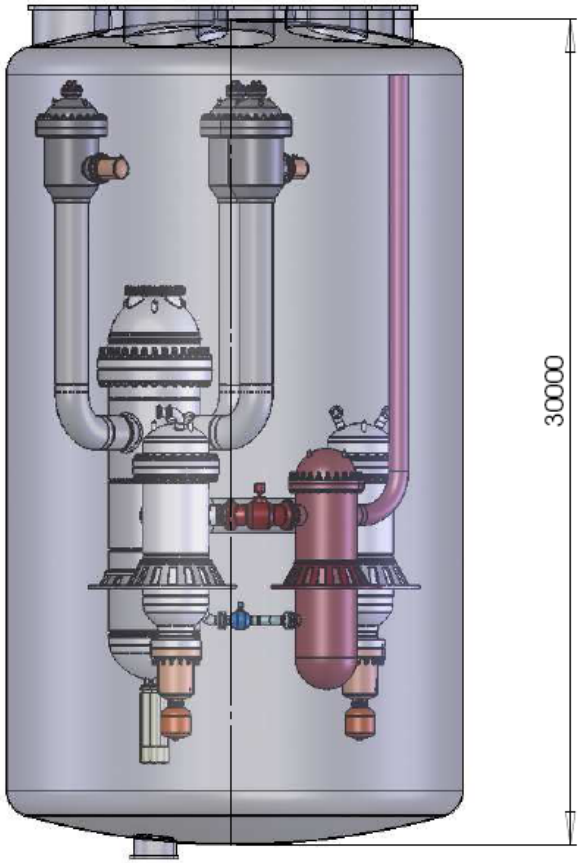
- **The CEA's GFR experimental reactor – 75 MWth Reactor**
- First step of experiments



3 Allegro

·The CEA's GFR experimental reactor – 75 MWth Reactor





3 Allegro

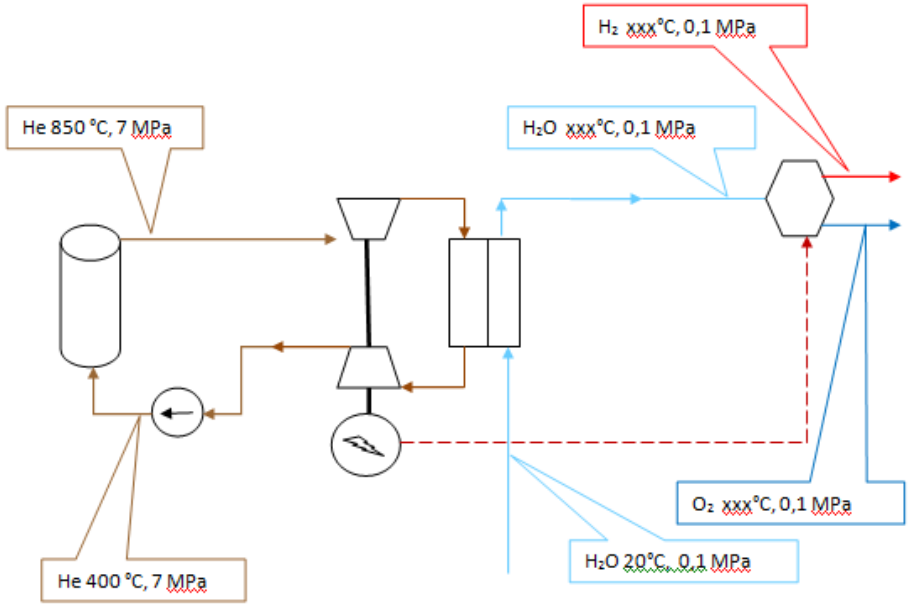
The CEA's GFR experimental reactor – 75 MWth Reactor

COMMENTS:

- **Allegro has no conversion systems**
- **At this project is secondary coolant water**
- **The operation with MOX has no sense for hydrogen production**

4 Conversion cycles

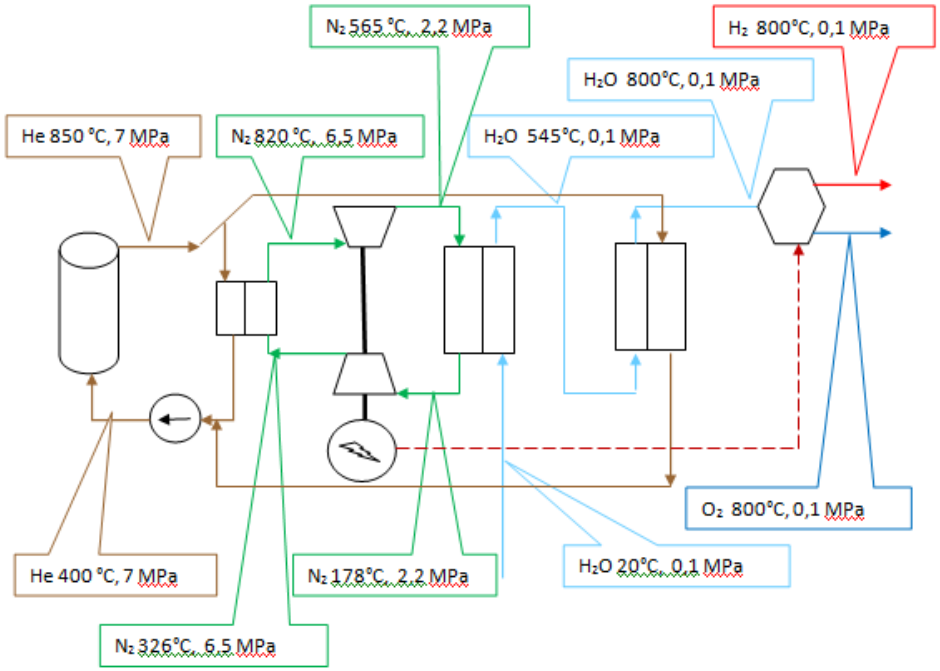
Schema 0



- Direct Brayton cycle, without regeneration
- Not acceptable solution, safety, contamination

4 Conversion cycles

Schema I



- Indirect Brayton cycle, without regeneration
- Realistic and acceptable solution

3 Allegro

H_2O –Hélium (3výměník)-protiproudý

	H_2O	Hélium
G,kg/hod	0,5	0,221
P,MPa	0,101	7
Tin/Tout,C	545/800	850/600
L(délka výměníku),m	~1,042	
Počet trubek	1	9
Průmer trubky,m	0,1	0,004/0,006

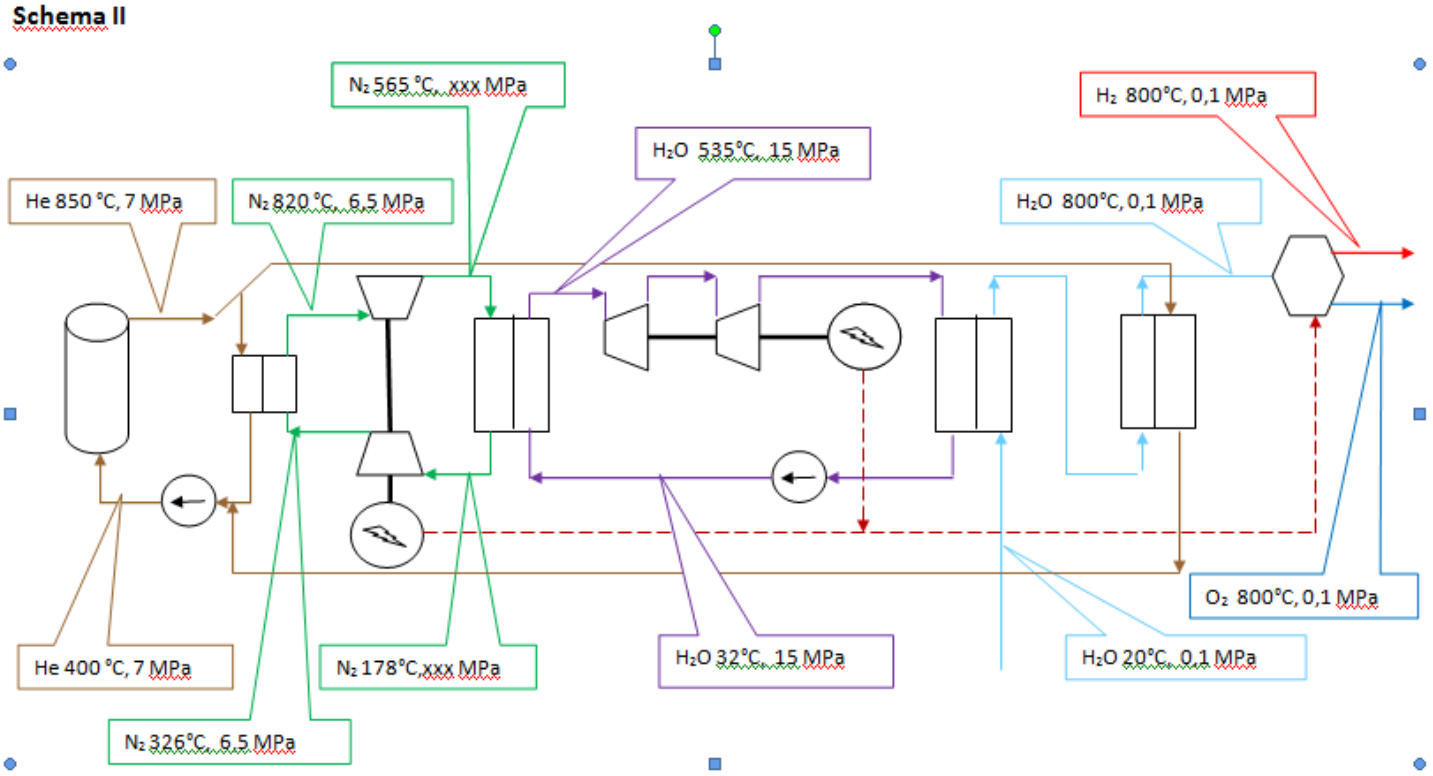
H_2O –Nitrogen (2výměník)-protiproudý

	H_2O	Nitrogen
G,kg/hod	0,5	4,208
P,MPa	0,101	2,2
Tin/Tout,C	20/545	565/178
L,(délka výměníku),m	~1,13	
Počet trubek	1	44
Průměr trubky	0,1	0,004/0,006

Nitrogen – Hélium (1výměník)-protiproudý

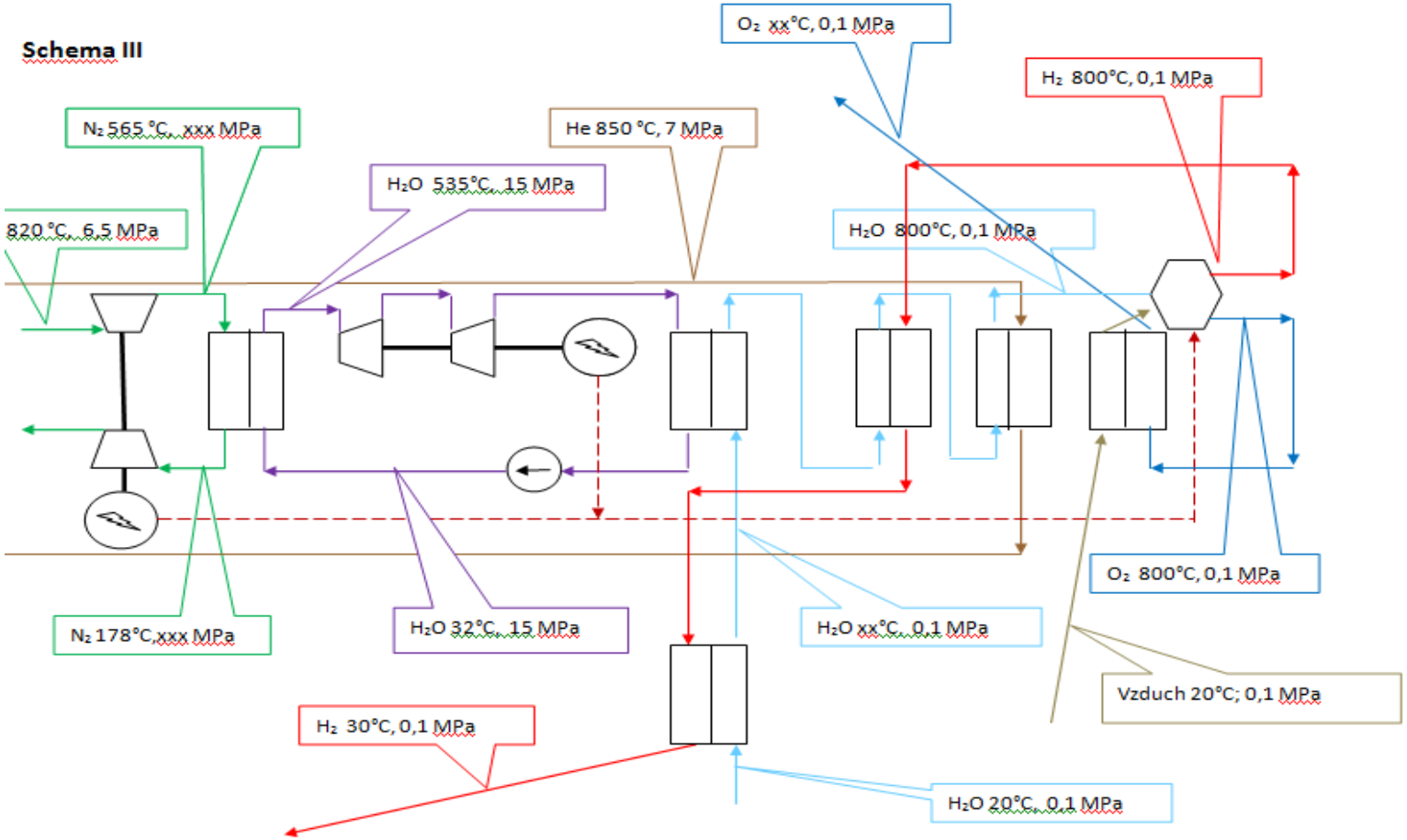
	Nitrogen	Hélium
G,kg/hod	4,208	1,83
P,MPa	6,5	7
Tin/Tout ,C	326/820	850/600
L(délka výměníku),m	~0,92	
Počet trubek	1	12
Průměr trubky	0,1	0,004/0,006

4 Conversion cycles



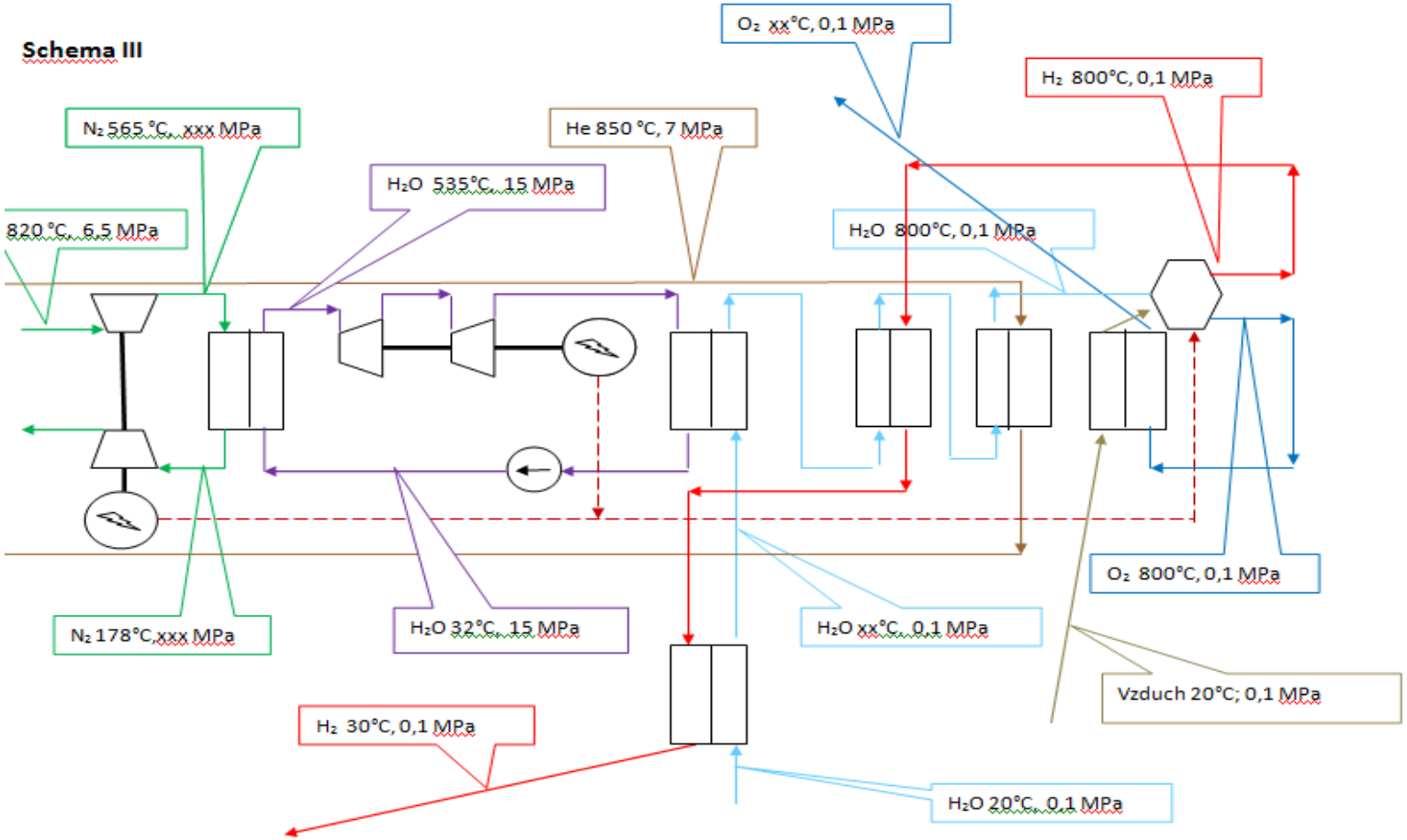
- Combined cycle, without regeneration
- Necessary growth of lower temperature of steam cycle, loss of efficiency

4 Conversion cycles



- Combined cycle, with regeneration
- Necessary growth of lower temperature of steam cycle, loss of efficiency

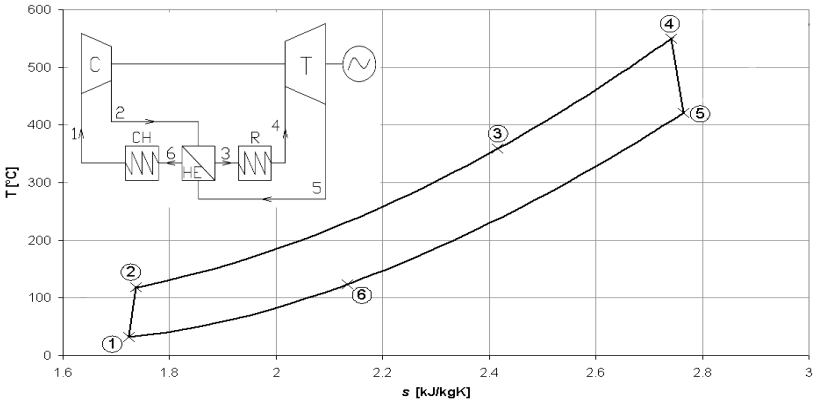
4 Conversion cycles



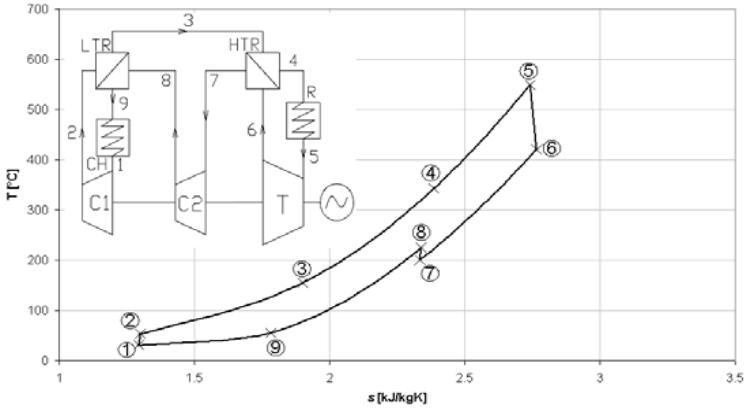
- Combined cycle, with regeneration
- Necessary growth of lower temperature of steam cycle, loss of efficiency

4 Conversion cycles

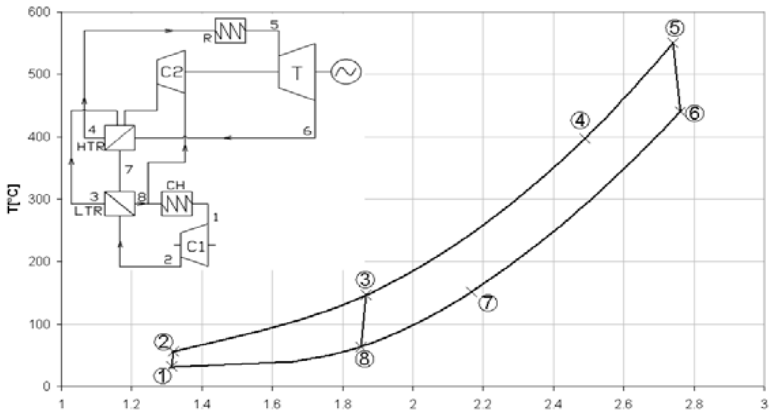
- Simple Brayton (A)



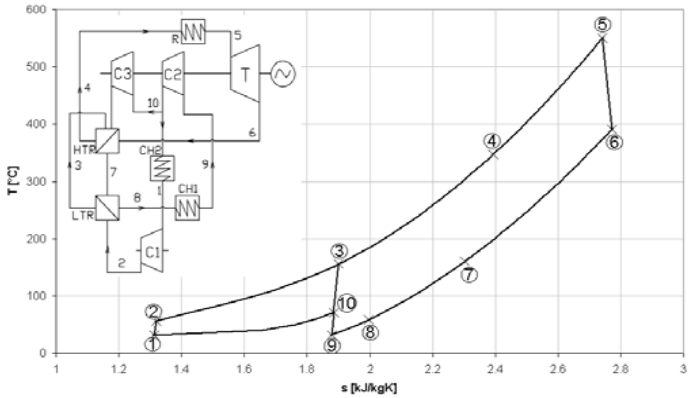
- Pre-compression (B)



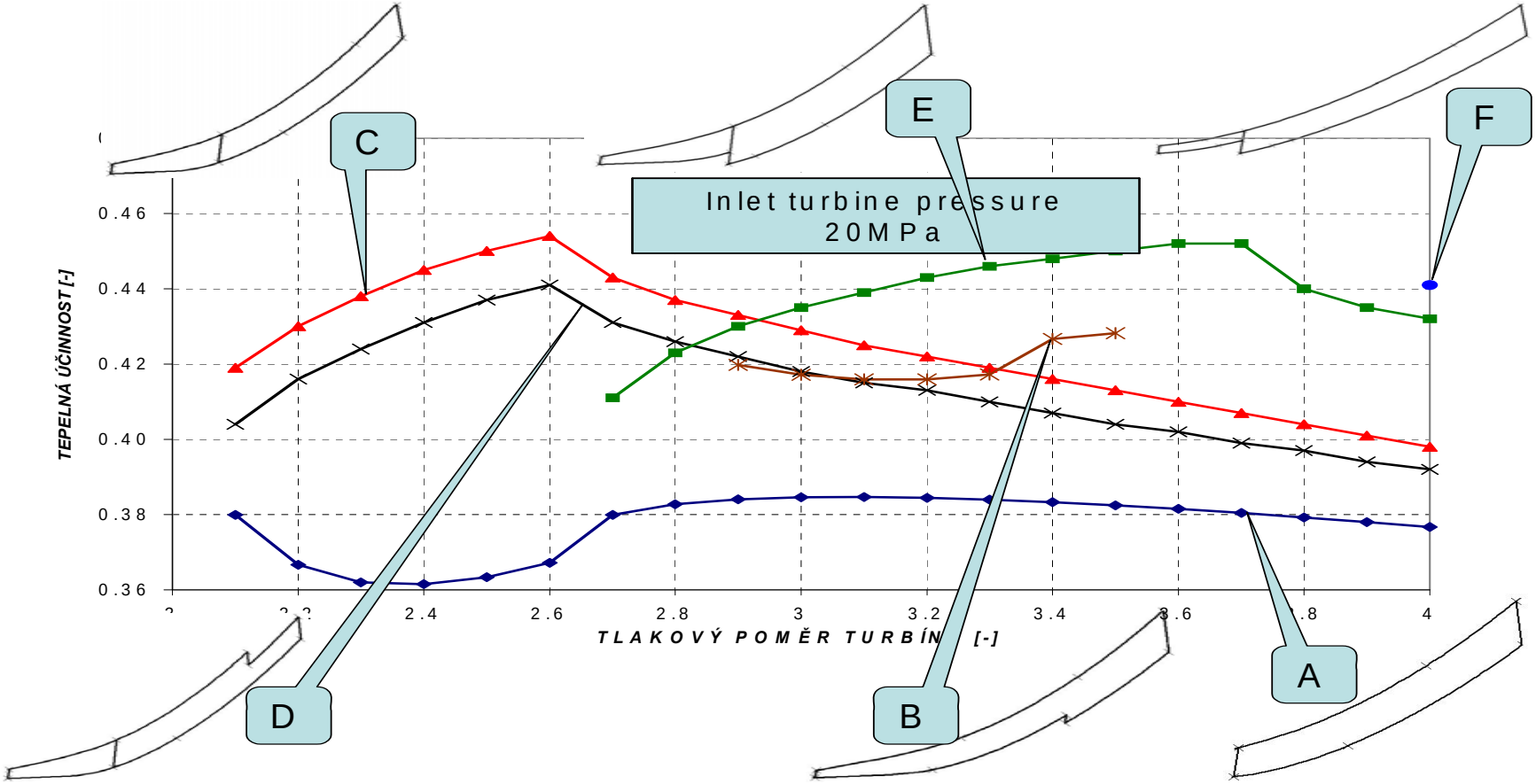
- Re-compression (C)



- Partial Cooling Cycle (E)



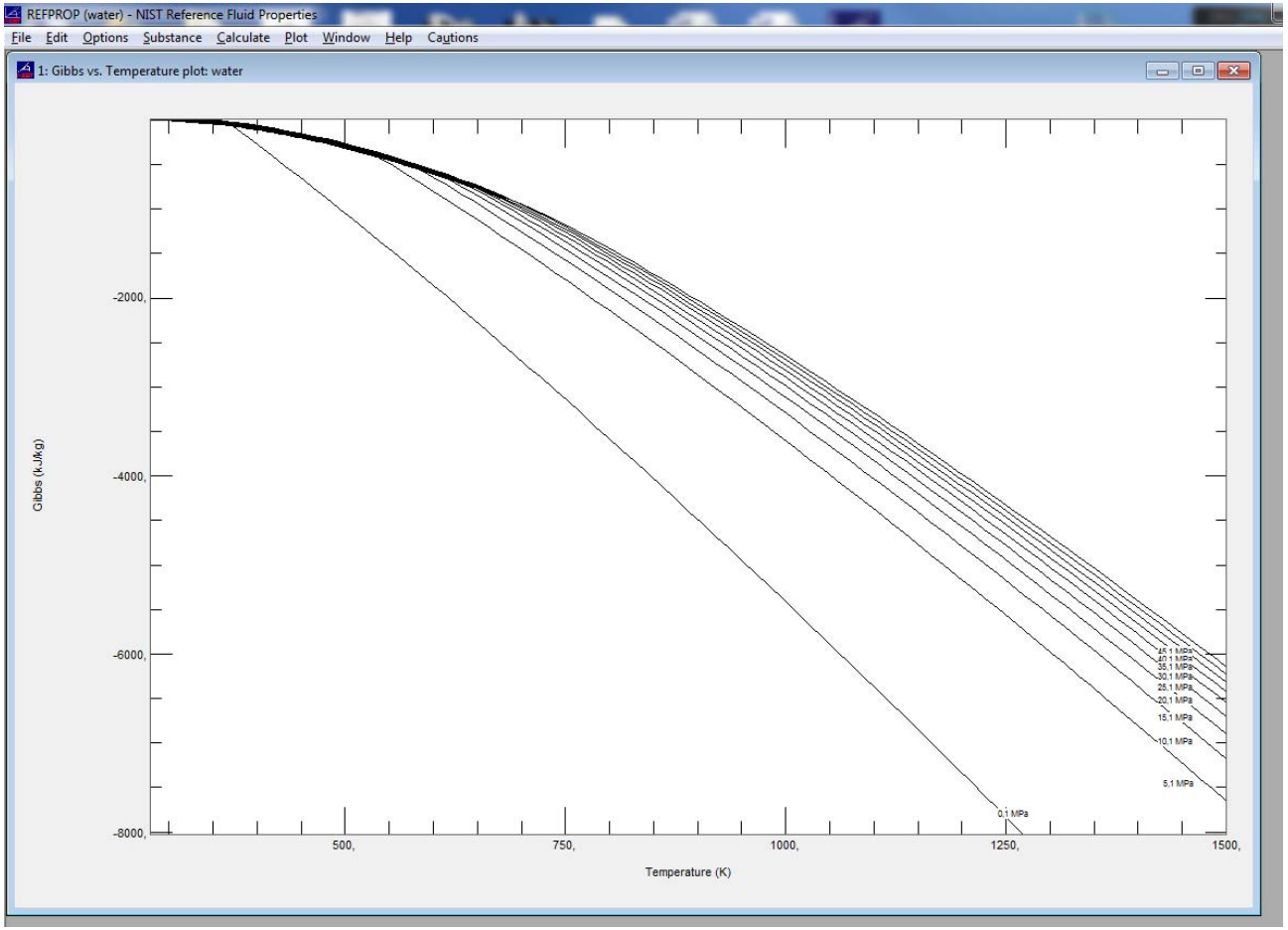
4 Conversion cycles



- Important difference to the steam cycle – no one cooling temperature

5 High temperature electrolysis

- The reduction of electricity consumption is done by Gibs energy



6 Main criteria

- **The input parameters:**
  - **- pressure and mainly temperature of GFR**
- **The output parametrs:**
  - **- pressure and temperature of hydrogen**
- **The internal paramentrs**
  - **-Cycle architecture**
  - **- Used media**
  - **- Paramemers of media (pressure, temperature)**
- **Optimal output – no losses at GFR (no cooling), no additional electric power**

7 Next steps

- The final list of conversion cycles
- The SW connected with NIST
- Results evaluation
- Cycles optimization (for example minimum of HX etc.)

8 Conclusions

- The developement of GFR is today freezed
- The defect connection with H2 production can lead to to new steps in R&Dof GFR
- Suggested GFR architecture (combined cycle) is not ideal for SOEC
- The finalyzing of the architectures optimization is important next steps
- Also the developement of SOEC of great power in importatnt step

Thank you for attention