Erratum to: State of the Art of Electricity Generation (2007-2017)

Diana Enescu[1], *Giovanni Vincenzo* Fracastoro[2], *Bruno* Panella[2] and *Filippo* Spertino[2,*]

[1]Valahia University of Targoviste, Electronics, Telecommunications and Energy Department, Targoviste, Romania
[2] Politecnico di Torino, Dip. Energia, Torino, Italy

Original article: E3S Web of Conferences **119**, 00019 (2019), https://doi.org/10.1051/e3sconf/201911900019

Paragraph 3 should be added between paragraph 2 and 4:

3 State of the art of nuclear power plants

Nuclear power plants contributed to the production of electricity in the world from around 13% in 2007 to around 10% in 2017. In 2007 443 reactors in 32 countries [19] were in operation (installed power of 376 341 MWe with a production of 2600 TWh), and in 2017 the number had risen to 446 units in 31 countries [20], (with installed power of 392 640 MWe with a production of 2635 TWh). The nuclear production in 2017 was affected mainly by Fukushima accident (most of the Japan reactors are still not operational), and the decreasing percentage from 2007 to 2017 depends also on the stronger increase of the total production of electricity in the world [4], as shown in Fig. 3.

In 2017 the country with the higher number of reactors and higher nuclear power was the USA (99 reactors for 102 GWe, which provided around 20 % of total electricity since 1990, that is, 56% of carbon-free electricity in 2017, operating at full capacity more than 92% of the time). France has 58 reactors (63 GWe), Japan has 42 reactors (39.7 GWe), although due to the accident at Fukushima only 9 are operational, China has 37 reactors (33.4 GWe) and Russia has 35 reactors (26.1 GWe).

At the same time, several currently operating nuclear power plants were set on a path for permanent shutdown, as a result of non-technical factors, such as economic challenges (USA) or policy decisions (Germany). In 2017, 59 reactors were under construction and 38 were planned, bringing the number of countries with nuclear plants to 36. China is currently constructing 18 reactors (19 GWe), one third of the reactors being constructed in the world, and the Russian Federation has 7 reactors under construction, including 2 small modular reactors on a floating barge.

In 2017 [20] the pressurized water reactors (PWR) constituted 65% of all the reactors (70% of power), the boiling water reactors (BWR) 17% (19% of power), the heavy water reactors (HWR) 11% (6% of power), the gas graphite reactors (GR) 3% (2% of power), the fast breeder reactors (FBR) only 0.4% (0.3% of power).

In 2017 few plants of the so- called Generation III reactors (such as American AP 1000, French EPR, Russian VVER 1200, or Chinese Hualong 1), with enhanced safety systems, were in construction. The safety system of the plants are based on passive systems, which do not need energy (either internal or external) to start and be effective. One major issue in the OECD countries is high capital costs (particularly after the Fukushima accident): there is also a great difference in capital costs between the USA, France, and the UK on one side and Russia, Korea and China on the other side (12,000 $/kW in USA against 5,000 $/kW in China).

Generation IV nuclear reactors are being developed through the international cooperation of 14 countries, with construction planned after 2030. These innovative systems are expected to be cleaner, safer and more efficient than previous generations, with radioactive waste minimization and non-proliferation.

Six nuclear systems have been selected and studied: sodium fast reactor, lead fast reactor (LFS), gas (Helium) fast reactor (GFS), molten salt reactor (MSR), (all with closed fuel cycle and breeding), very high temperature reactor (cooled by Helium) (VHTR), super critical water reactor (SCWR).

More recently, and also to address the high capital cost issue, advanced small modular reactors (SMRs) have been studied particularly in the USA and could be constructed within the next decade. These advanced reactors, envisioned to vary in size from a few MW up to hundreds of MW, can be used for power generation, process heat, desalination, or other industrial uses. SMRs can employ light water as a coolant or other coolants such as a gas, liquid metal, or molten salt. Advanced SMRs are characterized by a relatively small size and reduced capital investment; they may be sited in locations not possible for larger nuclear plants, and are fit for incremental power additions. SMRs also offer distinct safety, security and nonproliferation advantages. The American NuScale reactor

(60 MWe) is an example of an SMR. Should it become necessary, NuScale's SMR shuts itself down and self-cools for an indefinite period of time, with no operator action required, no additional water, and no AC or DC power needed. The NuScale Power Module's cost per kWh is competitive with other sources of base load electricity generation.

There are also some visionary projects like the traveling wave reactor (TWR) by TerraPower (founded by Bill Gates), which uses a once-through deep-burn fuel cycle to achieve many fast reactor capabilities (natural safety, reduced waste, reduction and eventual elimination of enrichment, and high fuel and thermal efficiency) without requiring fuel reprocessing. The reactor could be buried below ground, where it could run for an estimated 100 years.

The title of paragraph 5 should be replaced by the following text:

Conclusions (instead of "State of the art of PV and wind power plants")

References should be integrated with these last two:

19. NUCLEAR NEWS, American Nuclear Society, 51, 3, 63 (March 2008).
20. NUCLEAR NEWS, American Nuclear Society, 61, 3, 61 (March 2018).