SMRs – What will the impact be on ^{3}H and ^{14}C emissions?

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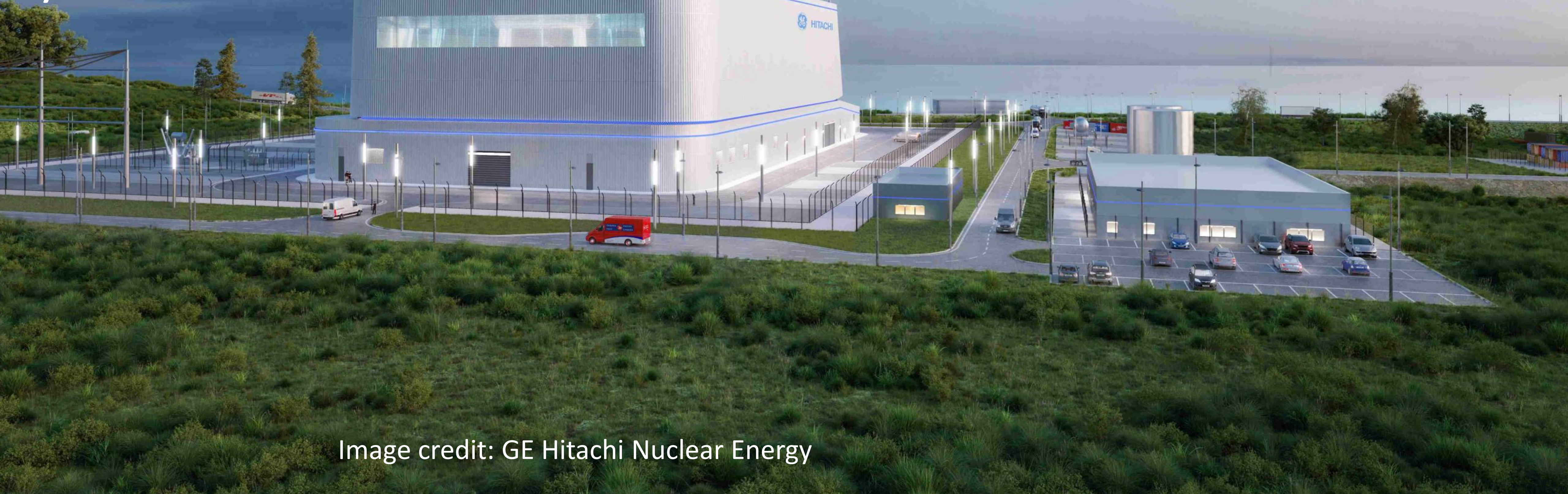


Image credit: GE Hitachi Nuclear Energy

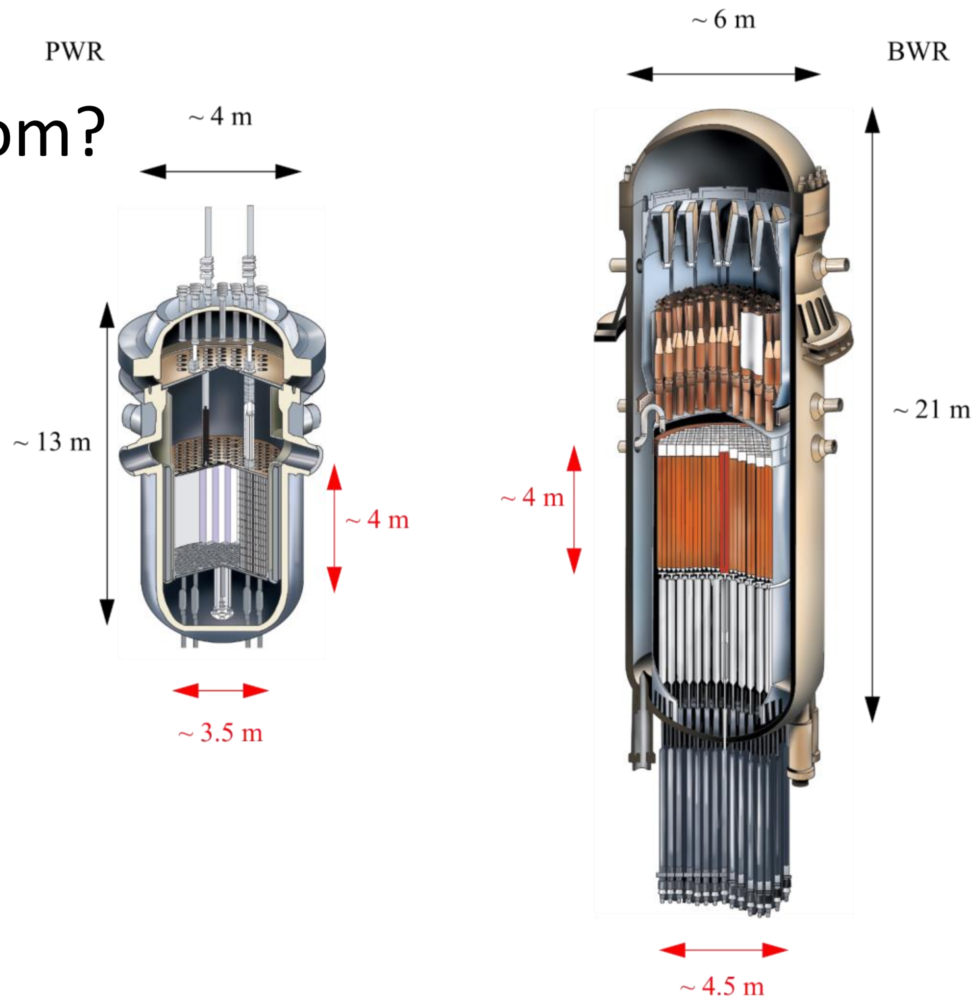
Background

- Electrification → 70–160 % increase in energy usage by 2050
- Nuclear power one alternative →
  - ~100 TWh
- Environmental Impact Assessment (EIA)
- ^{3}H and ^{14}C → weak beta-emitters, but:
  - Relatively long half-lives (^{3}H = 12.3 a and ^{14}C = 5730 a)
  - Ease of assimilation in organic matter

→Largest dose-contributors from operational releases

Traditional LNPPs

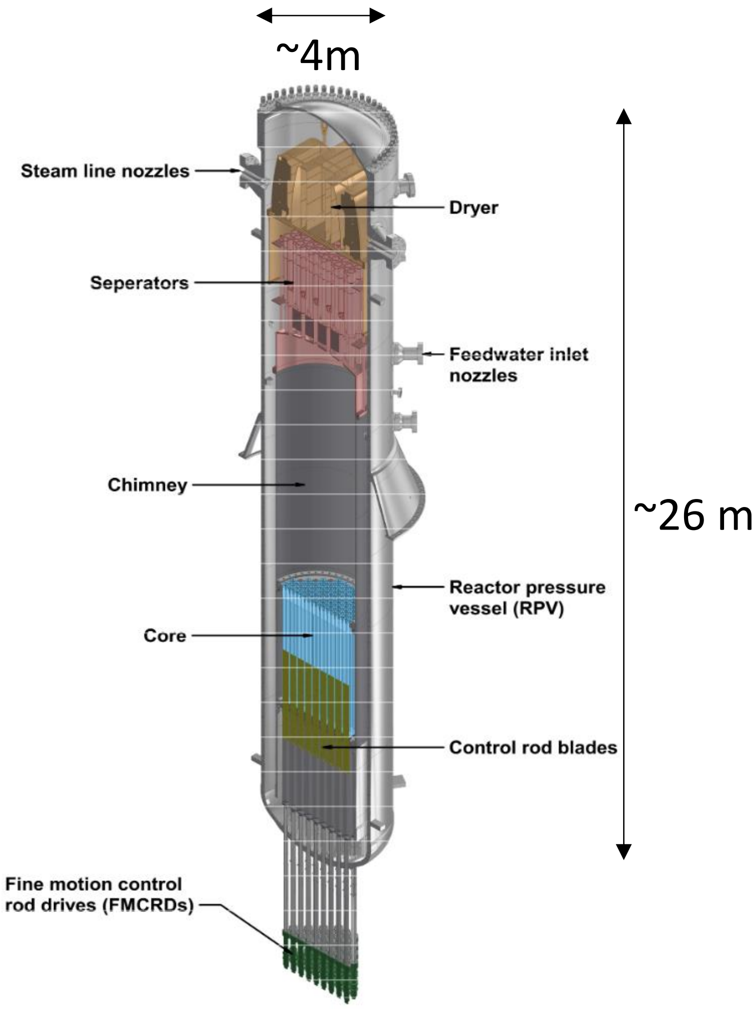
- Where does ^{3}H and ^{14}C come from?
- PWRs and BWRs
- ~600-1500 MW_e



Credit: Westinghouse Electric Sweden AB

What is an SMR?

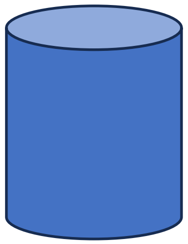
- SMR = **S**mall **M**odular **R**eactor
- SMRs have been suggeseted →
- Rolls-Royce SMR & GE-Hitachi BWRX-300
- Design can vary drastically
- New technology or scaled-down proven technology
- General: lower power than traditional LNPPs
- <300 MW_e
- Smaller plant footprint



BWRX-300. Credit: GE-Hitachi Nuclear Energy

Difference in emissions

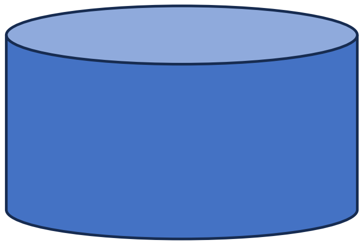
- Smaller core-size
- Typical PWR/BWR core volume: ~39/64 m^3
- BWRX-300 core volume (active): /19 m^3
- →larger surface area to volume ratio



Radius: 1m
Height: 2m

Volume: 6.28 m^3
Surface area: 18.85 m^2

Ratio: ~3



Radius: 2m
Height: 2m

Volume: 25.13 m^3
Surface area: 50.26 m^2

Ratio: 2

Difference in emissions

- Larger surface area to volume ratio
  - → higher neutron leakage
  - → higher fission rate required in the reactor to achieve criticality
  - → higher operational releases

”Simple” example

- Neutron leakage out of cylindrical PWR cores with 3 different geometries (based on 2-Group diffusion simulations):
- Core with heigth h and radius r
- Core with height h and radius 0.5r
- Core with height 0.5h and radius 0.5r
- Same volumetric power density assumed

Core dim (r, h)	Neutron leakage /Wscm^2	Ratio	Neutron leakage/Ws	Ratio
r, h	549.5	1	7.096e+8	1
0.5r, h	4572	8.32	2.51e+9	3.54
0.5r, 0.5h	9787	17.81	3.159e+9	4.45

What will we do?

- Not much publicized
- Not much focus on ^{3}H and ^{14}C
- Simulate core neutron flux for Rolls-Royce SMR and GE Hitachi BWRX-300 using Serpent → NEA-course in Paris
- Use calculated neutron flux for activation calculations in coolant – Not sure how yet
- Estimate operational releases of ^{3}H and ^{14}C
- Calculate effect on releases from new nuclear power

Questions?