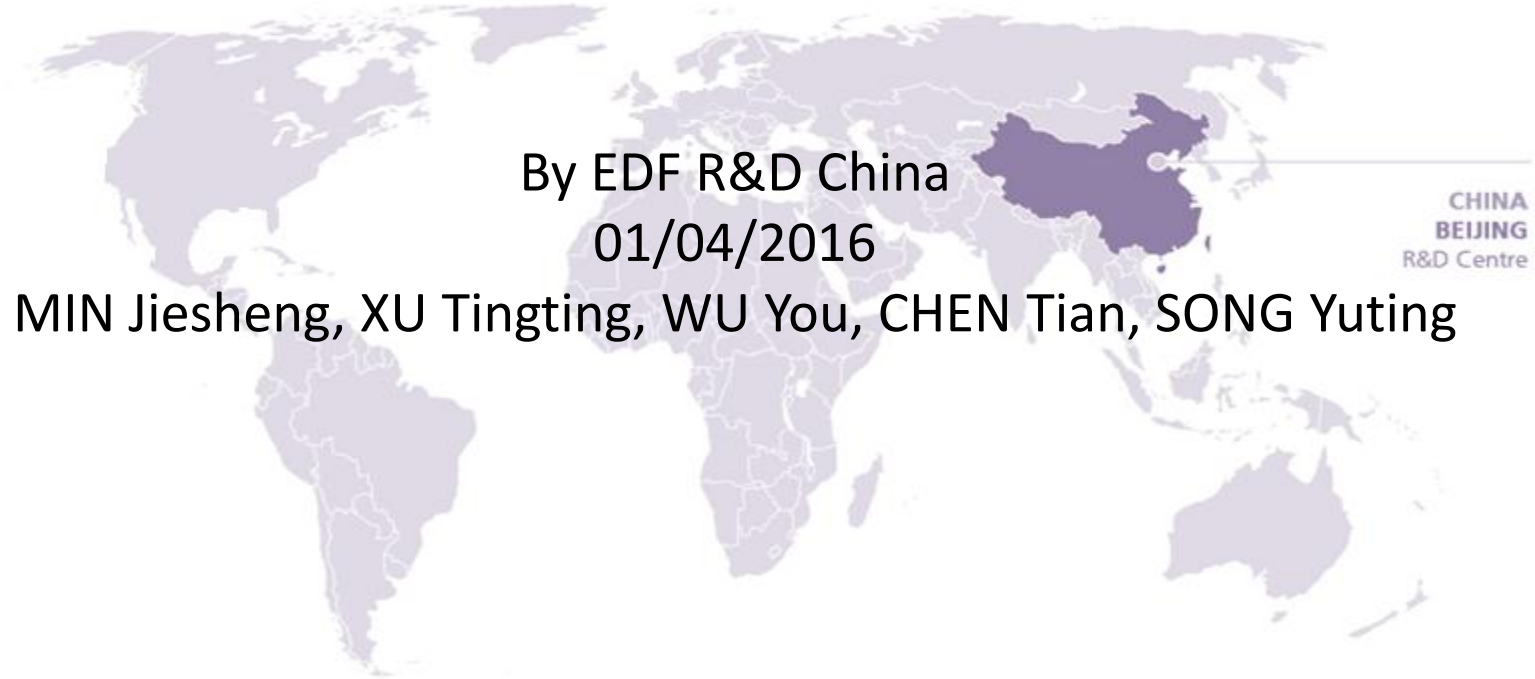
Activity and Partnership around *Code_Saturne* in China



By EDF R&D China

01/04/2016

MIN Jiesheng, XU Tingting, WU You, CHEN Tian, SONG Yuting

Organisation / 组织结构

THE EDF GROUP / 法国电力集团

THE ASIA PACIFIC BRANCH / 法电亚太区

EDF CHINA HOLDING / EDF中国投资公司

EDF R&D / 法国电力集团研究总院

EDF R&D CHINA CENTER / 法电中国研发中心

- POWER GENERATION
- GRID
- SUSTAINABLE CITY
- OPEN INNOVATION

EDF R&D CHINA CENTER
法国电力集团中国研发中心

EDF R&D China Center, created in June 2011 in Beijing, and works jointly with experts located in other EDF R&D centers in France, Germany, UK and Poland.

Our mission

- Strengthen cooperation between EDF and the Chinese scientific and industrial R&D actors in the energy sector
- Provide R&D support to EDF and its partners in China

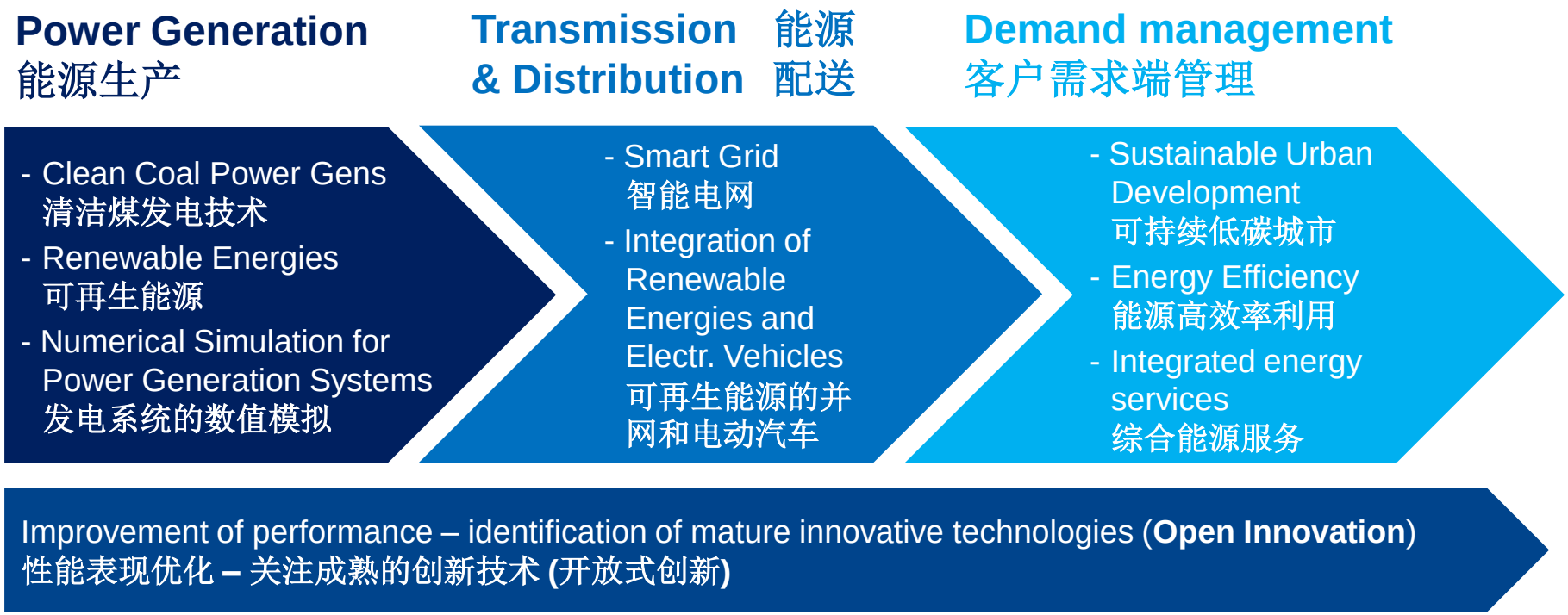
我们的使命

- 加强法国电力集团和中国科技界及工业科研机构在能源领域的合作
- 为集团及集团在中国的合作伙伴提供有强力的技术支持

法国电力集团中国研发中心创立于**2011**年**6**月，隶属于集团研发总部，与集团在法国、德国、英国和波兰的研发中心保持着紧密的合作关系

EDF R&D CHINA CENTER / 法国电力集团中国研发中心

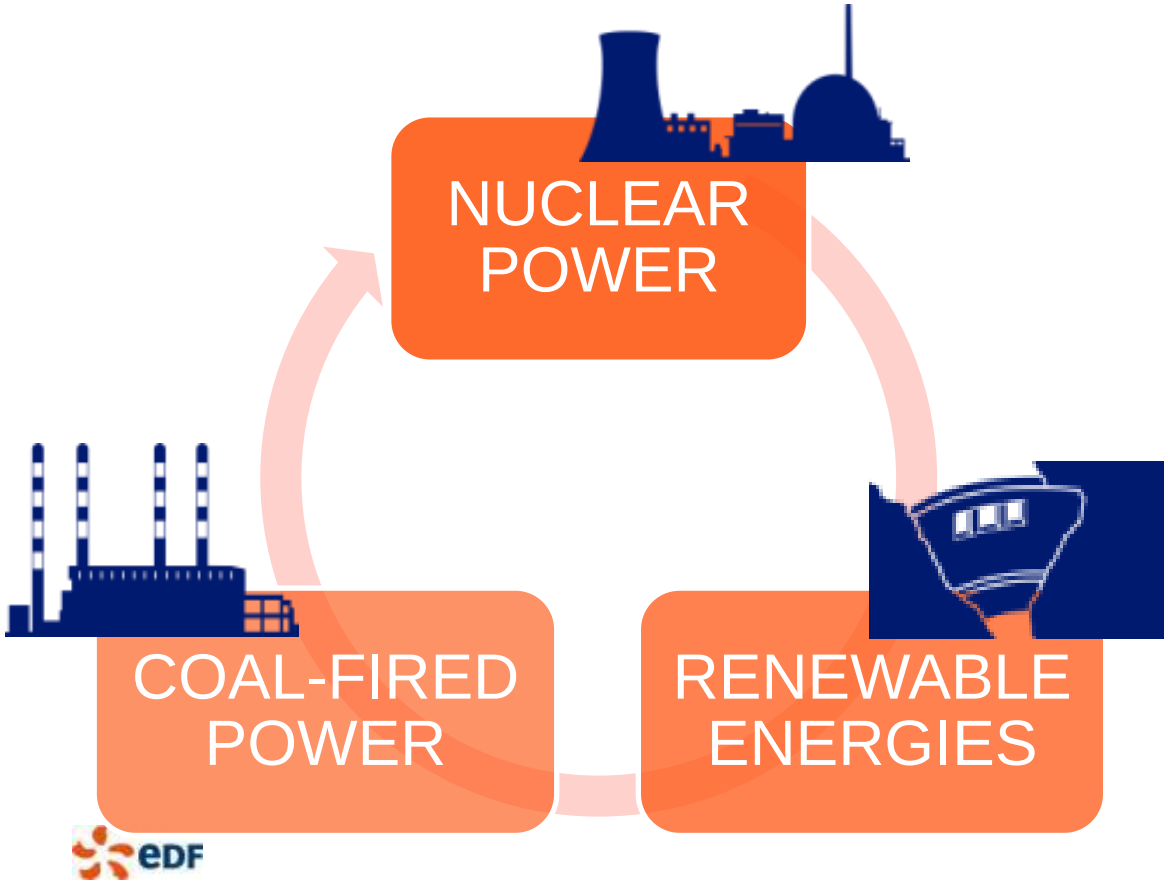
EDF R&D China Center is working on the key topics of EDF R&D
法国电力集团中国研发中心所涉及的研发核心领域



POWER GENERATION / 发电研究室

Taking advantage of EDF expertise as well as its **in-house softwares**, POWER GENERATION team uses **numerical simulation as a tool** to support EDF and its partners activities for Power Generation Systems:

借助于法电的**专业知识背景**及其**自主研发的软件**, 将**数值模拟**作为一种手段来支持法电和其合作伙伴在**发电系统**的业务:



COMPETENCES / 核心能力

- Thermo-Hydraulics
- Process Engineering
- Solid Mechanics
- Hydraulics
- Atmospheric Physics

TOOLS / 工具

- Code Saturne
- aspentech
- Dymola
- MATLAB R2013b
- Code_Aster
- TELEMAC
- POLYPHEMUS Air Quality Modeling System

APPLICATIONS / 应用

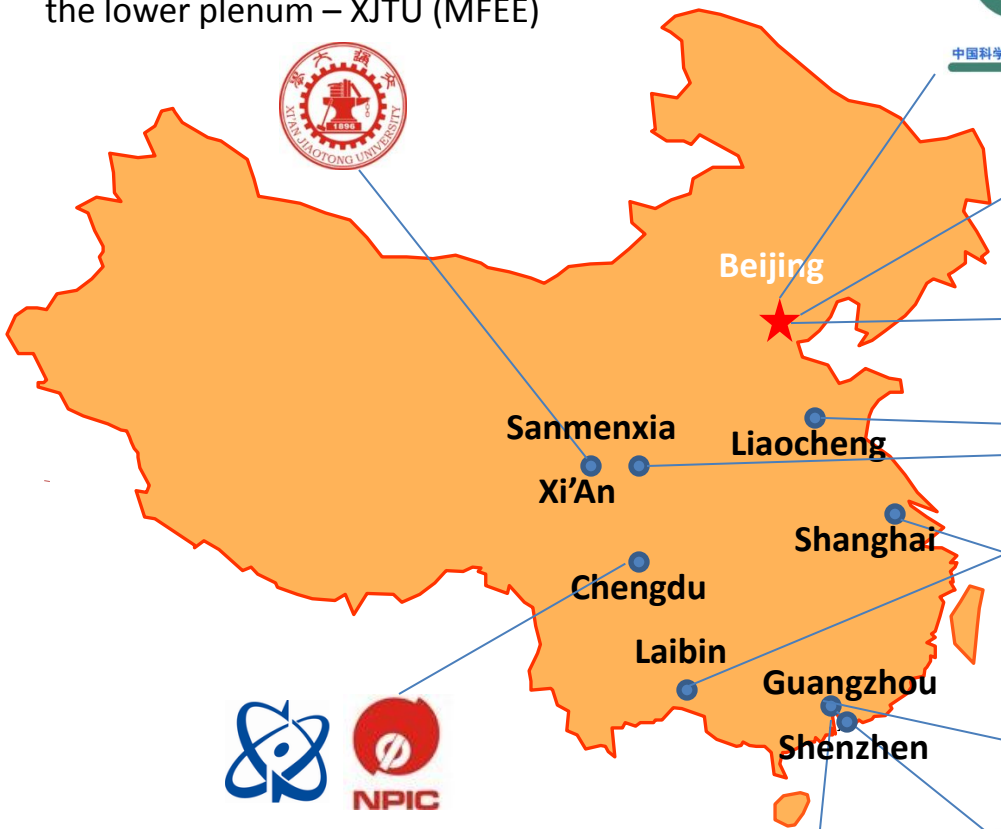
- Coal-fired
- CSP (Solar Tower)
- Nuclear
- Environment

EDF

Overview of *Code_Saturne* activity & partnership in China

[NUC] Flow diffuser optimization for PWR reactor – XJTU (MFEE/SEPTEN)

[NUC] Corium pool behavior inside the lower plenum – XJTU (MFEE)



[EnR] Tube deformation study for Concentrated Solar Power receiver– CAS-IEE (MFEE/MMC)

[NuC] Hydrogen dispersion inside the containment – Tsinghua U. (MFEE)

[HPC] Implementation of Code_Saturne on CAS-CNIC platform – CAS-CNIC (MFEE)

[ThF] Coal combustion optimization – support to EDF assets in China (MFEE)

[NuC] ALISA project / In-Vessel-Retention strategy – SJTU (MFEE)

[HPC] Implementation of Code_Saturne on Tianhe-2 platform – NSCC-GZ (MFEE)

[NuC] Steam dispersion and condensation inside the containment – CGN/IFCEN (MFEE)

[NuC] Reactor vessel flow simulation & experiment – NPIC/CNNC (MFEE)

[NuC] Severe accident activity ***Windows version*** – CNPRI (MFEE)

[ThF]_Coal combustion optimization for EDF local assets support

Context & Objective:

Blend coal combustion is largely used for Chinese coal-fired plant due to its cost reduction, which induces combustion efficiency degradation. Under such context, technical supports to EDF local thermal assets help to identify solutions to improve plant performance via combustion optimization.

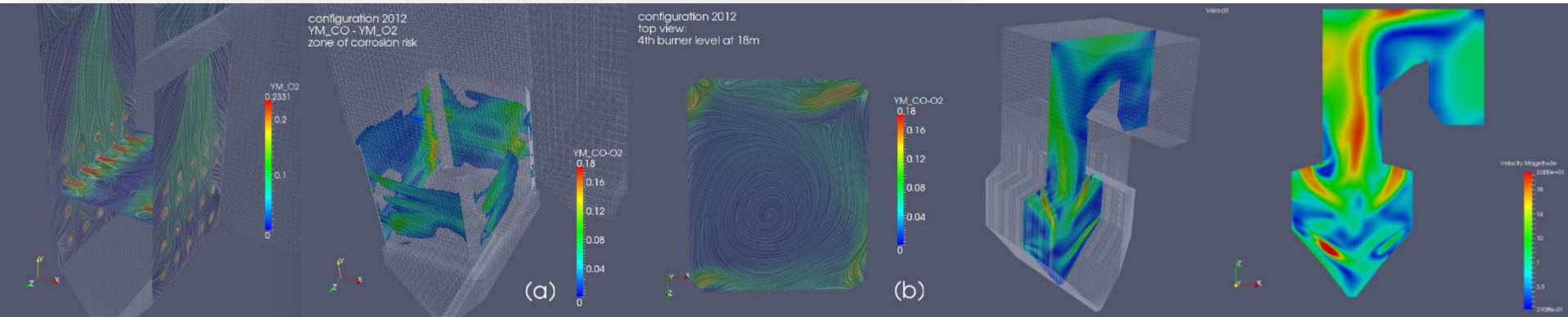
Project:

- ❑ Combustion optimization & high temperature corrosion – **Laibin B plant**
- ❑ Blend coal combustion optimization for 600 MW supercritical boiler – **Sanmenxia plant**
- ❑ Combustion optimization for 600 MW W-flame boiler – **Liaocheng plant**

Interest & outcome:

- ❑ Better understanding of coal combustion process inside the boiler;
- ❑ Identify potential improvement solutions to achieve low NO_x emission, less high-temperature corrosion and limited combustion efficiency degradation.

Sanmenxia – 600MW **Laibin B – 300MW** **Liaocheng – 600MW**



[EnR]_Tube deformation study for CSP receiver

Context & Objective:

Molten salt (MS) tube cold filling : Determine the thermal hydraulic behavior of molten salt during the receiver tube cold filling procedure: tube heating, crystallization, MS movement. Determine evolution of the temperature and flux density distribution on the receiver tubes under typical and extreme external scenarios: full sun radiation, half part cloud and full cloud. The creep deformation and the thermal fatigue behavior of a heat exchanger tube

Project:

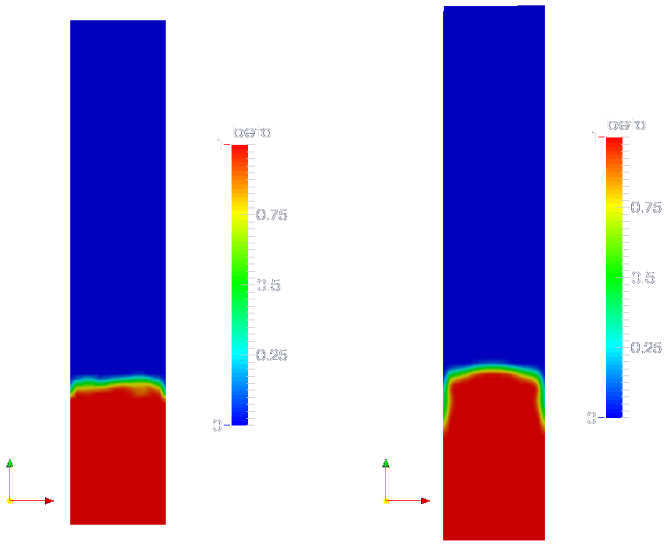
❑ Tube deformation study for CSP receiver – CAS-IEE

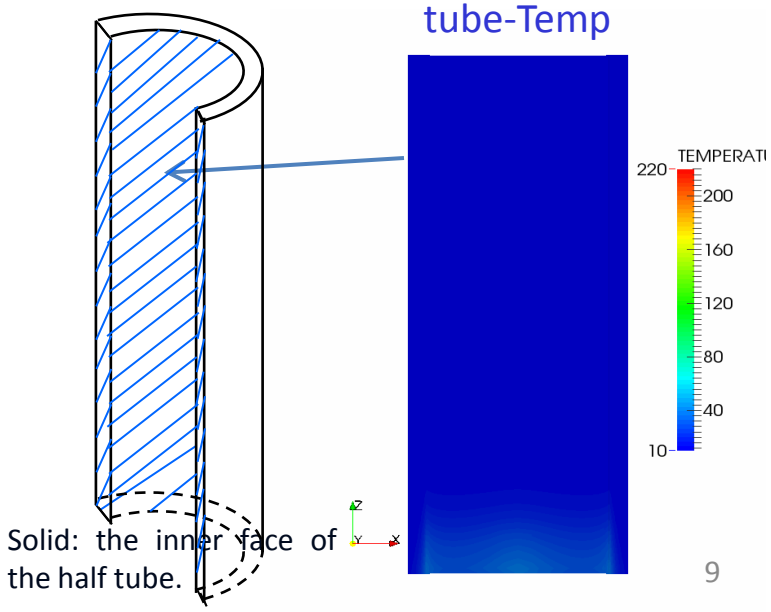
Interest & outcome:

❑ Understand the thermal hydraulic behavior of molten salt indicating MS solidification and blockage in the tubes

❑ Identifying the key input parameters to impact the MS penetration length

❑ Summarizing the conditions to succeed the cold filling



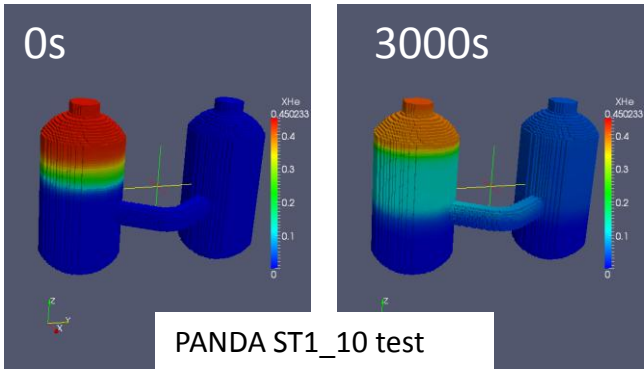


Solid: the inner face of the half tube.

[NUC]_Hydrogen dispersion inside the containment

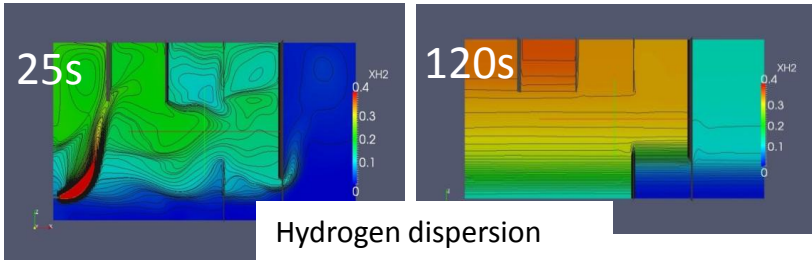
Context & Objective:

In the severe accident, abundant of Hydrogen could be generated via the cladding reaction. 11% Hydrogen will cause explosion in steam (4% in the air). For safety issue, in order to avoid deflagration caused by gas mix of hydrogen, its features during gas mixing in containment are needed be accurate.



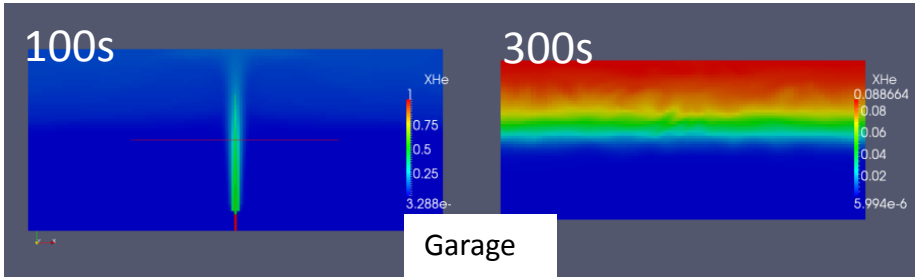
Project:

❑ Hydrogen dispersion inside containment – Tsinghua U.



Interest & outcome:

❑ Validation of new algorithm (Low-Mach Number) in different hydrogen mixing simulation for Code_Saturne

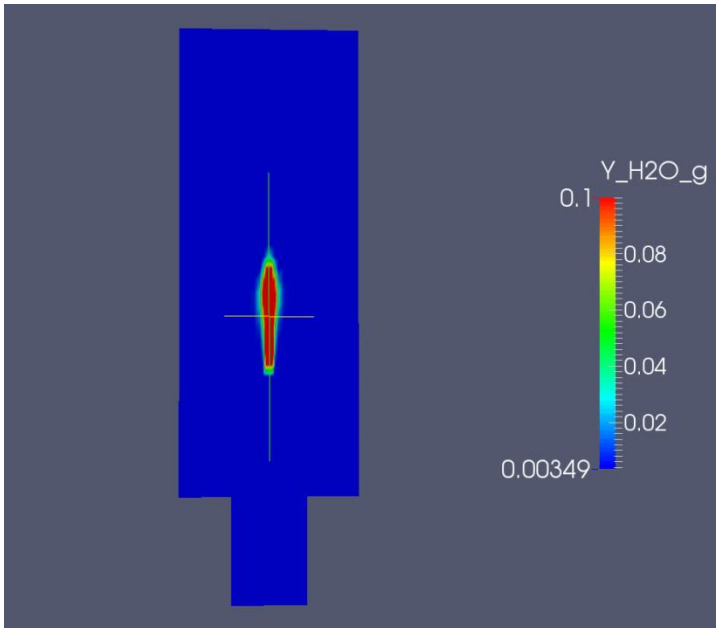


[NUC]_Steam dispersion and condensation inside the containment

Context & Objective:

Follow-up for previous study, in severe accident, the main safety issues are:
To be able to cool the reactor to avoid any breach of the reactor pressure vessel; to avoid uncontrolled pressure build-up in the containment by steam.

Existing models will be validated by benchmark test cases (used by the CFD community); and validated by measurement data provided by CGN via COTHYD test facility.



Project:

❑ Steam dispersion and condensation inside the containment – CGN/IFCEN

- Simulation of the steam dispersion in the containment
- Simulation of the steam condensation
- Simulation of spray effect on steam

Interest & outcome:

❑ Improvement and validation of the condensation model;
❑ Development of the spray model in *Code_Saturne*.
❑ To develop and validate models able to simulate such severe accident conditions in order to assess and improve the NPP safety:

[NUC]_Flow diffuser optimization for PWR reactor

Context & Objective:

To study **thermal-hydraulics** behavior into the vessel lower plenum representing a 4-loop PWR reactor. **The aim** of this study is, by means of **CFD** calculation, to identify the **optimal design for the Flow Diffuser (FD)** based on **flow-rate distribution** at the reactor core inlet where fuel assemblies are located.

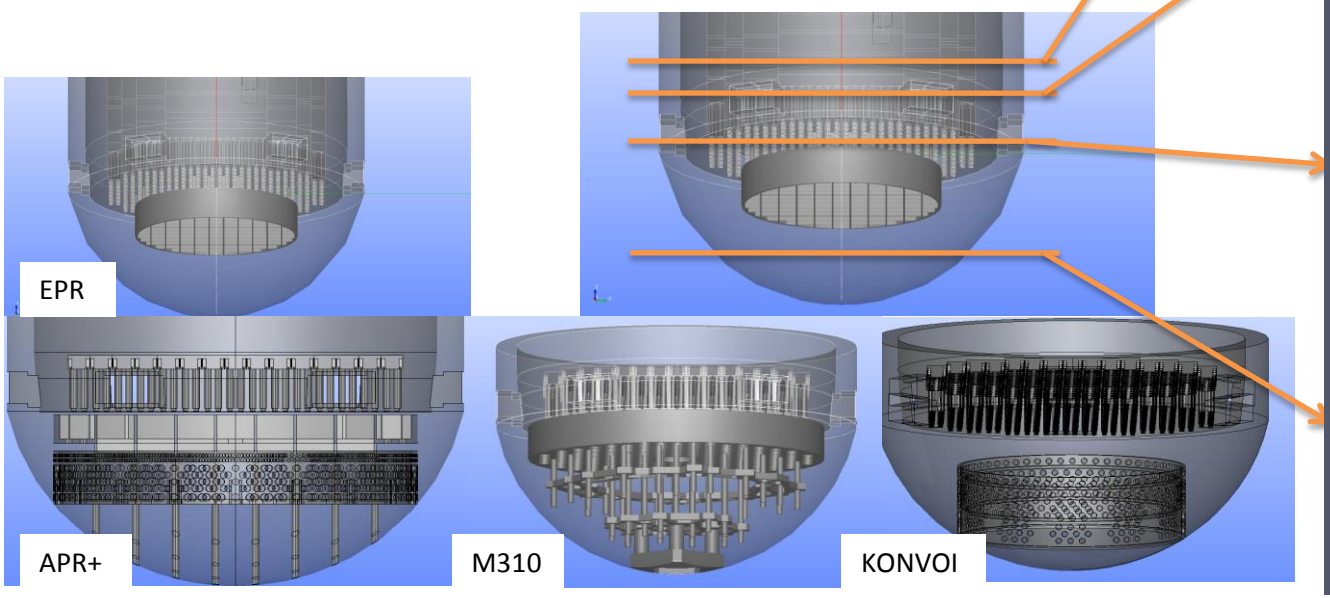
Project:

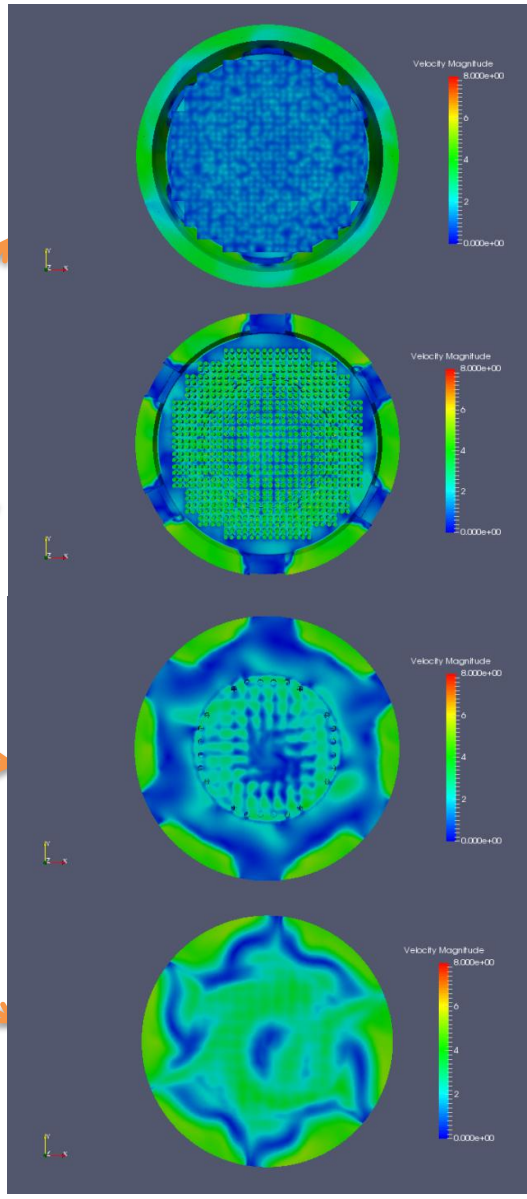
❑ Flow diffuser optimization for PWR reactor – XiAn Jiaotong U.

Interest & outcome:

❑ Providing guidance to EDF group in terms of new reactor design for flow diffuser located in the vessel lower plenum.

❑ Establishment of a reference High Performance Computing calculation with EDF in-house *Code_Saturne* in nuclear field.





[TI]_High Performance Computing

Context & Objective:

NSCC-GZ and CNIC act as **the hardware provider** and EDF provides **wide channels**, the strength of technical proficiency, professional support for an industrially-proved, open-source, HPC-based software.

Project:

❑ Feedback of intensive calculation with *Code_Saturne* on Chinese HPC platforms (CAS-CNIC and NSCC-GZ) equipped with accelerator xeon-phi

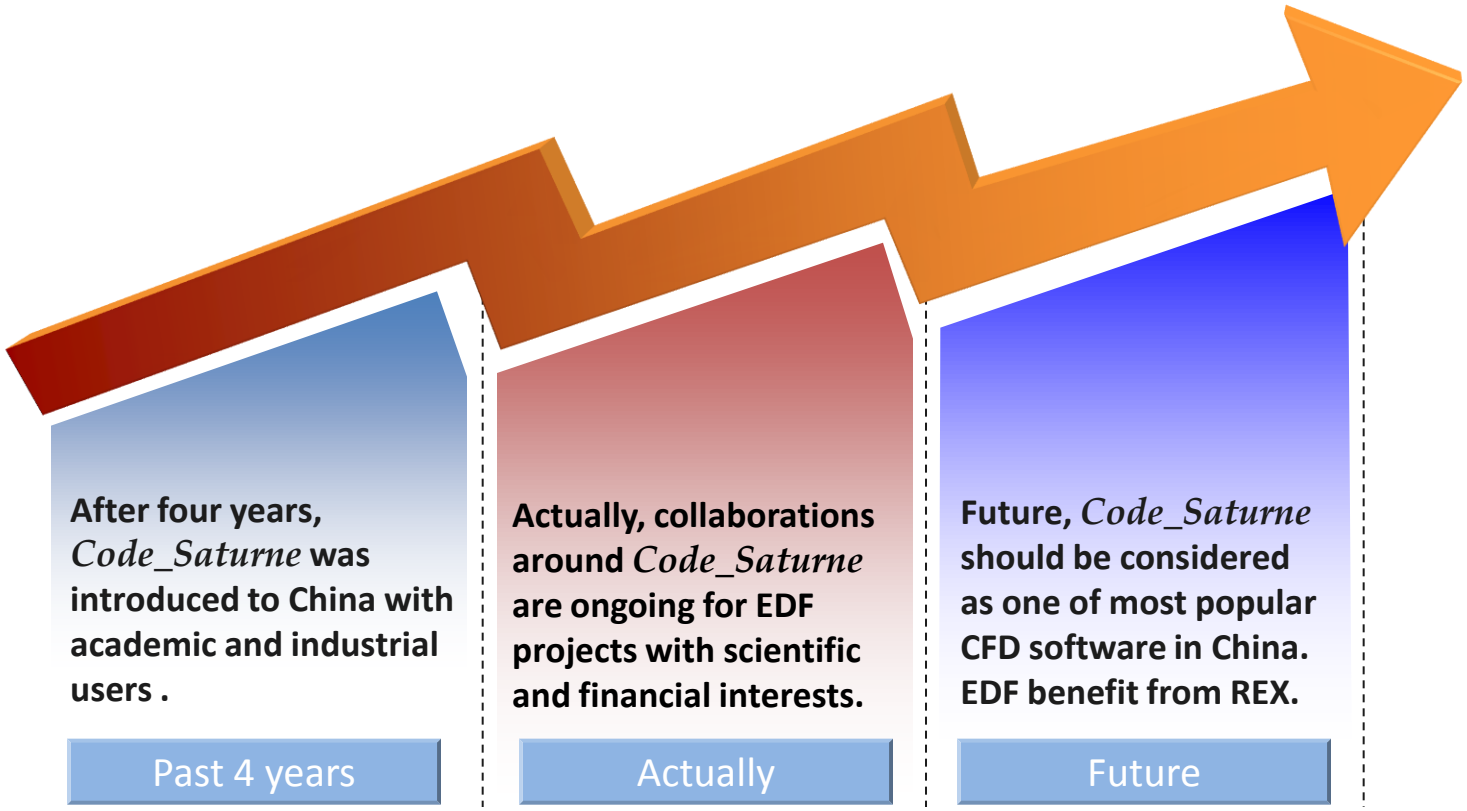
Interest & outcome:

❑ Vigorously promote Code Saturne HPC-based characteristic compared to commercial software (industrially-proved, open-source, HPC-based)

NSCC-GZ Tianhe II

CNIC “Era”

Conclusion and Perspectives



THE END

Contact:
WU You you.wu@edf.fr
MIN Jiesheng jiesheng.min@edf.fr

Thanks for your attention