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Joint ICTP-IAEA Course on Science and Technology of Supercritical Water Cooled Reactors

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OVERVIEW OF ON-GOING RESEARCH AND DEVELOPMENT (R&D) PROGRAMS

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(SC27) Overview of On-going Research and Development (R&D) Programs

Joint ICTP-IAEA Course on Science and Technology of SCWRs, Trieste, Italy, 27 June - 1 July 2011

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Objectives

Objectives of this Lecture are to:

- Identify necessities for R&D of SCWR and its major areas;
- Review On-going R&D activities undertaken worldwide; and
- Unveil opportunities for R&D.

Differences between SCWR and Conventional WCRs

- The SCWR is an innovative WCR based on the technologies of conventional WCRs and SC fossil-fired power plants.
- The major difference is the normal operating pressure and coolant and fuel cladding temperature ranges, i.e. limited to the reactor and the relevant systems.
- For the balance of plant (BOP), SC fossil-fired power plant technologies can be applied except radioactivity included in main steam.

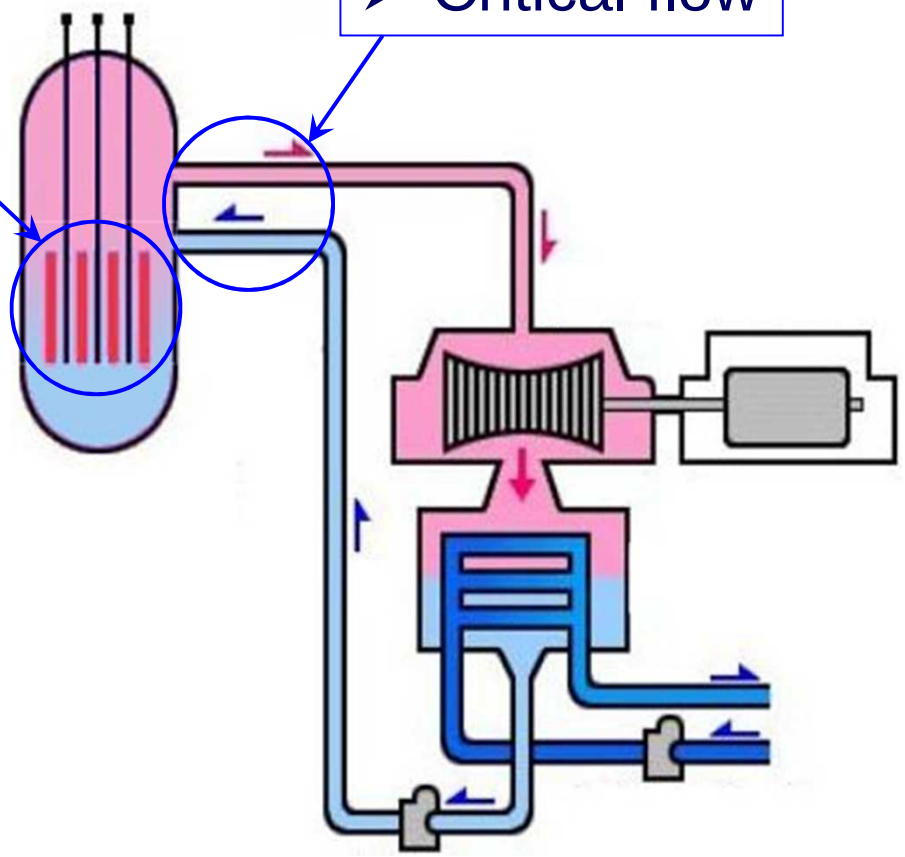
Necessities of R&D for SCWR

- The necessities of R&D arises mainly from the differences of the reactor systems:
  - Supercritical pressure water as coolant.
    - ⇨ Thermal-hydraulics of SCP water in bundle
    - ⇨ Water chemistry
  - High pressure/temperature in the core.
    - ⇨ Materials
  - Rector system
    - ⇨ Design of the plant total system
- No significant R&D will be necessary for BOP.

R&D Areas of SCWR
- Thermal-hydraulics -

- Heat transfer to SCW, especially in fuel bundles
- Pressure drop in fuel bundle
- Flow stability

- Critical flow



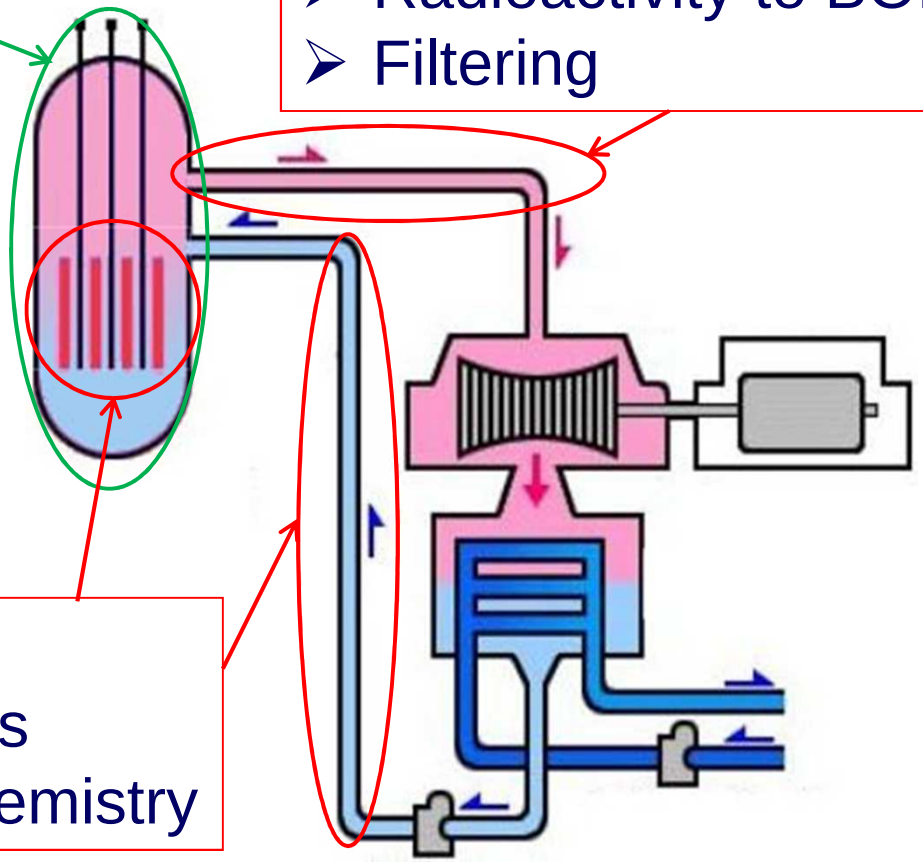
R&D Areas of SCWR
- Materials and Chemistry -

Materials
- Fuel cladding
- Thermal insulator
- Structure/Internals

Interaction of Materials and Chemistry
- Corrosion
- SCC

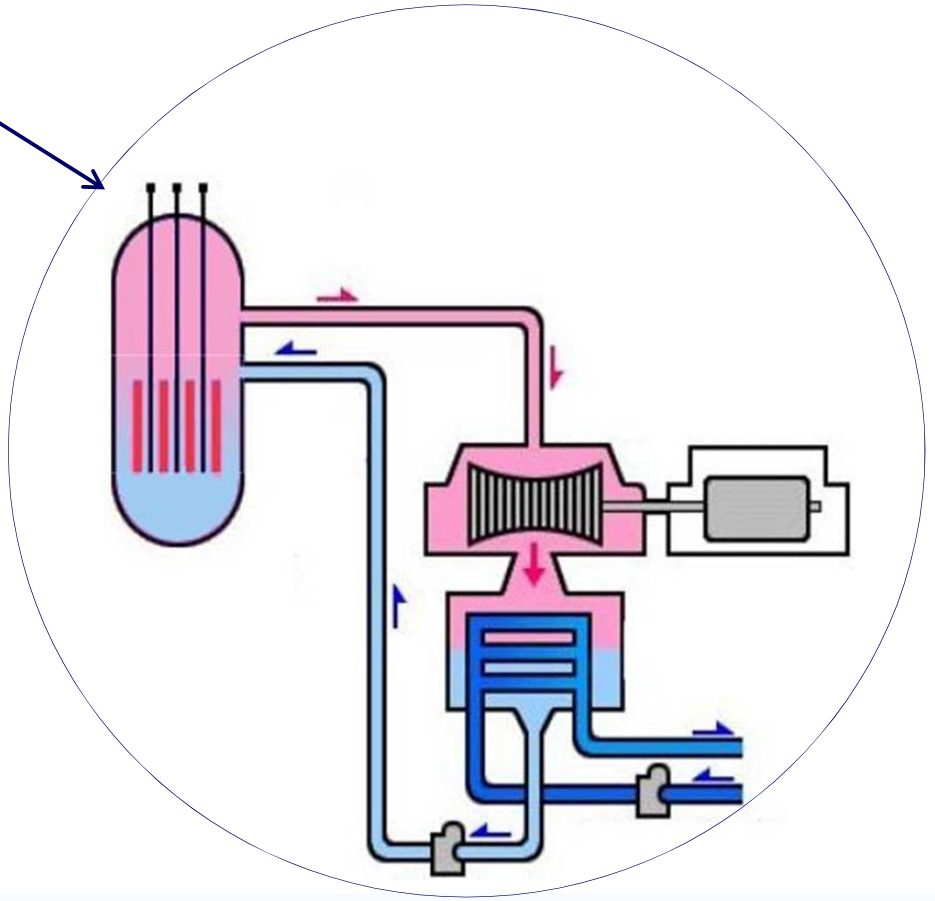
Chemistry
- Radioactivity to BOP
- Filtering

Chemistry
- Radiolysis
- Water chemistry



R&D Areas of SCWR
- Design -

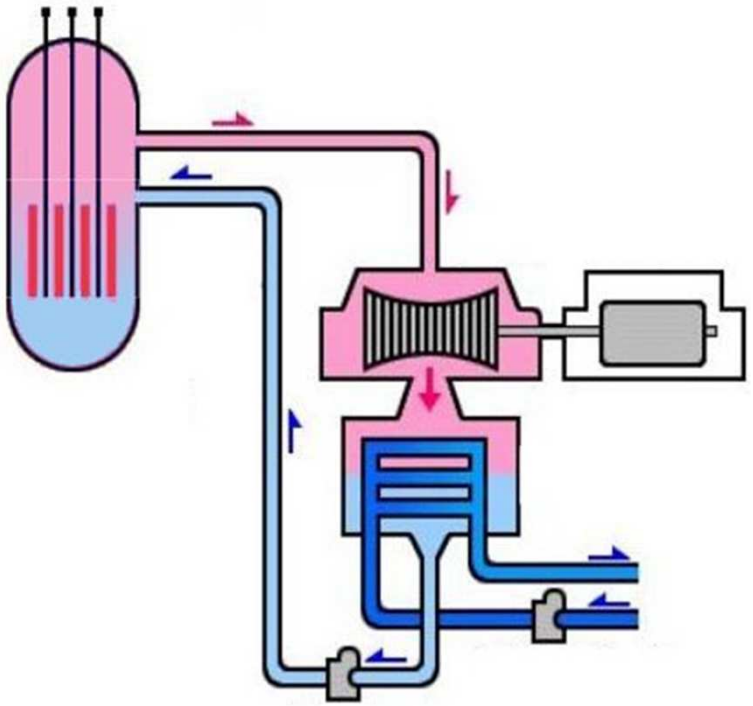
Design
- Optimal integration of systems
- Materials requirements and selection
- Safety system
- Startup system



R&D Areas of SCWR
- Other Areas -

Regulation
- Safety standard and guidelines
- Materials code

Application
- Hydrogen production
- Desalination

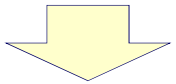


On-going R&D activities on SCWRs

- GIF (Generation-IV International Forum) has selected SCWR as one of Generation IV Nuclear Energy Systems:
  - Canada, EURATOM, and Japan are Members of System Steering Committee of SCWR;
  - They have started collaborative R&D on Thermal-hydraulics &Safety and Materials&Chemistry; and
  - They have had several Information Exchange Meetings for SCWR community including researchers from other countries.
- International Symposium on SCWRs (ISSCWR) has been held every 2 years.

International Symposium on SCWRs

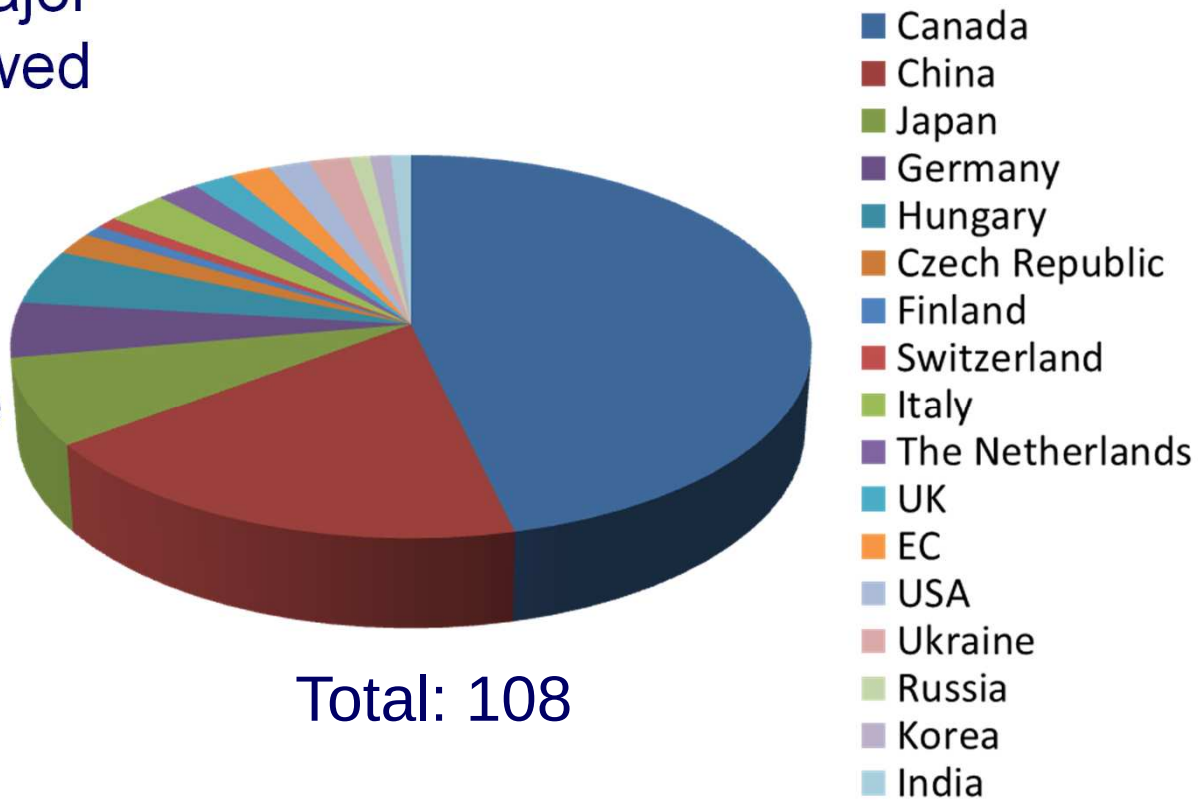
- The purposes of ISSCWR are:
  - provide a forum for discussion of advancements and issues;
  - sharing information and technology transfer; and
  - establishing future collaborations on research and developments for SCWRs between international research organizations.
- The 5th ISSCWR (ISSCWR-5) was held in Vancouver, Canada, March 13-16, 2011, hosted by Canadian Nuclear Society (CNS).
  - 108 papers were presented and discussed on various aspects of SCWR design and R&D.



The most recent R&D activities in the world

Number of Papers by Leading Country/International Organization

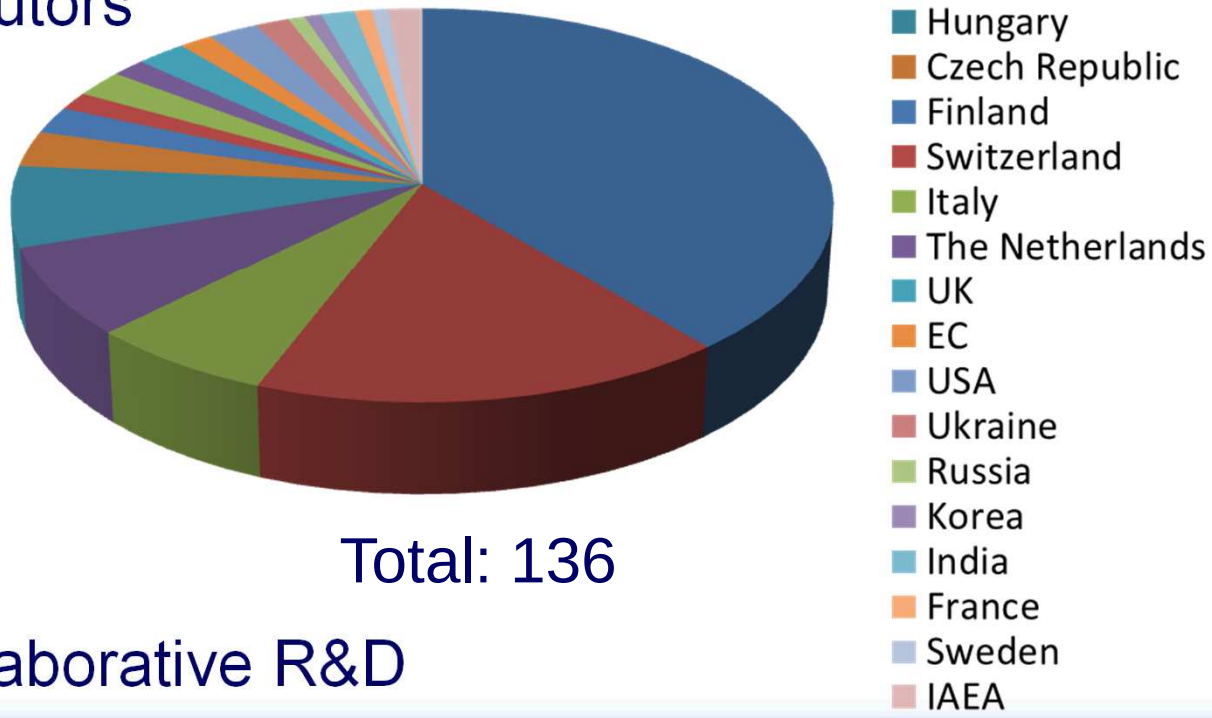
- Canada (50) and China (20) are major contributors followed by Japan (8).
- EURATOM could be the second or third if they are combined.



Total: 108

Number of Papers by Contributing Country/International Organization

- 20 countries and international organizations are involved.
- Canada (53) and China (23) are major contributors followed by Germany (10).
- No big change between the former pie chart.

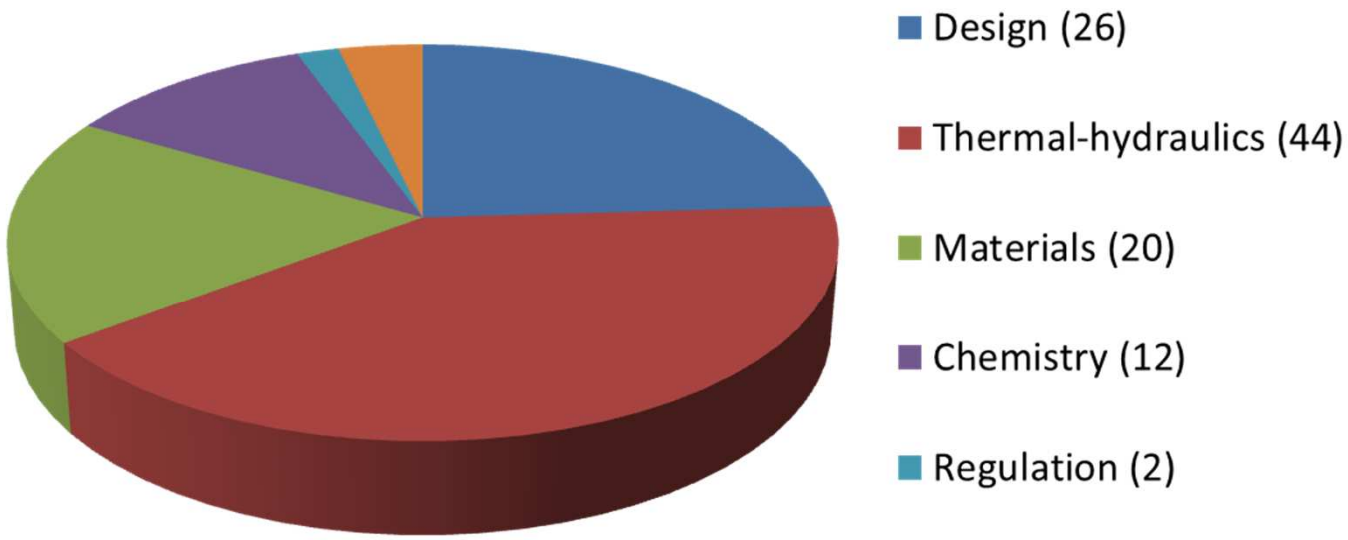


Total: 136

Small number of international collaborative R&D

Number of Papers by R&D Area

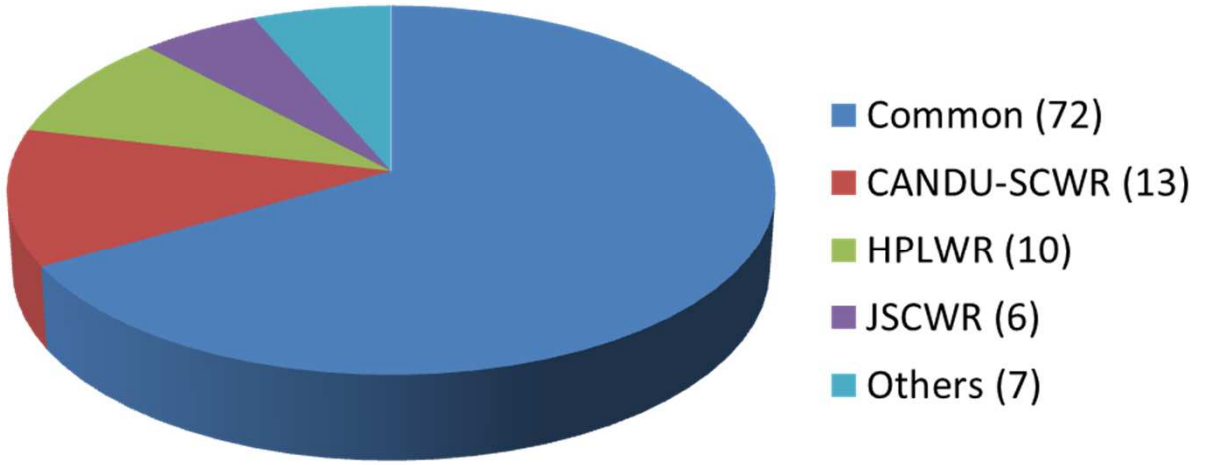
- Thermal-hydraulics (44), Materials&Chemistry (32) and Design (26) are dominant (>90%).



Total: 108

Number of Papers by Project

- Two thirds of the papers are not project-specific, i.e. common or fundamental R&D.
- CANDU-SCWR, HPLWR and JSCWR are three major project.

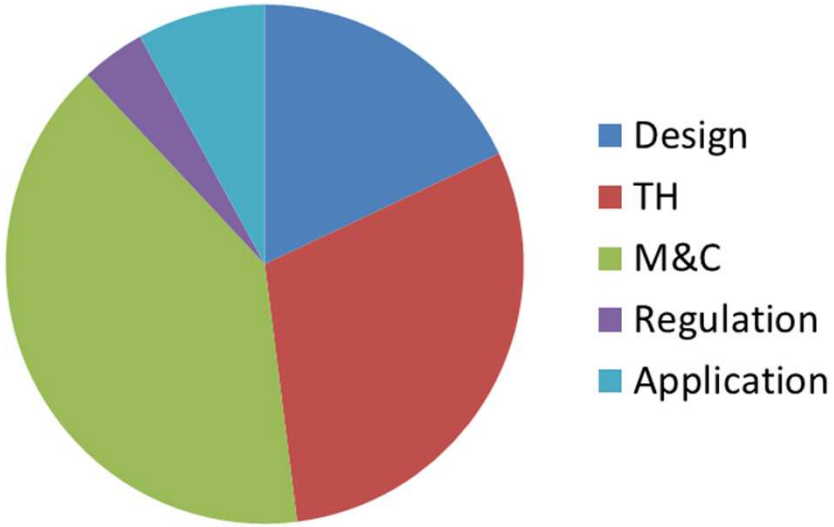


Total: 108

Number of Papers by Leading Country and R&D Area

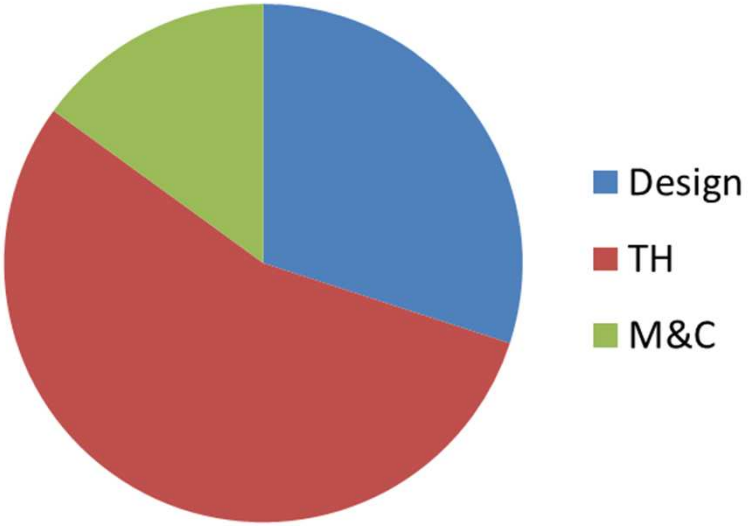
- Emphasis on R&D area is different from country to country.
  - ⇨ Collaboration will be efficient and effective.

Canada



Total: 50

China



Total: 20

Theme of Papers - Design -

- Conceptual plant design
- Concept assessment
- Core and fuel bundle/rod design
- Safety analysis
- Sliding-pressure startup
- Code development

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Theme of Papers
- Thermal-hydraulics -

- Heat transfer to SCP fluids
  - Heat transfer test
  - Heat transfer correlation/Lookup table
  - Heat transfer analysis (CFD/Subchannel)
  - Fluid-to-fluid scaling
- Flow stability
- Critical flow model
- Natural circulation

Theme of Papers
- Materials -

- Materials selection/assessment
- Corrosion
  - General corrosion test
  - Corrosion resistance with coating
  - SCC test
- Mechanical properties
- SCW loop plan

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Theme of Papers
- Chemistry -

- Radiolysis
- Kinetics of reaction
- Molecular dynamics simulation
- Crud deposition
- Filtration system

http://cdsagenda5.ictp.trieste.it/askArchive.php?base=agenda&categ=a10196&id=a10196/announcement

Theme of Papers
- Application/Regulation -

- Application
  - Hydrogen production
- Regulation
  - Safety principles for advanced reactor design
  - Applicability of Canadian regulations to SCWR

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Future R&D Theme (Personal View)

- Thermal-hydraulics and Materials&Chemistry will remain major areas of R&D. They are the ‘driving force’ to promote SCWR development.
- Design should be more emphasized to ‘steer’ all R&D to the right direction.
- International collaboration is efficient and necessary to proceed to the next phases.
- Regulation is a very important area and it should be considered in parallel to the concept development.

Summary

- The SCWR is an innovative WCR but its R&D areas are mostly limited to the reactor systems.
- Major R&D areas for SCWRs have been and will be Thermal-hydraulics, Materials and Chemistry, and Design (or Integration).
- According to analysis of papers submitted to ISSCWR-5;
  - Many countries and international organizations are involved in R&D for SCWR; but
  - Most of papers have been written in a single country.
- International collaboration will be more important.

References

1. U. S. DOE Nuclear Energy Advisory Committee and Generation IV International Forum, “A Technology Roadmap for Generation IV Nuclear Energy System”, GIF-002-00, December 2002.
2. Generation IV International Forum, 2010 Annual Report, OECD/NEA, 2011.
3. Canadian Nuclear Society, “The 5th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-5)”, Vancouver, British Columbia, Canada, March 13-16, 2011.

…Thank you for your attention!

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