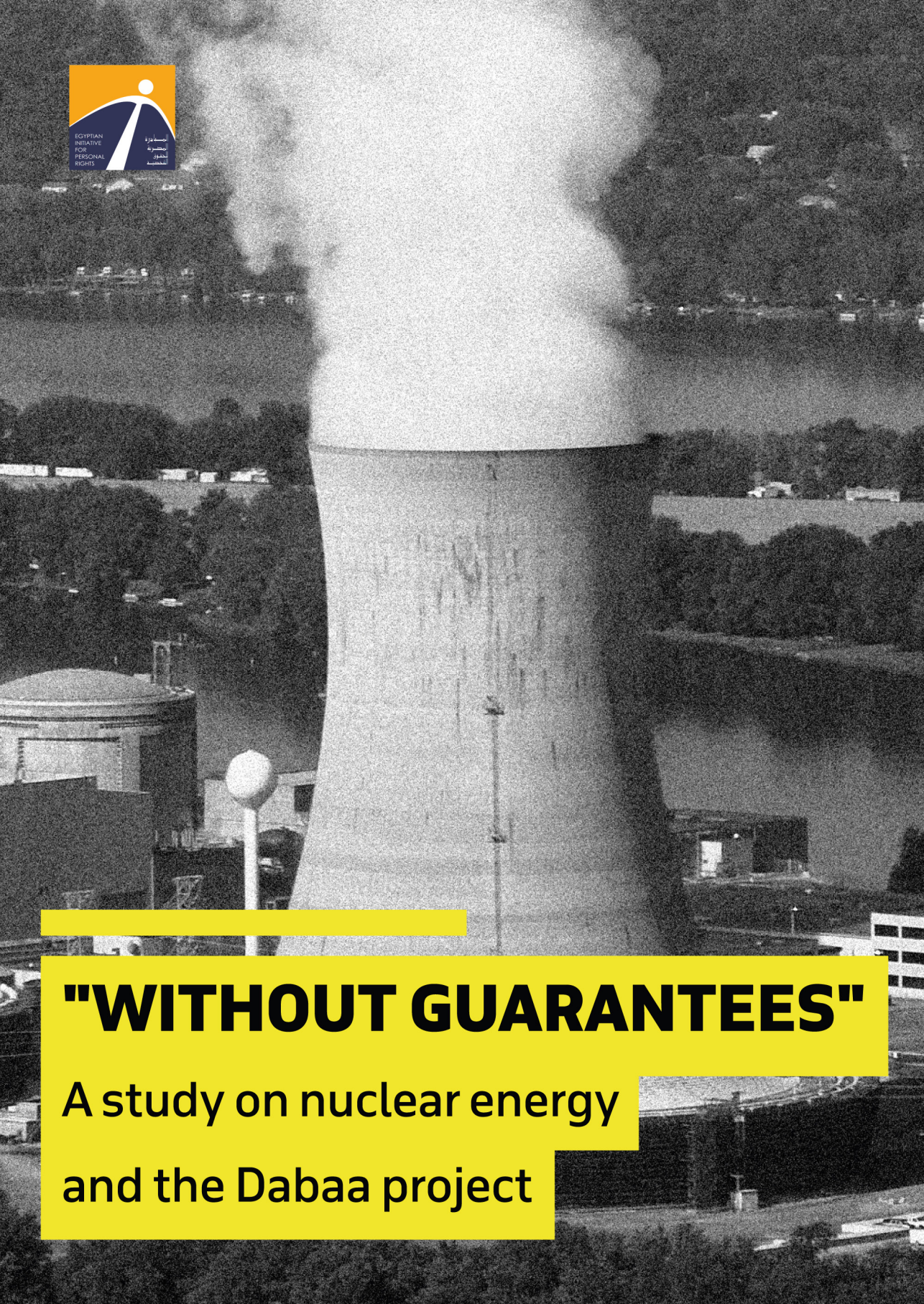

"WITHOUT GUARANTEES"

A study on nuclear energy and the Dabaa project

“Without guarantees”

A study on nuclear energy and the Dabaa project

First Edition in Arabic 2019

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Index

Introduction

The consequences of using nuclear energy affect the whole society and the future generations. International recommendations rightly stress on community participation, knowledge spreading and transparency in all matters related to nuclear energy. However, we think that the process of public participation concerning El Dabaa Nuclear Plant in Egypt was not satisfactorily done. This could be, at least partly, attributed to the complexity of the issues of energy in general and nuclear energy in particular.

This study seeks to provide simplified information on various aspects of nuclear power for the sake of facilitating and enriching the public dialogue and participation in the issues of nuclear energy in Egypt.

The study adopts a position that considers nuclear power an expensive, dangerous, risky and unsustainable source of electricity and that better alternatives exist, especially renewable energy. Renewable resources would guarantee energy security and accessibility while protecting health and environment.

This study is based on findings from international and local resources and data. The study consists of an introduction, an executive summary, seven chapters, and two annexes. Each chapter can be read independently, and each chapter begins with a summary of its content.

Chapter One contains a simplified explanation of generating electricity from nuclear energy. Chapter Two deals with the economics of nuclear power generation. Chapter Three deals with the effects of nuclear reactors on health and environment. Chapter Four discusses the problem of nuclear waste, and Chapter Five discusses risks of nuclear accidents. Chapter Six demonstrates the decline of the world›s nuclear energy and Chapter Seven discusses alternatives depending on renewable energy in the world and in Egypt.

Annex One explains the legislative and regulatory framework of Nuclear energy in Egypt and the most important stages of the Dabaa Project. Annex Two is about the Community Dialogue and the most important trends in opinions regarding the project, collected from what was published in the media.

Executive Summary

The study begins by explaining the basics of nuclear electricity generation. Generation of electricity from nuclear power is similar to other thermal generation like that of coal, natural gas, and oil except that in this case heat is created from nuclear fission and not from burning fuel. The nuclear reactor is the core of the nuclear plant. It is responsible for generating and controlling the release of heat. There are several kinds of reactors, applying different techniques. It was announced that the Russian company «Ross Atom» will build four reactors of the model 1200-VVER (Russian pressurized water reactor) in El Dabaa.

The basic fuel for a nuclear reactor is Uranium. Natural uranium passes through different stages of enrichment before it can be used in the reactor. Six countries supply 85% of the world's mined uranium. The economic uranium stores are expected to last for about 80 years only. The nuclear fuel inside the reactor is replaced periodically because it gets spent. This spent fuel is highly radioactive. Hundreds of thousands of tons of high level radioactive waste are stored beside the reactors all over the world. Up till now no safe long term disposal of this waste exists.

Nuclear power is the most expensive source of electricity compared to all traditional sources and to most renewable sources. The argument against nuclear energy is no longer restricted to risks and dangers but is increasingly based on costs and economics. The nuclear industry has long argued that nuclear reactors might be expensive to build but because the operating costs are very low, nuclear electricity is the cheapest. This claim has been continuously undermined by recent cost analyses.

> ***"Comparing the levelized costs of electricity (LCOE), shows that the cost of nuclear power is almost double that of combined gas cycle and the PV cells, and triple onshore wind ."***

That is why the nuclear power industry worldwide is facing huge difficulties in the markets. Investing in nuclear energy is becoming very risky due to the huge capital, the construction delay, the budget overruns and the cheaper alternatives.

> ***"Comparing the cost of building the nuclear plant in Dabaa to costs of building other power plants in Egypt shows that the Dabaa plant cost is almost 12 times that of a combined gas station, 6 times a wind farm and 3 times a photovoltaic solar plant of the same capacity."***

Different forms of subsidies are used to conceal the huge nuclear energy expenses. Subsidies shift costs from nuclear plant builders to governments and consumers. Some forms of subsidies are tax incentives, loan guarantees and purchase agreements.

> ***"The recent amendments of the Egyptian Nuclear Laws and Regulations grant the Dabaa plants lots of subsidies."***

Finally, adding what is called the hidden "indirect" costs of nuclear energy like environmental pollution and health costs, would make nuclear power extremely expensive.

Nuclear energy is not considered clean energy. Every aspect of the nuclear cycle carries risky consequences on health and environment. The operation of nuclear plants produces large quantities of radioactive materials. A fraction of this activity is typically emitted to the environment. Laws regulating nuclear activities allow the release of low ratios of radioactive materials to the surrounding environment assuming that low radiation levels do not affect human health, but this assumption is incorrect.

"Since the 1980s populations living near nuclear facilities have been complaining of increasing cancer cases especially among their children, studies confirmed this phenomenon."

Yet the relationship between increased cancer cases and nuclear facilities was denied for a long time and still is .

"But in 2006 an important study from the :American National Council Committee to Search for the Effects of Low Levels of Radiation, clearly proved that there is no safe dose of ionic radiation no matter how low."

Nuclear power plants use huge amounts of water for cooling. Withdrawing huge amounts of water, heating it up then discharging it into nearby water ecosystems, negatively impacts the water quality and the ecosystem diversity.

"The Eastern Mediterranean Region, where Dabaa is located, is one of the most suitable marine areas in the world for swimming and fishing, the construction of a nuclear power plant in Dabaa, will negatively affect water quality, ecosystem diversity and the economic activities that depend on them."

While more nuclear waste is accumulating around the world, there is no long term solution in sight.

Deep geological repositories are thought to be the safest way to store nuclear waste, but no country in the world has any of these warehouses. Only Finland started building one to be completed in the 22nd century.

"It is estimated that by 2020, the amount of highly radioactive waste from spent fuel will reach 445,000 tons. Nuclear waste from spent fuel is millions of times more radioactive than fresh uranium and remains likewise for thousands of years"

The accumulated waste poses eminent risks of contaminating the environment. There are many records of incidents when nuclear waste has been disposed of improperly, defectively or simply abandoned, washed away or stolen from temporary storages.

"Dumping waste in oceans was not banned till the nineties. Scientists found evidences of raised radioactivity in sea floors and in marine life. The dumped radioactive waste is making its way back to our bodies and food. "

Reprocessing of the used fuel is not a solution for nuclear waste and it may even increase the risk of nuclear weapons proliferation.

Nuclear reactors are, by their very nature, inherently dangerous. At any time, an unforeseen combination of technological failure, human error or even natural disaster may lead the reactor to getting out of control.

The nuclear industry claims that the probability of a major accident like Fukushima is very low.

"But some important research entities estimate that four serious accidents are expected during the next fifty years, and a possibility of another Chernobyl may be 50% in the next thirty years"

There is no authoritative comprehensive public record of nuclear accidents, but many lists of various sorts of accidents are found online. The effects of nuclear accidents are enormous and their consequences include injuries, acute radiation syndrome, chronic diseases and cancers, in addition to devastating social and economic losses. This study provides a summary of the five major accidents known in history namely: Kyshtym, Windscale-Sellafield, Three Mile Island, Chernobyl and Fukushima Daiichi.

Since the 1990s, nuclear energy has been on a continuous downward trend. Nowadays it only represents 10.5% of world electricity. Nuclear energy has never been very popular. Only 31 countries over the world use nuclear power to generate electricity, with the Big Five countries generating 70% of the total. Many Western countries are phasing out of nuclear power and this is shifting the market to developing countries. The future forecast for nuclear energy is not promising.

There are numerous options available to meet the world needs for electricity that are superior to nuclear energy. On top of these options are renewable energies which are cheaper, cleaner, safer and sustainable.

Wind and solar PV are leading the growth of renewable power. By the end of 2017, wind followed by solar PV were the cheapest of all sources of electricity and most attractive to energy investments. Affordable storage solutions are expected in the near future to overcome the variability and interruption of wind and solar powers. Egypt is endowed with abundant wind and solar resources. The IRENA renewable energy map analysis performed in 2018, showed that:

> ***"Egypt has the potential to supply 53% of its electricity from renewables by 2030. This would result in a reduction in total energy costs of USD 900 million"***

Chapter One: What is Nuclear Power?

1- Summary of the chapter

Generation of electricity from nuclear power is similar to other kinds of thermal generation like from coal, natural gas, and oil except that in this case heat is created from nuclear fission and not from burning fuel. The nuclear reactor is the core of the nuclear plant. It is responsible for generating and controlling the release of energy. There are different kinds of reactors which apply different techniques. ROSATOM will build four units of VVER-1200 reactors design (Russian water pressurized power reactor) in Dabaa.

The basic fuel for nuclear reactors is uranium because it is readily able to split. Natural uranium passes through different stages of enrichment before it can be used in the reactors. Six countries supply 85% of the world's mined uranium. The economic uranium stores are expected to last for about 80 years only. The nuclear fuel inside the reactor should be replaced periodically because it gets spent. This spent fuel is highly radioactive. Hundreds of thousands of tons of this high level radioactive nuclear waste are temporarily stored beside the reactors all over the world. Up till now no long term disposal of this waste exists. Finland is the only country which has a project for long term disposal of the waste which will be completed in the 22nd century. When a reactor is old it undergoes shut down and has to be decommissioned. Decommissioning is an expensive and lengthy process.

2- Generating electricity from nuclear power

Generation of electricity from nuclear power is fundamentally similar to other kinds of traditional power generation like coal, natural gas, and oil. All of these power sources are referred to as thermal power sources. Oil, coal, or natural gas is burnt to boil water or to make hot gases. The high pressure of the boiled water steam or gases is used to turn turbines that generate electricity. Nuclear power makes electricity in exactly the same way except that heat is created from nuclear splitting and not from burning fuel. When atoms split apart, called fission, they release heat, the heat is used to boil water.[1]

Reactor Core

The nuclear fission occurs in the reactor core. A nuclear reactor core produces and controls the release of energy from splitting the atoms of uranium fuel.[2]

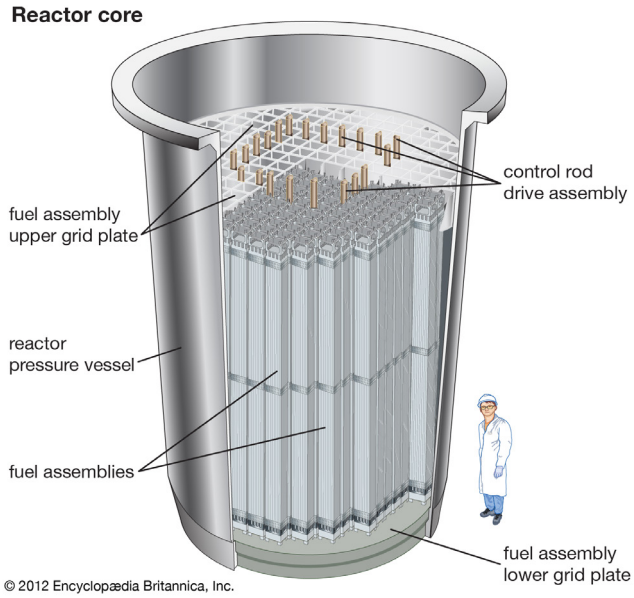
> ***"The reactor core is made of several hundred-fuel assemblies/rods containing thousands of small pellets of uranium fuel. These rods are enclosed in a concrete and steel containment. The reactor core sits inside a steel vessel surrounded by water."***

1- "Nuclear Energy Frequently Asked Questions · NIRS." NIRS. Accessed June 17, 2019. https://www.nirs.org/basics-of-nuclear-power/nuclear-power-frequently-asked-questions/

2- "How Does a Nuclear Reactor Make Electricity?" How Does a Nuclear Reactor Make Electricity? - World Nuclear Association. Accessed June 17, 2019. http://world-nuclear.org/nuclear-basics/how-does-a-nuclear-reactor-make-electricity.aspx

Fission occurs when the nucleus of the enriched uranium is hit by a neutron. The nucleus splits in two and some energy is released in the form of heat and two or three additional neutrons are thrown off. If enough of these expelled neutrons split the nuclei of other atoms releasing further heat and neutrons, a chain reaction can be achieved. When this happens over and over many millions of times, a very large amount of heat is produced from a relatively small amount of uranium.[3]

Fig (1): The core of a pressurized-water nuclear reactor [source: Encyclopædia Britannica]

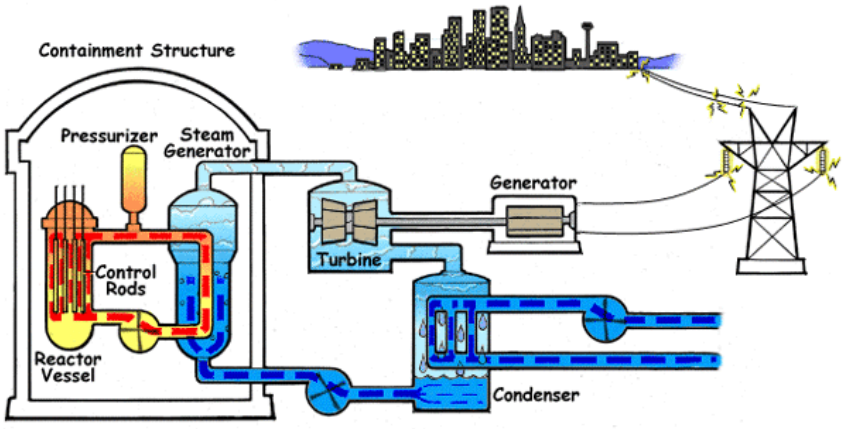


There are different models of reactors. In the pressurized water model, like the one to be used in Egypt, the water in the vessel is kept under pressure to remain liquid at a high temperature of over 320°C. The hot water in the primary circuit generates steam in a secondary circuit and this steam drives the turbine to produce electricity. The steam is then condensed and the water recycled[4].

3- "What Is Uranium? How Does It Work?" What Is Uranium? How Does It Work - World Nuclear Association. Accessed June 17, 2019. http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/what-is-uranium-how-does-it-work.aspx

4- Ibid, 'How does a Nuclear Reactor Make Electricity?'

Fig (2): Pressurised Reactor [source: United States Nuclear Regulatory Commission]



The fuel inside a reactor doesn›t work forever and must be replaced. About one-third or half of the fuel is removed every year or two to be replaced with fresh fuel. The old fuel is called spent fuel. Spent fuel is highly radioactive, it produces a lot of radiation and heat for very long time[5]

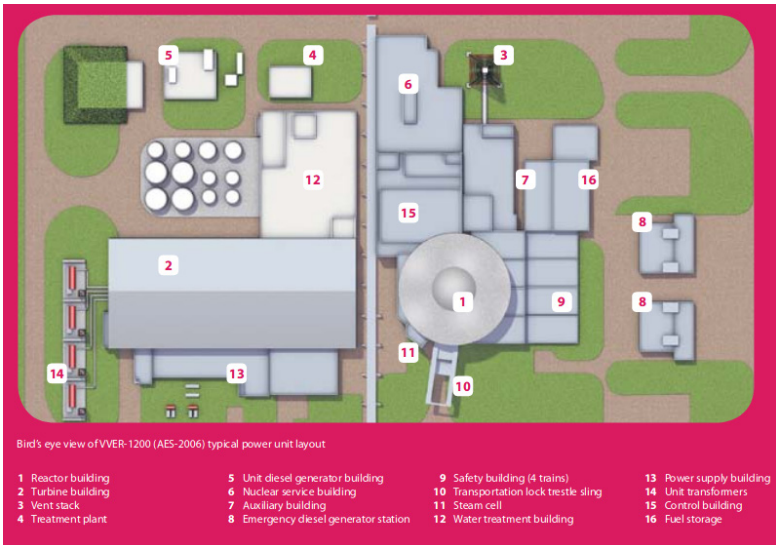
> ***"ROSATOM will build four units of design VVER-1200 (Russian water-pressurized power reactor) in Dabaa. The Dabaa will reference unit 1 of the Leningrad Phase II nuclear power plant in Russia. Rosatom will supply nuclear fuel throughout the plant›s entire lifetime, train personnel, and assist Egypt in operation and maintenance during the first 10 years of the plant›s operations.6ASE Group and 'ATOMPROEKT' provide engineering and construction.7"***

5- "Backgrounder on Storage of Spent Nuclear Fuel." United States Nuclear Regulatory Commission - Protecting People and the Environment. October 2013. Accessed June 17, 2019. https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/storage-spent-fuel.html.

6- "Projects." Rosatom State Atomi Energy Corporation ROSATOM Global Leader in Nuclear Technologies Nuclear Energy. Accessed June 17, 2019. https://www.rosatom.ru/en/investors/projects/.

7- "Engineering." Rosatom State Atomi Energy Corporation ROSATOM Global Leader in Nuclear Technologies Nuclear Energy. Accessed June 17, 2019. https://www.rosatom.ru/en/rosatom-group/engineering-and-construction/.

Fig (3): Bird's eye view of VVER-1200 (AES-2006) typical power unit layout [source: ROSATOM]



Cooling Systems

"Nuclear power plants are extravagantly water-wasting."

Nuclear reactors produce much more heat in the fission process than is needed to generate electricity. For each unit of electrical energy generated, two units of heat energy are released into the environment. Huge amounts of water are needed to cool this excess heat.[8]

There are two types of water cooling for nuclear plants:

a- Once-through system:

It takes water from sources like rivers, lakes, or oceans, circulates it through pipes to absorb heat from the system and discharges the now warmer water to the water source. This demands siting plants in places with abundant supplies of water.

b- Closed-loop system:

It uses cooling towers to expose the hot water from cooling to ambient air. Some of the water evaporates, the rest is then sent back to the condenser in the power plant. Fresh amounts of water are withdrawn to replace the amounts lost through evaporation in the cooling towers. These systems have lower water withdrawals but have higher water consumption.[9]

8- Union of Concerned Scientists. Nuclear Power and Water: Fact Sheet. December 2011. Accessed June 19, 2019.https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/fact-sheet-water-use.pdf

9- "How It Works: Water for Power Plant Cooling." Union of Concerned Scientists. Accessed June 19, 2019. https://www.ucsusa.org/clean-energy/energy-and-water-use/water-energy-electricity-cooling-power-plant#.XERHvdIzZdg

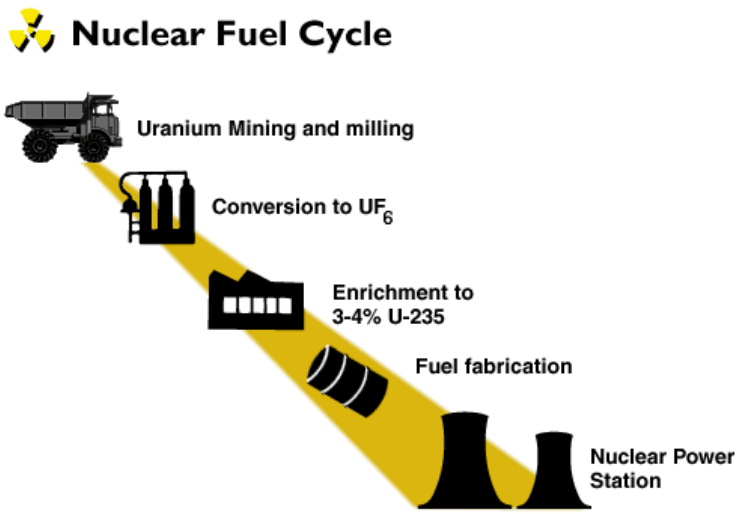
"For an average 1000 Megawatt plant, a typical once-through cooling system draws 500,000 gallons per minute, while Closed-cycle cooling system draws 20, 000 gallons of water per minute."

3- Nuclear Fuel: Uranium

The basic fuel for a nuclear power reactor is uranium because it is readily able to split. Natural uranium is a mixture of three forms (isotopes), uranium-238 (U-238), accounting for 99.2%; U-235 accounts for 0.7%; and U-234 accounts for 0.005%. For most kinds of reactors, the concentration of the U-235 isotope needs to be increased (enriched) from its natural level of 0.7% to 3-5%.

"A reactor with an output of 1000 megawatts, would contain about 75 tonnes of enriched uranium in its core.[10]"

Fig (4): Nuclear Fuel Cycle [source: Atomic Archive]



Uranium is widespread in many rocks and even in seawater. However, it is seldom sufficiently concentrated to be economically recoverable.[11]Uranium is finite and as supplies diminish costs rise. Since 2005, the price of mined uranium has soared from $12 to $45 a pound.[12]

10- Ibid, 'How does a Reactor make Electricity?'

11- "Uranium and Depleted Uranium." Uranium and Depleted Uranium - World Nuclear Association. Accessed June 17, 2019. http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-and-depleted-uranium.aspx

12- Smith, Gar, Ernest Callenbach, and Aileen Mioko-Smith. Chapter 3: Inherently Inefficient and Unreliable, Nuclear Roulette: The Case against a "Nuclear Renaissance". pp.16. San Francisco: International Forum on Globalization, 2011. 2011. Accessed June 17, 2019. http://ifg.org/v2/wp-content/uploads/2014/04/Nuclear_Roulette_book.pdf

"Six countries supply 85% of the world's mined uranium.13Kazakhstan, in 2017, supplied more than one third of world production.14 At the current rate of consumption the world supply of viable uranium would last for about 80 years.[15]"

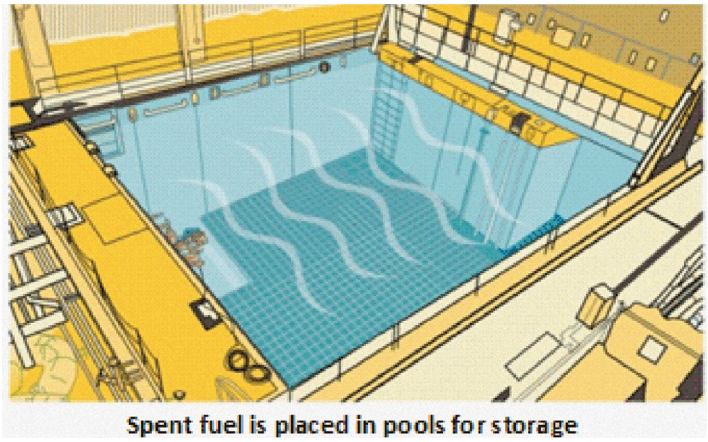
4- Nuclear Waste

Nuclear plants generate different kinds of radioactive waste. Radioactive waste has to be isolated and confined in appropriate disposal facilities for a sufficient period until it no longer poses a threat. The time radioactive waste must be stored depends on the amount of radioactivity in it.

a- High level waste:

Mainly from spent fuel. Every 18 months on average the used fuel is replaced with fresh fuel.[16]When the fuel rods are removed, they are 6-8 million times more radioactive than when they went into the reactor.[17]The spent fuel is removed from the reactors and put in deep pools of water. The pools contain large amounts of water to cool the fuel and to provide radiation shielding.[18]A loss of cooling water could result in the fuel heating and igniting the zirconium alloy cladding and releasing radioactivity.[19]

Fig (5): Example of Pool Storage [Source: United States Nuclear Regulatory Commission]



13- Ibid

14- Ibid, 'Uranium and Depleted Uranium'

15- Zyga, Lisa. "Why Nuclear Power Will Never Supply the World's Energy Needs." Phys.org. May 11, 2011. Accessed June 17, 2019. https://phys.org/news/2011-05-nuclear-power-world-energy.html#jCp

16- "The Nuclear Fuel Cycle." Nuclear Fuel Cycle Overview - World Nuclear Association. Accessed June 17, 2019. http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/nuclear-fuel-cycle-overview.aspx

17- Ibid, 'Nuclear Energy Frequently Asked Questions'

18- Ibid, 'What is Nuclear Energy?'

19- Ibid, Chapter 2, 'Nuclear Roulette',

After at least 5 years, spent fuel assemblies can be moved from the cooling pool to another pool (wet storage) or to air-cooled shielded casks (dry storage).[20]Pools and dry-casks are only safe for about 100 years.[21]Long term disposal of high-level waste would require deep burial and shielding for several hundred thousands of years.[22]

fig (6): Dry Casks Storage at the Connecticut Yankee Atomic Power Company [Source: Connecticut Yankee Atomic Power Company]

As of the end of 2009, there were about 240,000 tons of spent fuel in storage worldwide, most of these are stored at reactor sites.[23]

> ***"Although the nuclear power generation started 70 years ago, not a single long term repository exists."***

The only project for long term disposal of spent fuel exists in Finland (Onkalo spent nuclear fuel repository). Building the Onkalo began in 2004 and it will not be completed until the next century. Onkalo would have room for only Finland's nuclear wastes—about one percent of the world's growing stockpile of radioactive waste.

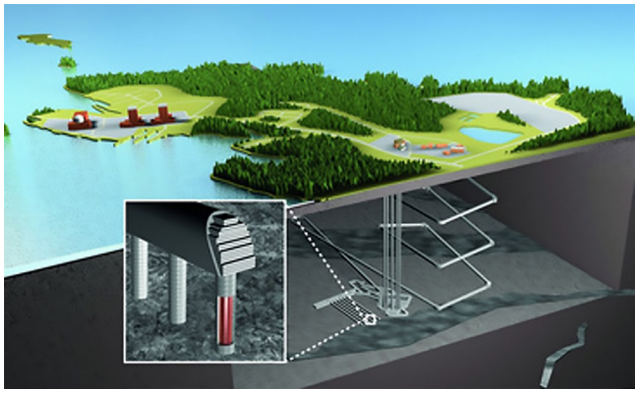
20- Ibid, 'What is Nuclear Energy?'

21- Ibid, Chapter 6, 'Nuclear Roulette',

22- Harold Feiveson, Zia Mian, M.V. Ramana and Frank von Hippel (eds), Spent Fuel from Nuclear Power Reactors: An Overview of a New Study by the International Panel of Fissile Materials, Draft for Discussion June 2011, fissilematerials.org. Accessed June 17, 2019. http://fissilematerials.org/library/ipfm-spent-fuel-overview-june-2011.pdf

23- Ibid

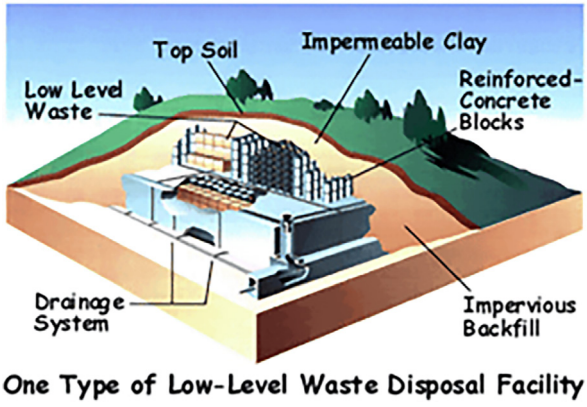
Fig (7): Illustrations of KBS-3 repository at Olkiluoto [source: Onkalo from Concept to Reality]



b. Intermediate-level waste (ILW)

This kind of waste contains intermediate amounts of radioactivity and in general requires shielding but not cooling. Intermediate-level waste includes resins, chemical sludge and metal claddings. They are buried in shallow repositories.

Fig (8): example of low-level waste disposal facility [source: United States Nuclear Regulatory Commission]



c- Low-level waste

Low-level waste includes paper, rags, tools, clothing, filters, and other materials which contain small amounts of mostly short-lived radioactivity. Most LLW are disposed of in shallow sanitary landfills.

5- Decommissioning of Nuclear Plants

If a nuclear plant is to be shut down, it must be decommissioned. Decommissioning means taking steps to reduce the level of radiation to a level that permits termination of the nuclear license and makes the site usable again.[24]To fully decommission a power plant, the facility must be deconstructed, any onsite nuclear waste safely disposed of and any radioactive materials removed or contained including nuclear fuel as well as irradiated equipment and buildings.

Decommissioning a nuclear reactor is a lengthy and costly process. Decommissioning can be done through:

a- Decontamination (DECON):

It involves removing all fuel and equipment from the power plant for separate storage and decontamination. It is relatively quick. Decommissioning the Haddam Neck plant using this method took ten years (1997-2007) at a total cost of $893 million.

b- Safe Storage (SAFSTOR):

It involves containing and monitoring the reactor and equipment for a long time to allow some radioactive decay. It takes a longer time. Decommissioning the Kewaunee Plant using this method started in 2003, anticipated to take 60 years and to cost nearly $1 billion.[25]

24- Ibid, 'What is Nuclear Energy?'

25- Ibid, 'Decommissioning Nuclear Reactors...'

Chapter Two: Nuclear Power is expensive.

1- Summary of the chapter

Nuclear power is the most expensive source of electricity compared to all traditional and to most renewable sources. The argument against nuclear energy is no longer restricted to risks and dangers but is increasingly based on costs and economics.

The nuclear industry has long argued that nuclear reactors might be expensive to build but because the operating costs are very low, nuclear electricity is the cheapest.These claims are continuously undermined by recent cost analyses and by the losses the nuclear energy companies face in the market.

The levelized cost of electricity (LCOE), shows that the LCOE of nuclear power is double the price from combined gas cycles and PV cells and triple the onshore wind. Nuclear power industry is having great difficulties in the market. The huge capital cost, the construction delay and the budget overruns in addition to the availability of cheaper alternatives make nuclear energy a risky investment.

On the national level, Comparing the cost of building the nuclear plant in Dabaa to other power plants shows that the nuclear cost is about 12 times that of a combined gas station, 6 times wind farm and 3 times PV plants, all of the same capacity.

Different forms of subsidies are used to conceal the huge nuclear energy expenses. Subsidies shift costs from nuclear plant owners to governments and consumers. Subsidies can be in different forms like tax incentives, loan guarantees or purchase agreements. The recent amendments of the Egyptian nuclear laws and regulations grant the Dabaa project many kinds of subsidies.

Adding the external costs like environmental and health costs would make nuclear power an even more expensive source of electricity.

2- Comparing Costs Internationally

> ***"The nuclear industry has long argued that nuclear power generates the cheapest electricity. But this claim has been contested"***

The electricity cost-benefit analysis environment has changed from the early days of the nuclear era when the pro nuclear governments and reactor vendors monopolized the preparation of cost analyses. Recently, stock markets and independent energy analysts have come forward with different estimates of the cost of nuclear power.[26]

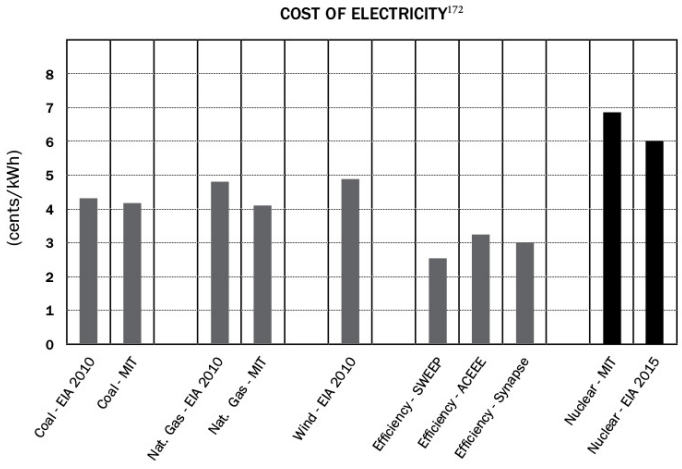
> ***"Nuclear power is the most expensive."***[27]

26- Cooper, Mark. "The Economics of Nuclear Reactors: Renaissance or Relapse?" Nuclear Monitor, No. 692-693, August 28, 2009. Accessed June 18, 2019. https://www.nirs.org/wp-content/uploads/mononline/nm692_3.pdf

27- Ansolabehere, Stephen, and Eric S. Beckjord. 2003. The Future of nuclear power an interdisciplinary MIT study. [Cambridge]: Massachusetts Institute of Technology. http://web.mit.edu/nuclearpower/pdf/nuclearpower-full.pdf.

Levelized cost of electricity (LCOE) is used to compare the cost of power coming from different sources. The LCOE takes into consideration the life time of the plant, construction, operation, maintenance and fuel costs. Although calculated LCOE may vary a bit between different entities performing the analysis, this did not alter the conclusion that nuclear is the most expensive source of electricity, as shown in the table.

Fig (9): Table showing cost of electricity across several technologies [source: Nuclear Information and Resource Service]



More recent studies showed it more clearly:
According to the EIA (US Energy Information Administration) report in 2017, the LCOE of nuclear power (90.1$/Mwh) was almost double the price from combined gas cycle (48.3$/Mwh) and photovoltaic cells (46.5$/MWh) and triple the onshore wind (37.1$/Mwh).

Fig (10): Table showing levelized cost of electricity for new generation sources entering service in 2023 [source: U.S. Energy Information Administration]

Table 1a. Estimated levelized cost of electricity (capacity-weighted average[1]) for new generation resouces entering service in 2022 (2017 $/MWh)

Plant type	Capacity factor (%)	Levelized capital cost	Levelized fixed O&M	Levelized variable O&M	Levelized transmission cost	Total system LCOE	Levelized tax credit[2]	Total LCOE including tax credit
Dispatchable technologies								
Coal with 30% CCS[3]	NB	NB	NB	NB	NB	NB	NA	NB
Coal with 90% CCS[3]	NB	NB	NB	NB	NB	NB	NA	NB
Conventional CC	87	13.0	1.5	32.8	1.0	48.3	NA	48.3
Advanced CC	87	15.5	1.3	30.3	1.1	48.1	NA	48.1
Advanced CC with CCS	NB	NB	NB	NB	NB	NB	NA	NB
Conventional CT	NB	NB	NB	NB	NB	NB	NA	NB
Advanced CT	30	22.7	2.6	51.3	2.9	79.5	NA	79.5
Advanced nuclear	90	67.0	12.9	9.3	0.9	90.1	NA	90.1
Geothermal	91	28.3	13.5	0.0	1.3	43.1	-2.8	40.3
Biomass	83	40.3	15.4	45.0	1.5	102.2	NA	102.2
Non-dispatchable technologies								
Wind, onshore	43	33.0	12.7	0.0	2.4	48.0	-11.1	37.0
Wind, offshore	45	102.6	20.0	0.0	2.0	124.6	-18.5	106.2
Solar PV[4]	33	48.2	7.5	0.0	3.3	59.1	-12.5	46.5
Solar thermal	NB	NB	NB	NB	NB	NB	NB	NB
Hydroelectric[5]	65	56.7	14.0	1.3	1.8	73.9	NA	73.9

3-Comparing Costs in Egypt

The building of the Nuclear plant in Dabaa with a capacity of 4800 MW, is estimated to cost 30 billion US$ and would need 12 years to be finished.[28] While constructing three natural gas combined cycle plants by Siemens with triple the capacity, cost 6 billion Euros and were finished in three years.[29]In addition, Siemens wind farm planned to be built in the coming seven years with a total capacity of 2000 MW is expected to cost € 2bn.[30]Solar photovoltaic stations in Binban with a total capacity of 1465 MW, estimated to cost 2 billion US$.[31]

> ***"Thus, the cost of building the nuclear plant in Dabaa is about 12 times the cost of building combined gas stations, 6 times the cost of a wind farm and 3 times the photovoltaic solar plants of the same capacity."***

By comparing the prices of generated electricity we find that the wind tariff in Jebel El Zayt in 2016 was 0.04 US $/kWh.[32]The LCOE from PV plants ranged from 0.079 - 0.181 US$/kWh in 2016, depending on the type of plant and that of combined gas cycle ranged between 0.076 and 0.115 US$/kW.[33]

PV prices in other countries in the region were even cheaper than Egyptian prices. For example, the Abu Dhabi complex achieved 2.42 cents/kWh for photovoltaic panels, Saudi Arabia›s Sakaka solar project achieved 1.79 cents. [34]

The LEOC of nuclear electricity in Egypt is not yet known but it is not expected to be lower

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28- "Russia to Loan Egypt $25bn for Nuclear Plant Construction." RT International. November 30, 2015. Accessed June 18, 2019. https://www.rt.com/business/324005-russia-egypt-plant-loan/

29- Associated Press. "Egypt Inaugurates Power Plant Projects." Power Engineering. July 24, 2018. Accessed June 18, 2019. https://www.power-eng.com/articles/2018/07/egypt-inaugurates-power-plant-projects.html

30- Farag, Mohamed. "Siemens Gamesa Establishes Wind Farms in Egypt with Investments of €2bn." Daily News Egypt. October 09, 2018. Accessed June 18, 2019. https://www.dailynewsegypt.com/2018/10/09/siemens-gamesa-establishes-wind-farms-in-egypt-with-investments-of-e2bn/

31-The Ministry of Electricity and Renewable Energy, 'Launching of MERE Projects: 24 July 2018'. Powerpoint Presentation. Accessed June 18 2019. http://www.moee.gov.eg/test_new/Launcing_newprojects.pdf

32- "IRENA Director-General Meets with Egypt President El-Sisi to Discuss Renewable Energy Deployment." International Renewable Energy Agency. December 15, 2016. Accessed July 22, 2019. https://www.irena.org/newsroom/pressreleases/2016/Dec/IRENA-Director-General-Meets-with-Egypt-President-el-Sisi-to-Discuss-Renewable-Energy-Deployment.

33- Noha Saad Hussein, Mohamed Abokersh, Christoph Kost and Thomas Schlegel, 'Electricity Cost from Renewable Energy Technologies in Egypt', Fraunhofer Institute for Solar Energy Systems ISE, December 2016. Accessed 18 July 2018. https://www.ise.fraunhofer.de/content/dam/ise/en/documents/publications/studies/Dec2016_Fraunhofer-ISE_LCOE_Renewable_Energy_Technologies_EN_v20_ns.pdf

34- البيان "مشروعات الإمارات خفّضت تكلفة الطاقة المتجددة عالمياً." محمد, عبد الحي. January 14, 2018. Accessed June 18, 2019. https://www.albayan.ae/economy/local-market/2018-01-14-1.3158876

4- Nuclear companies Losses in the market.

The high cost of generating nuclear electricity reflected on the inability of the nuclear industry to compete in markets.

> ***"In 2017, Westinghouse company, the largest nuclear power builder in history filed bankruptcy after massive losses.[35]AREVA, the French government owned company accumulated US$12.3 billion losses over the previous six years.[36]Of the 61 operational nuclear power plants in the United States 34 were losing money - $2.9 billion per year collectively.[37]"***

That same year, energy utilities shares in Europe had lost most of their value compared to the last decade. In Germany RWE lost −82%, E.ON −87%. In the UK, EDF lost −89%. In France, Engie lost−75%.[38] In Asia, the Chinese utility CGN, lost about 60 % of its share value since 2015. The Korean utility KEPCO, lost 37% of its value over 2016 year[39]

Nuclear Energy is a High Risk investment

Building a new nuclear plant is a high economic risk. Nuclear plants consume big capital and need a long time to be built and are very prone to delay and budget overruns.[40]

Over the sixties, the actual cost for building a nuclear plant was almost three times higher than the original projection for it. Over the seventies the actual cost became seven times the projected one.[41]

35- "New York Southern Bankruptcy Court Case 1:17-bk-10778 - Westinghouse..." Inforuptcy. Accessed June 18, 2019. https://www.inforuptcy.com/filings/nysbke_273415-1-17-bk-10778-westinghouse-international-technology-llc#docket_text

36- Mycle Schneider, Antony Froggatt (with Julie Hazemann, Tadahiro Katsuta, M.V. Ramana, Juan C. Rodriguez, Andreas Ruedinger and Anges Stienne) The World Nuclear Industry: Status Report 2017, A Mycle Shcneider Consulting Project, Paris, September 2017. pp 34 Accessed June 18 2019. https://www.worldnuclearreport.org/IMG/pdf/20170912wnisr2017-en-lr.pdf

37- Polson, Jim. "Why Nuclear Power, Once Cash Cow, Now Has Tin Cup." Bloomberg.com. July 14, 2017. Accessed June 2019 https://www.bloomberg.com/news/articles/2017-07-14/why-nuclear-power-once-cash-cow-now-has-tin-cup-quicktake-q-a

38- Ibid, Schneider et al.

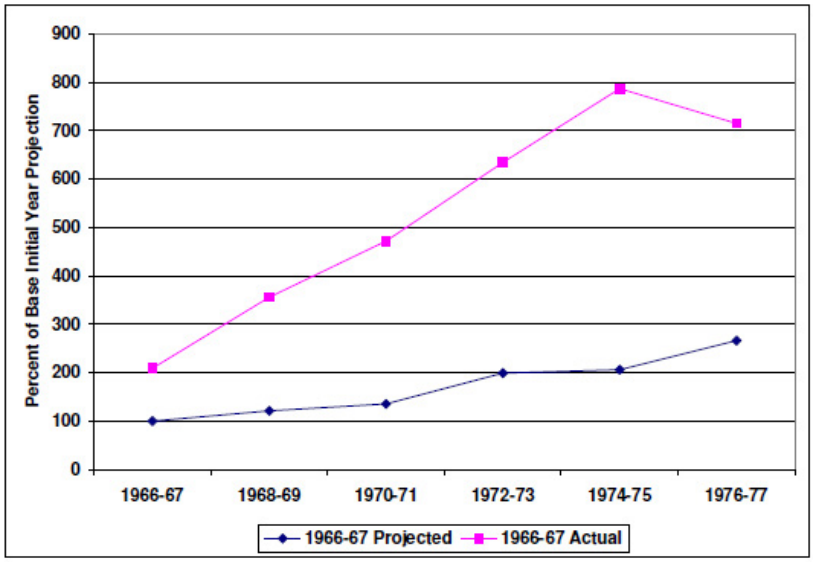
39- Ibid

40- Energy Informer. "Nuclear Construction: Never On Time, Or Budget." Breaking Energy. August 15, 2014. Accessed June 18, 2019. https://breakingenergy.com/2014/08/15/nuclear-construction-never-on-time-or-budget/

41- Ibid, Energy Informer.

Fig (11): Actual and Projected Capital Costs by Date of Commencement of Construction, Completed Reactors [source: Nuclear Monitor, based on the Energy Information Administration, January 1 1986]

Figure IV-2: Actual and Projected Capital Costs by Date of Commencement of Construction, Completed Reactors



Soaring, uncertain costs continued in more recent projects. In 2004 the projected cost of a new reactor in Maryland USA by was $2-2.5 billion, by 2008 the estimated cost was $9.6 billion, the final overall costs are likely to reach $13-15 billion.[42]

5- Hidden Costs

a-Subsidies

Nuclear reactors are not able to compete economically in the marketplace without massive subsidies. Subsidies shift costs and risks to consumers and taxpayers.[43]It is most revealing that nowhere in the world where there is a free competitive market for electricity, has one single nuclear power plant been initiated.[44]

> ***"Calculating nuclear electricity costs may be falsely lowered by subsidies but this doesn't mean that resources are not consumed. Subsidies must be added to pocketbook cost to complete the estimate of costs. When this is done it would make nuclear power even much more expensive."***[45]

42- Ibid, Smith.

43- Ibid, Cooper

44- "UNFAIR AID: The Subsidies Keeping Nuclear Energy Afloat." Nuclear Monitor. World Information Service on Energy. June 24, 2005. Accessed June 18, 2019. https://www.wiseinternational.org/nuclear-monitor/630-631/unfair-aid-subsidies-keeping-nuclear-energy-afloat

45- Ibid, Cooper

Subsidies can take many forms. Some examples of subsidies include[46]:

Limiting the amount of primary insurance, caps on the total liability of nuclear operators in the event of a serious accident, production tax credits, loan guarantees, tax incentives that make capital accessible, power purchase agreements, decommissioning and waste disposal subsidies.

Subsidizing Nuclear in Egypt

> ***"The recent amendments of the Egyptian nuclear laws and regulations grant the Dabaa project many kinds of subsidies."***

For example, the regulations exempt the nuclear station authority, the owner of the plant, from custom taxes and from other taxes and fees and from all taxes on the interest of foreign loans. They also exempt subcontracted companies from custom duties and taxes and from the commitment to the minimum rate of distribution of profits, and exempts foreigners working in the projects from all taxes on salaries and wages.[47]

b-Excluding Externalities

Externalities or external costs may include environmental costs, health care costs, pollution and climate change costs.

> ***"Nuclear Industry does not pay the External costs (externalities) but they are paid by society at large. One study estimated the external cost of EU countries from the nuclear industry at 2.7 billion euros a year.[48]***

The calculation of external costs is not a simple task because of the uncertainties and assumptions involved.[49]But not incorporating external costs implies that these costs are zero which is clearly wrong and unjust.

46- Fatal Flaws of Nuclear Energy, Public Citizen. April 2006. Accessed 18 July 2019. https://www.citizen.org/wp-content/uploads/fatalflawssummary.pdf

47- "Egyptian Initiative for Personal Rights." EIPR Objects to Nuclear Energy Laws and Demands That Nuclear Plant Contracts Not Be Signed before Laws Are Reviewed. December 10, 2017. Accessed June 18, 2019. https://eipr.org/en/press/2017/12/eipr-objects-nuclear-energy-laws

48- Ibid, 'False Promises.'

49- Staff of Nuclear Information and Resources Service, 'False Promises', Nuclear Information and Resources Service. May 2008. Accessed 18 July 2019. https://www.nirs.org/wp-content/uploads/falsepromises.pdf

Chapter Three :Dangerous Impacts on Health and Environment

1- Summary of the Chapter

Nuclear energy is not "clean" energy. Every aspect of the nuclear fuel cycle releases ionizing radiation and toxic materials. Ionizing radiation can break molecular bonds causing unpredictable chemical reactions. Acute exposure to high doses of ionizing radiation can kill within a matter of days or weeks. Exposure to low levels of radiation on a prolonged basis can damage bodies and result in cancer.

A Nuclear plant normally produces large quantities of radioactive materials. A fraction of this radioactivity is released into the environment. Laws regulate the levels of these emissions which are claimed to be harmless. The claim about harmless low levels of radiation proved to be false. Since the 1980s populations living near nuclear facilities have complained of increasing cancer cases especially among their children. Many studies confirmed the phenomenon, yet many refrained from blaming the nuclear plants for it on the basis that radiation levels were too low to cause cancer.

But an important report was released in 2006 by the US National Research Council for researching the effects of low levels of radiation, which concluded that there is no such "safe dose" of ionizing radiation even at the very low levels.

Nuclear power plants use huge amounts of water for cooling. The process of withdrawing huge amounts of water, heating it up, then discharging it into water ecosystems has huge negative environmental impacts on water quality and ecosystem diversity.

The East Mediterranean where Dabaa is located is one of the most oligotrophic marine areas in the world (clear water suitable for swimming and fishing). The Nuclear Power Plant in Dabaa would alter water quality in the area. This possible degradation would negatively affect fishing and touristic activities.

2- Radiation from nuclear power plants

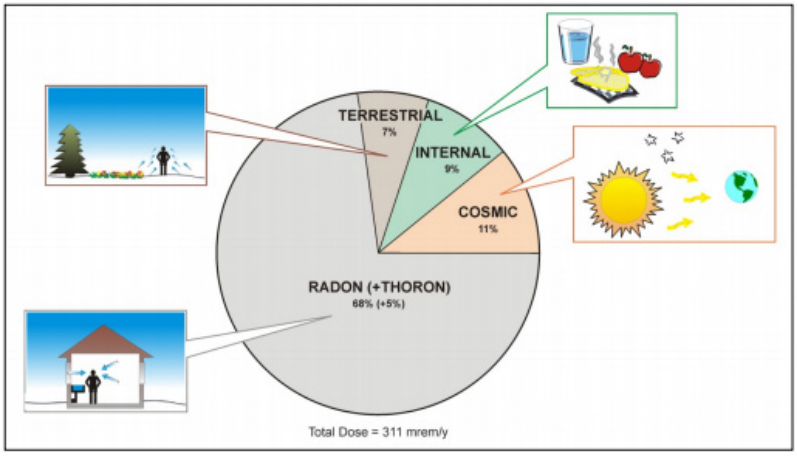
Radiation is energy that travels in waves and sometimes in particles. It includes visible light, ultraviolet light, radio waves and others. Each type of radiation has different properties. Non-ionizing radiation can shake or move molecules. Ionizing radiation can break molecular bonds causing unpredictable chemical reactions.[50]

Humans are exposed to natural background radiation every day from the ground, the buildings, air, food, and the universe. The amount of terrestrial radiation varies geographically. Average annual exposures worldwide to natural radiation sources would generally be in the range of 1–10 mSv, with 2.4 mSv being the estimate of the central value.[51]

50- Cindy Folkers, Radiation Basics, Nuclear Information and Resource Service. Accessed June 18 2019. https://www.nirs.org/wp-content/uploads/radiation/radiationbasics.pdf

51- "Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2" at NAP.edu." National Academies Press: OpenBook. 2006. Accessed June 18, 2019. https://www.nap.edu/read/11340/chapter/1

Fig (12): Natural Background Radiation in the United States [source: United States Nuclear Regulatory Commission]



"Even exposure to natural sources of radiation is not without danger. About one-half of natural human radiation exposure comes from radon. Radon is the second leading cause of lung cancer in the United States. It causes 15,000 to 22,000 lung cancer deaths each year"[52]

Radon was identified as a health problem when scientists noted that underground uranium miners died of lung cancer at high rates.

Increasing human exposure by creating nuclear facilities is clearly very unwise risky behaviour. Humans, through nuclear power, bomb production and testing have created and released man-made radioactive elements (radionuclides) that were previously unknown in nature.[53]

> ***"The operation of nuclear plants produces large quantities of radioactive materials. A fraction of this activity is typically emitted to the environment each year in airborne and liquid form."***

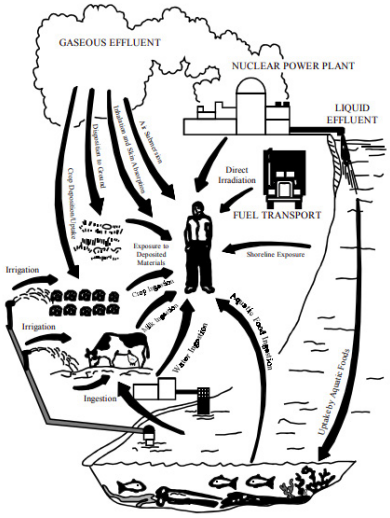
Elements like Krypton, Xenon, Iodine, Bromine, Cobalt, Cesium, Chromium, Tritium, Zirconium are routinely vented into the air, carried to downwind rivers, land and residents.[54]

52- "Radon and Cancer." National Cancer Institute. December 6, 2011. Accessed June 18, 2019. https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/radon/radon-fact-sheet#q6

53- Ibid, Folkers

54- Committee on the Analysis of Cancer Risks in Populations near NuclearFacilities-Phase I. "TABLE 2.2, Common Radionuclides in Reported Liquid Effluent Releases from Nuclear Plants - Analysis of Cancer Risks in Populations Near Nuclear Facilities - NCBI Bookshelf." National Center for Biotechnology Information. March 29, 2012. Accessed June 18, 2019. https://www.ncbi.nlm.nih.gov/books/NBK201991/table/tab2_2/?report=objectonly

Fig (13) Some Pathways of Gaseous and Liquid Radioactive Wastes after processing and how they may be released to the environment [source: Reactor Concepts Manual: Radioactive Waste Management]



Sometimes "inadvertent" radioactive release from a plant may occur which raises the amounts of radioactivity regularly emissioned from a nuclear plant.[55]

3- Impact of Radiation on Health

Exposure to ionizing radiation causes immediate and delayed health effects depending on the dose and rate of exposure. Very large doses of radiation can cause Acute Radiation Syndrome. Its symptoms include hair loss, skin burns, nausea, gastrointestinal distress and death. Exposure to low levels on a prolonged basis can result in different kinds of cancers.[56]For example plutonium-23 causes lymphoma or leukaemia, iodine-131 causes thyroid cancer and strontium-90 causes breast cancer. [57]

Laws regulate the allowed radiation exposure from nuclear reactors. For example, the US sets the limit of 1mSv/year for the general public. For workers, the maximum dose must not exceed 50 mSv per year and 100 mSv for a set of 5 consecutive years.

(1 mSv=100 mrem).[58]

55- Ibid, 'Table 2.2, Common Radionuclides.'

56- "CDC Radiation Emergencies | Acute Radiation Syndrome." Centers for Disease Control and Prevention. April 4, 2018. Accessed June 18, 2019. https://www.cdc.gov/nceh/radiation/emergencies/ars.htm?CDC_AA_refVal= https://emergency.cdc.gov/radiation/ars.asp See also, Smith, 'Nuclear Roulette'

57- Kyne, Dean, and Bob Bolin. "Emerging Environmental Justice Issues in Nuclear Power and Radioactive Contamination." International Journal of Environmental Research and Public Health 13, no. 7 (2016): 700. Accessed June 18, 2019. doi:10.3390/ijerph13070700.

58- NRC Occupational Dose Limits, United States Nuclear Regulatory Commission. Accessed June 19 2019. https://www.nrc.gov/images/about-nrc/radiation/dose-limits.jpg

These levels of exposure have been claimed to result in no harmful health effects.[59]The U.S. NRC and many other regulatory bodies in many countries,[60]claim that biological effects from exposure to low levels of radiation are very small and may not be detectable. But this is not true.

Leukemias in Children around Nuclear Plants:

Evidence on the harm from chronic exposure to low levels of radiation in different areas in the world were accumulating over the years.

"Populations living near nuclear facilities complained of increasing cancer especially leukaemias among their children. Studies and surveys confirmed this increase".

#A study performed by the British Office of Population Censuses and Surveys, over the period 1959- 1980 reported higher incidence of leukaemia in children in the vicinity of the Sellafield fuel reprocessing facility in England.[61]

#Results from another study in 1993 on the same region covering the period from 1984-1990 matched the same findings.[62]

Higher incidence of leukaemia was found in children who lived within a few kilometres of the Aldermaston and Burghfield military weapon facilities in England (1989).[63]

Reports of excess leukaemia cases in young people living near the Dounreay Nuclear Power Development Establishment in northern Scotland, confirmed by The Committee on Medical Aspects of Radiation in the Environment (COMARE) 1986.[64]

The Atomic Energy Control Board of Canada (AECB) undertook several studies which found an increased prevalence of leukaemia in children living near nuclear facilities (1989 and 1991).[65]

59- Ibid, Kyne and Bolin

60- Statements from Governments and Expert Panels Concerning Health Effects and Safe Exposure Levels of Radiofrequency Energy (2000-2010), October 4 2010. EMF & Health. Accessed June 19 2019. http://www.emfandhealth.com/Expert_Reviews_Quotations_2000-2010__10-04-10_.pd

61- Forman, David, Paula Cook-Mozaffari, Sarah Darby, Gwyneth Davey, Irene Stratton, Richard Doll, and Malcolm Pike. "Cancer near Nuclear Installations." Nature 329, no. 6139 (October 8, 1987): 499-505. Accessed June 19, 2019. doi:10.1038/329499a0.

62- Draper, G. J., C. A. Stiller, R. A. Cartwright, A. W. Craft, and T. J. Vincent. "Cancer In Cumbria And In The Vicinity Of The Sellafield Nuclear Installation, 1963-90." BMJ: British Medical Journal 306, no. 6870 (1993): 89-94. Accessed June 2019. http://www.jstor.org/stable/29718138.

63- Jablon, Seymour, Zdenek Hrubec, and John D. Boice, Jr. "Cancer in Populations Living Near Nuclear Facilities." IAEA Bulletin 265, no. 11 (February 1991): 1403. Accessed June 19, 2019. doi:10.1001/jama.1991.03460110069026.

64- W. S. WATSON (1996) The measurement of radioactivity in people living near the Dounreay Nuclear Establishment, Caithness, Scotland, International Journal of Radiation Biology, 70:2, 117-130, DOI: 10.1080/095530096145111

65- McLaughlin, J.R., Clarke, E.A., Nishri, E.D. et al. Cancer Causes Control (1993) 4: 51. https://doi.org/10.1007/BF00051714

The US National Cancer Institute, revealed a significant increase in childhood leukaemia in areas closest to reactors (1990).[66]

#A study of the incidence of childhood malignancies in 20 areas surrounding major nuclear installations in Germany reported a 10 % increase of risk for the incidence of childhood malignancies near nuclear installations especially within 5 km, 1992.[67]

#The Oxford Survey of Childhood Cancer study in 1995 reported a 40 % increase in the cancer rate among children below age 15 at exposure to low radiation doses in the range of 10 to 20 mSv.[68]

#Similar Studies of cancer in children following radiation exposure in utero or in early life indicate that radiation-induced cancers can occur at doses as low as 10 mSv.[69]

In 2001 a survey which included all people under the age of 25 years living in area from 0-35 Km from La Hague nuclear waste reprocessing plant in France between 1978 and 1998 showed an increased incidence of cancer.[70]

In 2007 the Radiation and Health in Durham Study, in Ontario Canada, found statistically significant increases compared to Ontario levels in combined cancers, breast cancer, thyroid cancer, bladder cancer, multiple myeloma, leukaemia and congenital neural tube defects in the vicinity of the Pickering and Darlington nuclear reactors[71]

#In 2009 reports about the cancer rate for people under the age of 25 living near the Fermi nuclear plant in Michigan said rates rose to more than triple the state average since 1988.[72]

In 2008 the famous KiKK study in Germany provided compelling evidence of a positive relationship between a child's risk of leukaemia and residential proximity to a nuclear power plant. The study was contracted by the German government and the Childhood Cancer Reg-

66- Janiak MK. Epidemiological evidence of childhood leukaemia around nuclear power plants. Dose Response. 2014;12(3):349–364. Published 2014 Feb 25. doi:10.2203/dose-response.14-005.Janiak

67- Michaelis, J., Keller, B., Haaf, G. et al. Cancer Causes Control (1992) 3: 255. https://doi.org/10.1007/BF00124259

68- Ibid, 'Health Risks from Exposure..'

69- R Doll, and R Wakeford, Risk of Childhood cancer from fetal irradiation. Imperial Cancer Research Fund Cancer Studies Unit, Radcliffe Infirmary, Oxford UK. An International Journal of Radiology, Radiation, British Institue of Radiology. Published January 28, 2014. Volume 70, Issue 830.https://doi.org/10.1259/bjr.70.830.9135438

70- Guizard AV, Boutou O, Pottier D, et al. The incidence of childhood leukaemia around the La Hague nuclear waste reprocessing plant (France): a survey for the years 1978-1998. J Epidemiol Community Health. 2001;55(7):469–474. doi:10.1136/jech.55.7.469

71- Ibid, McLaughlin

72- Melzr, Eartha Jane. "CANCER QUESTIONS GROW AROUND FERMI NUCLEAR PLANT IN MICHIGAN." Precaution. February 17, 2009. Accessed June 19, 2019. http://www.precaution.org/lib/09/prn_cancer_near_fermi_plant.090217.htm

istry at the University of Mainz (GCCR)[73]

The KiKK study examined all cancer cases around all 16 nuclear reactors in Germany between 1980 and 2003. This included 1,592 patients under five years of age with cancer and 4,735 controls. The study is statistically strong and its findings are statistically significant. The findings have also been confirmed by two meta-analyses.[74]

The Kikk study showed a statistically significant malignancy increase (2.2-fold increase in leukaemia and 1.6-fold increase in solid tumors) among children under five years of age living in the inner 5 km circle around nuclear power plants when compared to residence outside this area.[75]

All these cases of increased cancer around nuclear facilities all over the world can hardly be due to chance, yet many studies although confirming the increase in cancer did not connect it to nuclear plants. It was claimed that the radiation doses from the nuclear facilities were too low to cause any harm.[76]low levels of radiation were considered safe, but this is not true:

There are no safe levels of radiation

An important report was released in 2006 by the commission specifically formed by the "US National Research Council to Research the Effects of Low Levels of Radiation". The report was the seventh in a series that addresses the effects of exposure to low doses of ionizing radiation on human health.[77]After years of work the commission concluded that it is unlikely that a threshold exists for the induction of cancer although the occurrence of radiation-induced cancers at low doses will be small. Approximately one person in 100 would develop cancer from a dose of 0.1 Sv above background levels, and one per thousand from an exposure of 0.01 Sv. The report concludes:

> ***"There are no safe levels of radiation. Even sometimes a single radiation track resulting in the lowest exposure possible traversing the nucleus of an appropriate target cell has a low but finite probability of damaging the cell's DNA. Women and children are more susceptible to radioactive risks."[78]***

73- Kaatsch, Peter, Claudia Spix, Sven Schmiedel, Renate Schulz-Rath, Andreas Mergenthaler, and Maria Blettner. "Epidemiologische Studie Zu Kinderkrebs in Der Umgebung Von Kernkraftwerken : (KiKK-Studie) ; Zusammenfassung / Summary ; Teil1: Fall-Kontroll-Studie Ohne Befragung ; Teil 2: Fall-Kontroll-Studie Mit Befragung ; Vorhaben StSch 4334." DORIS. 2007. Accessed June 19, 2019. https://doris.bfs.de/jspui/handle/urn:nbn:de:0221-20100317939

74- Ghirga: Cancer in children residing near nuclear power plants: an open question. Italian Journal of Pediatrics 2010 36:60

75- Cathy Vakil and Linda Harvey, Human Health Implications of Uranium Mining and Nuclear Power Generation, May 2009. http://www.abolition2000.org/a2000-files/Human_Health_Implications_Uranium_Mining_and_Nuclear_%20Power_Generation.pdf

76- Ibid, Ghirga

77- Ibid, "Health risks from Exposure .' https://www.nap.edu/read/11340/chapter/1

78- Ibid, 'Health Risks from Exposure...'

4- Impact of Nuclear Plants on Water and Environment

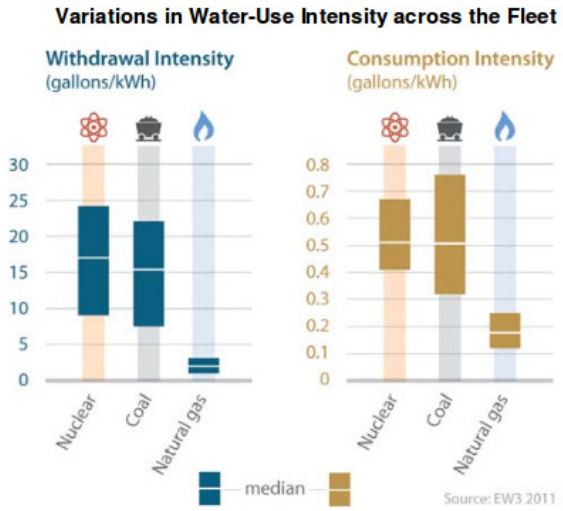
Nuclear reactors produce much more heat in the fission process than is needed to generate electricity. For each unit of electrical energy generated, two units of heat energy are released into the environment; nuclear reactors are 33% efficient. Huge amounts of water are needed to cool this excess heat.[79]An average 1000 Megawatt plant once-through cooling system, draws 500,000 gallons of water a minute, while a closed-cycle cooling system draws 20,000 gallons per minute.[80]

The average nuclear plant withdraws nearly 8 times as much water as the average natural gas plants, and 11% more than the average coal plant. A Nuclear power plant consumes three times as much water as natural gas, and about 4% more than coal plants.[81]

In the event of serious accidents like reactor overheating, It needs a supply of 10-30 thousand gallons of water per minute for at least 30 days after the reactor is turned off .[82]

> ***"Nuclear power plants use more water per unit of electricity produced than any other power plants."***

Fig (14): Variations in Water-Use Intensity by Fuel and Cooling Technology [source: Union of Concerned Scientists]



79- Union of Concerned Scientists. Nuclear Power and Water: Fact Sheet. December 2011. Accessed June 19, 2019.https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/fact-sheet-water-use.pdf

80- Lina P. Funter et al, Licensed to kill: How nuclear power industry destroys endangered marine wild life- and ocean habitat to save money (2001), available at https://www.nirs.org/wp-content/uploads/reactorwatch/licensedtokill/LiscencedtoKill.pdf

81- Ibid, licensed to kill

82- How it Works: Water for power plants cooling, Union of concerned scientists. Accessed June 19,2019 https://www.ucsusa.org/resources/water-power-plant-cooling#.XERHvdIzZdg

The huge water intake pipes that draw these huge amounts of water suck up also marine fishes and animals at a very high velocity, once drawn in, they get trapped against prevention devices such as screens, bars, and nets. Larger animals like turtles for example, may drown or suffocate. Smaller organisms may be sucked through the entire reactor system and are often scalded by the heated water or crushed before being discharged into the waterway as debris. The debris discharged in the waterways clouds the water curtailing the light and oxygen needed by plant and animal marine life and deteriorating the water quality.

The heated water dramatically alters the immediate marine environment causing fatal diseases for marine organisms and seabirds. Warmer temperatures also drive away indigenous species of fish and attract other invading organisms further stressing the displaced species and threatening their survival.[83]

Life on land suffers significant impacts from uranium mining. All tailings piles release radon gas and long-lived radioactive isotopes into the air, rivers, and aquifers. Serious accidents can make this pollution more grave. In 1979, about 94 million gallons of contaminated liquid tailings burst from a containment dam in New Mexico, sweeping tons of radioactive wastes into the Rio Puerco River.

In 1984, a flash flood flushed four tons of tailings into the Colorado River, which provided irrigation for farms and drinking water for cities in Nevada and southern California.[84]

5- Impacts of Dabaa plant on Environment

The Dabaa project is located on the North coastline of the Mediterranean sea between Alexandria and Marsa Matrouh. It lies within 5 Km of Di Majoca and Coronado coastal resorts. It will be constructed on an area of 45 square kilometres, with an extension of 15 kilometres on the sea coast.

Fig (15): location of Dabaa Nuclear Plant [source: Google Earth]

83- Ibid, 'Licensed to Kill'

84- Ibid, 'False Promises'

The Mediterranean is a large marine ecosystem which is under severe pressures from multiple human activities. It harbours 1/3 of the global maritime traffic and it is the first tourist destination in the world, It is also subject to fishing overexploitation, land based pollution and hydrocarbons extraction activities.[85]Ecological indicators, such as community biomass, trophic levels, catch and diversity fishing indicators, reflect such pressure and show overall ecosystem degradation.[86]

The eastern Mediterranean Sea, where Dabaa is located is a rare exception of this ecosystem degradation.[87]The Dabaa area is one of the most oligotrophic marine areas in the world (clear water suitable for swimming and fishing). It is also a rare precious exception for Egypt's coasts compared to the Alexandria Region or the Delta region.[88]

> ***"The expected degradation of ecosystem diversity and water quality by the plant and related activities in Dabaa would negatively affect the economic activities relying on them like fishing and touristic activities beyond repair".***

85- The 2016 Status of Marine Protected Areas in the Mediterranean: Main Findings. MedPan, RAC/SPA. 2016. Accessed June 19 2019. http://d2ouvy59p0dg6k.cloudfront.net/downloads/medpan_forum_mpa_2016___brochure_a4_en_web_T_.pdf

86- Piroddi, Chiara, Marta Coll, Camino Liquete, Diego Macias, Krista Greer, Joe Buszowski, Jeroen Steenbeek, Roberto Danovaro, and Villy Christensen. "Historical Changes of the Mediterranean Sea Ecosystem: Modelling the Role and Impact of Primary Productivity and Fisheries Changes over Time." Scientific Reports 7, no. 1 (March 14, 2017). Accessed June 19, 2019. doi:10.1038/srep44491.

87- Gharib, Samiha M., Zeinab M. El-Sherif, Ahmed M. Abdel-Halim, and Ahmed A. Radwan. "Phytoplankton and Environmental Variables as a Water Quality Indicator for the Beaches at Matrouh, South-eastern Mediterranean Sea, Egypt: An Assessment." Oceanologia 53, no. 3 (September 26, 2011): 819-36. Accessed June 19, 2019. doi:10.5697/oc.53-3.819

88- Annual report on water quality data from the coastal waters of The Mediterranean Sea, 2000. Ministry of Energy and Renewable Energy. Accessed on June 19 2019. http://www.eeaa.gov.eg/eimp/reports/EIMP%20Med_%20water%20rep_2.pdf

Chapter Four: The Unsolvable Issue of Nuclear Waste

Fig (16): Decay of old radioactive material container [source: shutterstock]

1- Summary of the Chapter

The total amount of High level waste from spent fuel generated by 2020 is estimated at 445 thousand tons. The spent fuel waste is millions of times more radioactive than fresh uranium and stays active for thousands of years.

While more nuclear waste is accumulating, there is no long term solution in sight. These amounts of high radioactive materials are simply kept in temporary pools and dry casks all around the world.

Deep geological repositories, believed to be the safest way for long term disposal, are not available.

The accumulated waste poses eminent risk of radioactive leakage into the environment. There are many records of incidents when nuclear waste was disposed of improperly, defectively, or simply abandoned, washed away or stolen from waste storages.

Dumping waste in the oceans was not banned till the nineties. Scientists are finding evidence of raised radioactivity levels in sea floors and in marine life. The dumped waste is making its way back to our bodies and food. Reprocessing of the used fuel is not the solution, it may even increase the risk of nuclear proliferation.

2- Piles of Risk

The high level nuclear waste of spent fuel is millions of times more radioactive than fresh uranium and stays active for a very long time.[89]

89- Mary Olson. NIRS EnergyFactSheets: Reprocessing is not the "solution" to the Nuclear Waste Problem. Nuclear Information and Resource Service. January 2006. Accessed June 2019. https://www.nirs.org/wp-content/uploads/factsheets/reprocessisnotsolution.pdf

"Over ten thousand metric tons of heavy metal (tHM) from spent fuel are unloaded each year from nuclear plants all over the world. The total amount of spent fuel generated by 2020 is estimated at 445 thousand tons"[90]

Some radioactive atoms in the spent fuel have very long half- life:

Plutonium has a half-life of 24 thousand years.[91]
Technetium(Tc-99) has a half-life of 220 thousand years.[92]
Cesium-137 and strontium-90 have half-lives of approximately 30 years.[93]

Fig (17): Radioactive waste barrels [source: Shutterstock]

The accumulated waste poses eminent risk of radioactive leakage into the environment. There are many records of incidents when nuclear waste has been disposed of improperly, defectively or simply abandoned or stolen from waste storages.

Here are some examples:

In 1968 waste stored in Lake Karachay in the Soviet Union was blown over the area during a dust storm after the lake had partly dried out.[94]

90- Storage and Disposal of Sepnt Fuel ad High Level Radioactive Waste. 2006. International Atomic Energy Agency. Accessed June 24 2019. https://www-legacy.iaea.org/About/Policy/GC/GC50/GC50InfDocuments/English/gc50inf-3-att5_en.pdf

91- "Backgrounder on Plutonium." United States Nuclear Regulatory Commission - Protecting People and the Environment. March 2017. Accessed July 22, 2019. https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/plutonium.html.

92- "Technetium 99." Radioactivity. Accessed July 22, 2019. http://www.radioactivity.eu.com/site/pages/Technetium_99.htm.

93- "Hazardous Isotopes." Radioactivity and Radiation. Accessed July 22, 2019. https://www.geigercounter.org/radioactivity/isotopes.htm.

94- Alexey O. Merkushin, Karachay Lake is the Storage of the Radioactive Wastes under Open Sky. Ozyorsk Technological Institute of Moscow Physical Engineering Institute.Accessed June 20 2019. https://inis.iaea.org/collection/NCLCollectionStore/_Public/33/011/33011239.pdf

In 1975 a low-level radioactive waste facility located in Kentucky, collapsed under heavy rainfall into the trenches making them radioactive[95]

In 2018, the US health authorities revealed radioactive material leakage from waste drums stored in the St. Louis area, the soil has been polluted and the nearby Coldwater Stream. [96]

Scavenging of abandoned radioactive material has been the cause of several cases of radiation exposure mostly in developing countries which may have weaker regulations and awareness.[97]

Fig (18): Damaged drum with radioactive waste inside WIPP, New Mexico, USA. The picture was taken on 2014-05-15 during investigations for the cause of radioactive contamination. Site is Panel 7, Room 7 [Source: Wikimedia]

Risk of nuclear proliferation

"Each ton of spent fuel contains around 10 kilograms of plutonium— enough to build a primitive nuclear bomb. Any country with minimal industrial skills can build a small quick and dirty bomb from spent fuel. A reprocessing plant is capable of extracting a bomb's-worth of plutonium a day.[98]"

95- Directions in Low-Level Radioactive Waste Management: A Brief History of Commercial Low-Level Radioactive Disposal. Idaho National Engineering Laboratory EG&G Idaho, Inc. August 1994. Accessed June 20 2019. https://inis.iaea.org/collection/NCLCollectionStore/_Public/26/026/26026627.pdf

96- CBS News. "Federal Health Officials Agree Radioactive Waste in St. Louis Area May Be Linked to Cancer." CBS News. August 07, 2018. Accessed June 20, 2019. https://www.cbsnews.com/news/radioactive-waste-cancer-federal-health-officials-acknowledge-possible-link/.

97- Kennedy, Duncan. "Mafia 'sank Ships of Toxic Waste'." BBC News. September 16, 2009. Accessed June 20, 2019. http://news.bbc.co.uk/2/hi/europe/8257912.stm

98- Victor Gilinsky, Harmon Hubbard, and Marvin Miller, 'A Fresh Examination of the Proliferation Dangers of Light Water Reactors, Washington, DC: The Nonproliferation Policy Education Center, October 22, 2004. Accessed June 21 2019. http://npolicy.org/userfiles/file/Taming-A%20Fresh%20Examination%20of%20the%20Proliferation%20Dangers.pdf

No long term solution in sight:

The policy of nuclear waste management so far has been to store the waste somewhere, without planning for what to do with it later. These high radioactive materials are simply kept in temporary pools and dry casks all around the world. Deep geological repositories, where the waste should be kept shielded very deep for very long periods and which is believed to be the safest ways of storing the nuclear waste, are not available anywhere in the world.

So far, the only country which is building a deep geological repository is Finland. The project (Onkalo) started in 2004 and will be finished next century. The repository is supposed to stand for 100 thousand years and would cost 3.5 billion euros.[99]

There are still doubts whether these repositories can hold for such a long time and resist shifts of tectonic plates that are capable of moving mountain ridges and lifting islands out of the sea, and remain untouched for hundreds of thousands of years.[100]

> ***"The problem of nuclear waste remains with no solution and is an ugly legacy that we leave for future generations"***

3- Dumping in Our bodies

After World War II and for decades the nuclear industries used the oceans as a dumping ground. .

Fig (19): Single radioactive barrel floating in the ocean by morning light [source: dreamstime]

-United States dumped more than 110,000 waste containers in the ocean.[101]

99- Kauranen, Anne. "Finns to Bury Nuclear Waste in World's Costliest Tomb." Phys.org. June 07, 2016. Accessed July 27, 2019. https://phys.org/news/2016-06-finns-nuclear-world-costliest-tomb.html#jC.

100- Zyga, Lisa. "Why Nuclear Power Will Never Supply the World's Energy Needs." Phys.org. May 11, 2011. Accessed July 27, 2019. https://phys.org/news/2011-05-nuclear-power-world-energy.html#jCp.

101- Kozakiewicz, Patrick. "The Disposal of Nuclear Waste into the World's Oceans." CBRNe Portal. January 27, 2014. Accessed June 20, 2019. http://www.cbrneportal.com/the-disposal-of-nuclear-waste-into-the-worlds-oceans/

-Russia dumped some 17,000 containers, 19 ships containing radioactive waste, 14 nuclear reactors including five containing spent fuel; and the K-27 nuclear submarine with two loaded reactors.[102]

-European states dropped 28,500 containers of waste into the English Channel, some of which are now discovered to have leaks.[103]

Defective insulation of the containers, leaks, volcanic activity and tectonic movement make the radioactive waste in the oceans potentially catastrophic. This practice was not banned till the nineties

The Wall St. Journal recently reported that plutonium levels are 1,000 times above normal just 50 miles from San Francisco.[104]Biologists found a link between the increase of skin ulcers on seals and walruses in Alaska, and the leakage of thousands of tons of radioactive water into the ocean from the 2011 accident in Fukushima.[105]

"The dumped radioactive waste is making its way back to our bodies and food"

4- Reprocessing is not the solution

Reprocessing the nuclear waste has been claimed to help solving the waste problem but this is not true.

Reprocessing entails transferring the spent fuel rods to a reprocessing facility, the rods are then chopped into pieces, the pieces are chemically dissolved and the resulting solution is separated into three basic outputs: uranium, plutonium and high level waste. The uranium can be re-enriched into nuclear fuel again. Plutonium can be mixed with uranium to make mixed oxide fuel (MOX) that can be used as a fuel for some nuclear reactors. MOX fuel is harder to control and twice as deadly as uranium fuel if control is lost.[106] High level waste (HLW) from reprocessing needs to be handled similarly to waste from spent fuel. Waste reprocessing increases Risk of Nuclear Proliferation.[107]

102- Dattaro, Laura. "The Soviet Union Dumped a Bunch of Nuclear Submarines, Reactors, and Containers into the Ocean." VICE News. February 20, 2015. Accessed June 20, 2019. https://news.vice.com/en_us/article/vbn9e9/the-soviet-union-dumped-a-bunch-of-nuclear-submarines-reactors-and-containers-into-the-ocean

103- "Nuclear Waste Barrels Remain Strewn across Floor of English Channel - Report." RT International. April 12, 2013. Accessed June 20, 2019. https://www.rt.com/news/nuclear-waste-english-channel-785/

104- Kozakiewicz, Patrick. "The Disposal of Nuclear Waste into the World's Oceans." CBRNe Portal. January 27, 2014. Accessed July 22, 2019. http://www.cbrneportal.com/the-disposal-of-nuclear-waste-into-the-worlds-oceans/.

105- Slavikova, Sara. "7 Reasons Why Nuclear Waste Is Dangerous." Greentumble. December 27, 2017. Accessed June 21, 2019. https://greentumble.com/7-reasons-why-nuclear-waste-is-dangerous/

106- Mary Olson. NIRS Energy Fact Sheet: Reprocessing Is Not the "Solution" to the Nuclear Waste Problem. Nuclear Information and Resource Service. January 2006. Accessed June 21 2019. https://www.nirs.org/wp-content/uploads/factsheets/reprocessisnotsolution.pdf

107- Victor gilinsky, Harmon Hubbard, and Marvin miller, A fresh examination of the proliferation dangers of light water reactors, 2004, Accessed june 2019 http://npolicy.org/userfiles/file/Taming-A%20Fresh%20Examination%20of%20the%20Proliferation%20Dangers.pdf

Chapter Five: Nuclear Accidents

1- Summary of the chapter

Nuclear reactors are, by their very nature, inherently dangerous. At any time, an unforeseen combination of technological failures, human errors or natural disasters could lead to a reactor quickly getting out of control.

The nuclear industry claims that the probability of a major accident like Fukushima is very low but many serious studies disagree significantly. For example, important researchers estimate four serious accidents to occur during the next fifty years, and a 50% possibility of another Chernobyl in the next thirty years.

There is no authoritative and comprehensive public record of nuclear accidents, nonetheless, many unofficial lists of various sorts of accidents are spreading online.

Nuclear accident consequences are enormous. Health effects vary from injury and death from explosions, to acute radiation syndrome, chronic diseases, cancers and mental disorders. Socio- economic consequences may be devastating.

This chapter presents briefs on the top five known serious accidents in history, namely: Kyshtym, Windscale-Sellafield, Three Mile Island, Chernobyl and Fukushima Daiichi.

2- Possibilities of nuclear accidents in the future.

Nuclear Accident is defined by the International Atomic Energy Agency (IAEA) as «an event that has led to significant consequences to people, the environment or the facility." Examples of these significant consequences include "lethal effects to individuals, spread of radioactive isotope to the environment, or reactor core melt."[108]

> ***"Nuclear reactors are, by their very nature, inherently dangerous. Nuclear Accidents happened and will continue to happen. At any time, an unforeseen combination of technological failure, human error or natural disaster could lead to the reactor getting out of control."*** [109]

Even the nuclear industry does not deny this fact, but it claims that the probability of a major accident is very low that, with more than 400 reactors operating worldwide, the probability of a reactor core meltdown would be in the order of one in 250 years.[110]

108- "International Nuclear and Radiological Event Scale (INES)." IAEA. November 22, 2017. Accessed June 21, 2019. https://www.iaea.org/topics/emergency-preparedness-and-response-epr/international-nuclear-radiological-event-scale-ines.

109- Greenpeace, An American Chernobyl: Nuclear "Near Misses" at U.S. Reactors since 1986. August 25 2006. Accessed June 21 2019. https://www.greenpeace.org/usa/wp-content/uploads/legacy/Global/usa/report/2007/9/an-american-chernobyl-nuclear.pdf

110- Prof Tessa Morris-Szuki, Prof David Boilley, Dr. David McNiell, Arnie Gundersen, Fairewinds Associates. Lessons from Fukushima: Executive Summary. Greenpeace International. February 2012. Accessed June 21 2019. https://www.sortirdunucleaire.org/IMG/pdf/greenpeace-2012-lessons_from_fukushima-summary.pdf

But other estimations exist and are quite different:

> ***"An interdisciplinary team from MIT has estimated that given the expected growth of nuclear power at least four serious nuclear power accidents would be expected from 2005–2055."***[111]

> ***"Scientists at the Max Planck Institute for Chemistry in Main said that based on the operating hours of all civil nuclear reactors and the number of nuclear meltdowns that have occurred in the past, such events may occur once every 10 to 20 years"***[112]

> ***"Scientists from ETH Zurich in Switzerland and Aarhus University in Denmark based their work on a comprehensive list of nuclear accidents and concluded that there is a 50% chance that a Chernobyl event occurs in the next 27 years."***[113]

Simple observation of the past tells us a significant nuclear accident has occurred approximately once every decade.[114]

In addition to the "unforeseen" accidents, nuclear reactors are increasingly attracting hostile military attacks. Nuclear power plants were potential targets originally considered for the September 11, 2001 attacks.[115] The cyber attacks against nuclear facilities are rising too,[116]like the

cyber attack against Iran›s nuclear program in 2008,[117]and against South Korea›s nuclear plant in December2014.[118]

> ***"Anyow, the danger of an accident is measured not only by possibilities of occurrence, but also by consequences, and the consequences of a nuclear accident can be extremely grave."***

111- The Future of the Nuclear Fuel Cycle: An Interdisciplinary MIT Study. Massachusetts Institute of Technology. 2011. Accessed June 21 2019. https://energy.mit.edu/wp-content/uploads/2011/04/MITEI-The-Future-of-the-Nuclear-Fuel-Cycle.pdf

112- "Probability of Contamination from Severe Nuclear Reactor Accidents Is Higher than Expected." Max-Planck-Gesellschaft. May 22, 2012. Accessed June 21, 2019. https://www.mpg.de/5809418/reactor_accident

113- Emerging Technology from the ArXiv. "The Chances of Another Chernobyl Before 2050? 50%, Say Safety Specialists." MIT Technology Review. April 21, 2015. Accessed June 21, 2019. https://www.technologyreview.com/s/536886/the-chances-of-another-chernobyl-before-2050-50-say-safety-specialists/

114- Benjamin K. Sovacool. Second Thoughts about Nuclear Power: A Policy Brief - Challenges Facing Asia. January 2011. Accessed June 21 2019. https://issuu.com/nuslkyschool/docs/rsu-policy-brief-2nd-thoughts-nuclear-

115- John F. Ahearne, Albert V. Carr, Jr, Harold A. Feiveson, Daniel Ingersoll, Andrew C. Klein, Stephen Maloney, Ivan Oelrich, Sharon Squassoni, and Richard Wolfson. The Future of Nuclear Power in the United States. Federation of American Scientists/Washington and Lee University. February 2012. Accessed June 25 2019. https://fas.org/pubs/_docs/Nuclear_Energy_Report-lowres.pdf

116- Hitchin, Penny. "Cyber Attacks on the Nuclear Industry." Cyber Attacks on the Nuclear Industry - Nuclear Engineering International. September 15, 2015. Accessed June 21, 2019. https://www.neimagazine.com/features/featurecyber-attacks-on-the-nuclear-industry-4671329

117- Zetter, Kim. "Stuxnet Missing Link Found, Resolves Some Mysteries Around the Cyberweapon." Wired. February 26, 2013. Accessed June 21, 2019. https://www.wired.com/2013/02/new-stuxnet-variant-found/

118- McCurry, Justin. "South Korean Nuclear Operator Hacked amid Cyber-attack Fears." The Guardian. December 23, 2014. Accessed July 28, 2019. https://www.theguardian.com/world/2014/dec/22/south-korea-nuclear-power-cyber-attack-hack.

Nuclear accidents consequences are enormous. Health effects vary from injuries and deaths from the explosion, to acute radiation syndrome, chronic diseases and cancers.[119]Health effects also include mental health disorders like post traumatic stress disorder and depression.[120]The socio- economic consequences of nuclear accidents due to evacuation, loss of jobs and properties in addition to costs of decontamination can be very devastating

How Many Accidents in the past?

There is no authoritative comprehensive public record of nuclear reactors accidents.[121]

Yet, many sorts of unofficial lists are available on the web, we have:

-Lists of civilian accidents.[122]

-Lists of criticality accidents.[123]

-List of military accidents.[124]

-Lists of accidents from sealed sources.[125]

-Lists of accidents from vehicles.[126]

-Lists of accidents with multiple fatalities and/or more than US$100 million damage between 1952-2011.[127]

-Lists of serious accidents.[128]

119- Elena Buglova, Radiation Health Effects, Incident and Emergency Centre, Department of Nuclear Safety and Security, IAEA, 2009. Accessed 28 July 2009. https://www-pub.iaea.org/MTCD/Meetings/PDFplus/2009/36489/p36489/Top%201.1%20E.%20Buglova.pdf

120- Bromet, Evelyn J. "Mental Health Consequences of the Chernobyl Disaster." Journal of Radiological Protection 32, no. 1 (March 6, 2012). Accessed June 21, 2019. doi:10.1088/0952-4746/32/1/n71

121- Minh Ha-Duong, V. Journé. Calculating nuclear accident probabilities from empirical frequencies. Environment Systems and Decisions, Springer, 2014, 34 (2), pp.249-258. ff10.1007/s10669-014-9499-0ff. ffhal-01018478v2f

122- https://en.wikipedia.org/wiki/List_of_civilian_nuclear_accidents

123- https://en.wikipedia.org/wiki/Criticality_accident#Incidents

124- https://en.wikipedia.org/wiki/List_of_military_nuclear_accidents

125- United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. UNSCEAR 2008: Report to the General Assembly with Scientific Annexes. Volume II: Scientific Annexes C, D and E. United Nations, New York. April 2011
http://www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_C.pdf

126- United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. UNSCEAR 2008: Report to the General Assembly with Scientific Annexes. Volume II: Scientific Annexes C, D and E. United Nations, New York. April 2011. http://www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_C.pdf

127- Rogers, Simon. "Nuclear Power Plant Accidents: Listed and Ranked since 1952." The Guardian. March 14, 2011. Accessed July 28, 2019. https://www.theguardian.com/news/datablog/2011/mar/14/nuclear-power-plant-accidents-list-rank#data

128- https://www.theguardian.com/news/datablog/2011/mar/14/nuclear-power-plant-accidents-list-rank#data.

Greenpeace organization has documented nearly 200 "near misses"incidents at U.S. nuclear reactors from 1986 till 2007. Near misses are precursors to severe core damage accidents. Of these, eight were the most significant, but the most worrying was that only one of the most significant eight was on the NRC's regulatory radar prior to the problem.[129]

Many accidents probably remain undeclared.[130]Secrecy, denying, defective information and under evaluation of losses are usual practices from authorities in context of nuclear accidents,[131],[132] even in catastrophic size accidents like Chernobyl. After the Chernobyl explosion, the Soviet authorities remained silent, the first health risk warning came from Sweden, days after the accident, when the measurements showed a 40% rise in radiation levels above normal. It took three weeks, until the Soviet Union officially admitted one of the biggest accidents in the history of nuclear power. Up till now a lot of information about the incident is missing and most probably will remain that way.[133]

3- The Five worst known nuclear accidents in History

(Kyshtym, Windscale-Sellafield, Three Mile Island, Chernobyl, Fukushima)

In 1990, The International Atomic Energy Agency (IAEA) introduced The International Nuclear and Radiological Event Scale (INES).[134]The scale can be used as a tool for the quick assessment of nuclear accidents, level 7 is the worst and level 1 is the mildest.

129- Ibid, 'An American Chernobyl..'

130- MaloneJun, Patrick, and Center for Public Integrity. "A Near-disaster at a Federal Nuclear Weapons Laboratory Takes a Hidden Toll on America's Arsenal." Science. June 29, 2017. Accessed June 21, 2019. https://www.sciencemag.org/news/2017/06/near-disaster-federal-nuclear-weapons-laboratory-takes-hidden-toll-america-s-arsenal

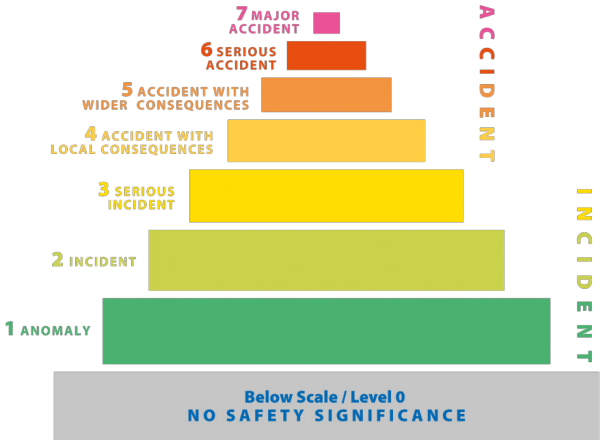
131- Honicker, Clifford T. "AMERICA'S RADIATION VICTIMS: The Hidden Files." The New York Times. November 19, 1989. Accessed June 21, 2019. https://www.nytimes.com/1989/11/19/magazine/america-s-radiation-victims-the-hidden-files.html

132- Wedler, Carey. "The Worst Nuclear Disaster in US History That You've Never Heard About." The Anti-Media. September 28, 2015. Accessed June 21, 2019. https://theantimedia.com/the-worst-nuclear-disaster-in-us-history-that-youve-never-heard-about/

133- History.com Editors. "Test Triggers Nuclear Disaster at Chernobyl." History.com. February 09, 2010. Accessed June 21, 2019. http://www.history.com/this-day-in-history/nuclear-disaster-at-chernobyl

134- Ibid, 'International Nuclear and Radiological Event Scale (INES)..'

Fig (20): INES Rating Description [source: International Atomic Energy Agency]



Below are short briefs of the five worst known nuclear accidents in history.

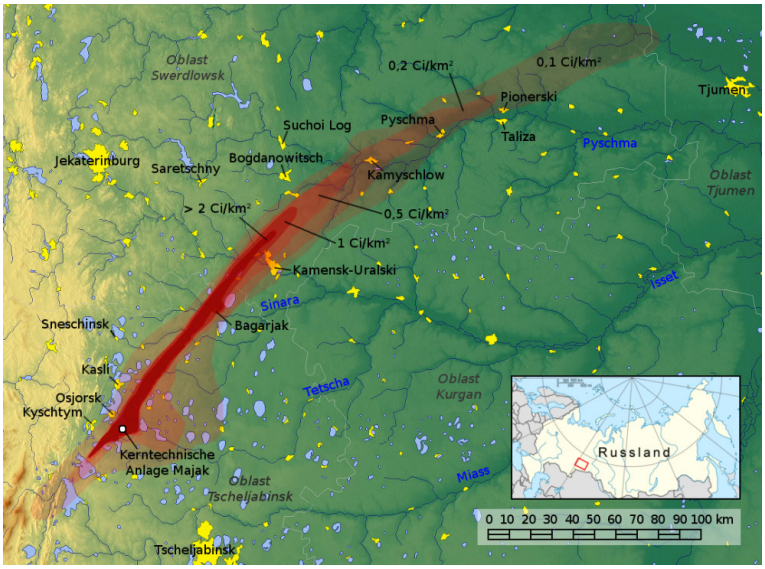
1- Kyshtym, Mayak, Former Soviet Union -INES Level 6- 29 September 1957:

It is the third-most serious nuclear accident ever recorded after the Chernobyl and Fukushima Daiichi disasters. The accident took place in Mayak in the former Soviet Union. It occurred at a plutonium production site for nuclear weapons and fuel reprocessing.

The cooling system in one of the radioactive waste tanks failed. The tank containing about 70–80 tons of liquid radioactive waste exploded and the explosion threw the 160-ton concrete lid into the air and released an estimated 800 PBq of radioactivity (petabecquerel is an SI unit of radioactivity).

Most of the radioactive contamination settled out near the site of the accident and polluted the Techa River. A cloud containing 80PBq of radionuclide spread out over hundreds of kilometres. The fallout of the cloud resulted in a long-term contamination of an area up to 20,000 km2. At least 22 villages were exposed to radiation from the disaster.

Fig (21): Map of the East Urals Radioactive Trace (EURT): area contaminated by the Kyshtym disaster [source: Wikimedia Commons]



The populations of the affected areas were not initially informed of the accident. A week later an operation for evacuating 10,000 people from the affected areas started without giving them an explanation of the reasons for evacuation.[135]To reduce the spread of radioactive contamination after the accident, contaminated soil was excavated and stockpiled in fenced enclosures that were called «graveyards of the earth»[136]

It was only in 1976 (18 years later) that the nature and extent of the disaster became known to the world. Because of the secrecy surrounding Mayak, the number of fatalities and long term consequences remain unknown till now.[137][138]

135- DE SANCTIS, ENZO. MONTI, STEFANO. RIPANI, MARCO. ENERGY FROM NUCLEAR FISSION: An Introduction. SPRINGER INTERNATIONAL PU, 2016.https://bit.ly/2SJpWRz

136- Goetschel, Samira. "'The Graveyard of the Earth': Inside City 40, Russia's Deadly Nuclear Secret." The Guardian. July 20, 2016. Accessed June 21, 2019. https://www.theguardian.com/cities/2016/jul/20/graveyard-earth-inside-city-40-ozersk-russia-deadly-secret-nuclea

137- Dr. Zhores Medvedev. 'Two decades of dissidence'. New Scientist. 4 November 1976. Vol 72 No. 1025. Accessed June 2019. https://books.google.com.eg/books?id=JqEhtUjqORIC&pg=PA264&redir_esc=y#v=onepage&q&f=true

138- Greenpeace International. Mayak: A 50 Year Tragedy. September 2007. Accessed June 21 2019.https://www.greenpeace.org/archive-international/Global/international/planet-2/report/2007/9/mayak-a-50-year-tragedy.pdf

2- The Windscale-Sellafield -INES Level 5- 10 Oct 1957:

Windscale facility lies on the northwest coast of England which is now known as Sellafield.

Fire took place in Unit one of the two-graphite-moderated reactors which continued for three days. The fire released 14000 terabecquerels of radioactive materials which spread over the United Kingdom and Europe. No one was evacuated from the surrounding area, but milk from about 500 km2 of nearby countryside was destroyed (diluted a thousandfold and dumped in the Irish Sea).[139]

Some of the fuel rods from the reactor were removed and the reactor itself was sealed and left intact. In the year 2000, it was estimated that the core still contained 9.12 TBq from 4.0 kg of plutonium-239 (half-life 24,000 years).[140]

Sellafield has a track record of numerous accidents. One accident, occurred in April 2005, included a large leak where 20 tons of uranium and 160 kgs of plutonium leaked from a cracked pipe.[141]

Ireland and Scandinavian countries including Norway and Denmark, bitterly opposed the contamination of Irish sea from the Sellafield. The Irish government took its complaints to the UN in 2001, saying pollution from the site broke the UN convention on the law of the sea.[142]

3- Three Mile Island, Pennsylvania, United States -INES Level 5- March 28, 1979:

A loss of coolant in one of the reactors at Three Mile Island Nuclear Station led to partial meltdown and the release of radioactive substances into the environment. At the beginning the plant owners said everything was under control but later the same day, the situation was declared :more complex, schools were closed and residents were urged to stay indoors. Evacuation of pregnant women and preschool age children within a five-mile radius was advised. Two days later the evacuation zone was extended to a 20-mile radius and 140,000 people left the area[143].

139- McGeoghegan, D.; Whaley, S.; Binks, K.; Gillies, M.; Thompson, K.; McElvenny, D. M. (2010). "Mortality and cancer registration experience of the Sellafield workers known to have been involved in the 1957 Windscale accident: 50 year follow-up". Journal of Radiological Protection. 30 (3): 407–431. Bibcode:-2010JRP....30..407M. doi:10.1088/0952-4746/30/3/001. PMID 20798473

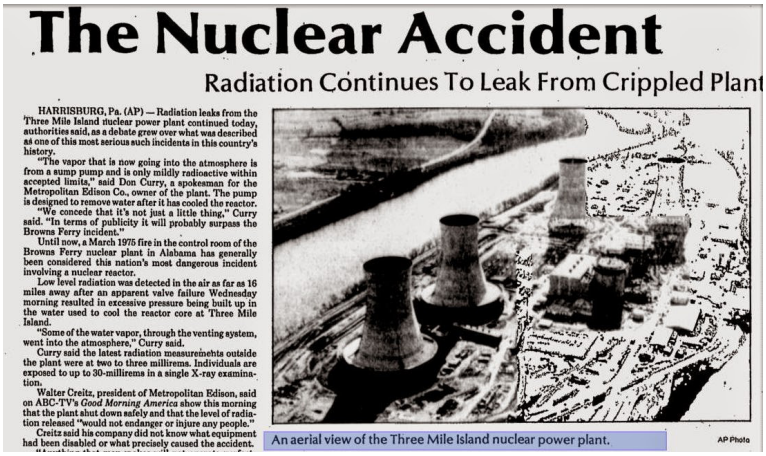
140- D G Pomfret Safety and Dose Management During Decommissioning of a Fire Damaged Nuclear Reactor. International Radiation Protection Association. 2000. Accessed June 21 2019. http://www.irpa.net/irpa10/cdrom/00322.pdf

141- Brown, Paul. "Huge Radioactive Leak Closes Thorp Nuclear Plant." The Guardian. May 09, 2005. Accessed June 21, 2019. https://www.theguardian.com/society/2005/may/09/environment.nuclearindustry

142- Walker, Peter. "From Windscale to Sellafield: A History of Controversy." The Guardian. April 18, 2007. Accessed June 21, 2019. https://www.theguardian.com/environment/2007/apr/18/energy.nuclearindustry

143- Peterson, Cass. "A Decade Later, TMI's Legacy Is Mistrust." The Washington Post. March 28, 1989. Accessed June 22, 2019. https://www.washingtonpost.com/wp-srv/national/longterm/tmi/stories/decade032889.htm?nored&noredirect=on

Fig (22): A scan of a headline detailing the release of radioactive waste [Source: Bruce A. Sarte on History]



The Nuclear Accident

Radiation Continues To Leak From Crippled Plant

HARRISBURG, Pa. (AP) — Radiation leaks from the Three Mile Island nuclear power plant continued today, authorities said, as a debate grew over what was described as one of this most serious such incidents in this country's history.

"The vapor that is now going into the atmosphere is from a sump pump and is only mildly radioactive within accepted limits," said Don Curry, a spokesman for the Metropolitan Edison Co., owner of the plant. The pump is designed to remove water after it has cooled the reactor.

"We concede that it's not just a little thing," Curry said. "In terms of publicity it will probably surpass the Browns Ferry incident."

Until now, a March 1975 fire in the control room of the Browns Ferry nuclear plant in Alabama has generally been considered this nation's most dangerous incident involving a nuclear reactor.

Low level radiation was detected in the air as far as 16 miles away after an apparent valve failure Wednesday morning resulted in excessive pressure being built up in the water used to cool the reactor core at Three Mile Island.

"Some of the water vapor, through the venting system, went into the atmosphere," Curry said.

Curry said the latest radiation measurements outside the plant were at two to three millirems. Individuals are exposed to up to 30-millirems in a single X-ray examination.

Walter Creitz, president of Metropolitan Edison, said on ABC-TV's *Good Morning America* show this morning that the plant shut down safely and that the level of radiation released "would not endanger or injure any people."

Creitz said his company did not know what equipment had been disabled or what precisely caused the accident.

An aerial view of the Three Mile Island nuclear power plant. AP Photo

In total, approximately 93 PBq of radioactive gases, and 560 GBq of iodine-131 were released into the environment. A commission was created in April 1979 to investigate the accident. The commission report showed that the relief valve which caused the fault had previously failed on 11 occasions, and although the engineers had reported the problem, the company did not react properly.[144] Cleanup started in August 1979, and officially ended in December 1993, with a total clean-up cost of about $1 billion.[145]

4- Chernobyl, Ukrainian, Former Soviet Union- INES Level 7- 26 April 1986:

The Chernobyl accident is considered the most disastrous nuclear accident in history both in terms of costs and casualties.

It occurred on 26 April 1986 in the No.4 reactor at the Chernobyl Nuclear Power Plant. A combination of inherent reactor design flaws and personal errors resulted in uncontrolled reactions. The temperature reaching 2,000 degrees led to a violent explosion that toppled the 1,000-ton reactor seal and sent huge quantities of radioactive materials in the atmosphere. The fuel rods melted, setting off a ten-day fire and triggering more radiation release.

Thirty six hours after the accident, people were evacuated from an area of 10 km adjacent to the plant. In the following months more than 130 thousand people were moved from an area of 30 km. Workers brought to clean the area by washing houses and scraping the topsoil, but the benefits were

144- Hopkins, A. (2001), Was Three Mile Island a 'Normal Accident'?. Journal of Contingencies and Crisis Management, 9: 65-72. doi:10.1111/1468-5973.00155

145- Press, The Associated. "14-Year Cleanup at Three Mile Island Concludes." The New York Times. August 15, 1993. Accessed June 22, 2019. https://www.nytimes.com/1993/08/15/us/14-year-cleanup-at-three-mile-island-concludes.html

limited and the area was considered restricted to humans for an indefinite time.[146]

The Chernobyl accident resulted in the emission of radiation equivalent to 100 times the bombs of Hiroshima and Nagasaki together, and exposed more than eight Millions of people in Belarus, Russia and Ukraine to radiation.[147] Although the cloud of radiation was concentrated over Belarus, Russia and Ukraine, more than half of the total amount emitted from Chernobyl exceeded these areas to cover 40% of Europe, and in the end spreading all over the world.[148]

Fig (23): photo of reactor no.4 [Source: Chernobyl Guide]

The remains of Building No. 4 were surrounded by a large lid called the sarcophagus.The sarcophagus was finished in December 1986, and was intended to provide safety for the crews at the power plant. Reactor No. 3 continued to generate electricity until the year 2000.[149]

Health and Economic consequences

The full aftermath of the Chernobyl accident will probably never be truly known, but what we know so far is shocking. According to official reports, thirty-one people died instantly and 600,000 workers involved in firefighting and cleaning operations were exposed to high doses of radiation. The UN report, released in 2000, indicated that half a million children still live in the affected areas, 73 thousand people suffer from permanent disabilities, 46 thousand out of 200 thousand who participated in the rescue operations were disabled. In some areas the rate of thyroid cancer has increased

146- Scientific Independent An :((TORCH Chernobyl on Report Other The Summer. David and Fairlie Ian 20 Effects Environmental and Health of Evaluation years After the Nuclear Disaster Providing critical Analysis of a recent report . Commissioned Organisation Health World the and Agency Atomic International the Parliament. April 2006. Accessed June 2019. http://media.freeola.com/ European the in Greens/EFA MEP by other/14705/torch_executive_summary-1.pdf

147- Ibid, A nuclear Roulette"

148- Ibid TORCH report

149- http://lib.ru/MEMUARY/CHERNOBYL/dyatlow.txt

100 times with more than 10 thousand cases reported, and that there is evidence of lung, heart and kidney diseases related to radiation.[150]

Unofficial estimates are much worse. A report issued by the National Academy of Sciences of Belarus in 2010 estimated some 93 thousand deaths and 270 thousand cancer cases due to the repercussions of the Chernobyl accident. The Ukrainian National Commission for Radiation Protection estimated the death toll by 500 thousand people.[151] And twenty four years after the disaster, the wildlife study in the exclusion zone around Chernobyl to plant and animal life was overwhelming.[152]

As for the economic losses, some Ukrainian experts estimated the economic damages that hit their country at about 200 billion dollars, which is enormous, especially if compared to Ukraine's GDP in 2001, which was 37 billion dollars only.[153],[154],[155]

5- Fukushima Daiichi, Japan- INES level 7, 11 march 2011:

An earthquake and tsunami that occurred on 11 of March 2011, led to failure of the emergency power supply of the Fukushima-Daiichi nuclear power plant. Radioactive gas from reactors 1&2 was intentionally released to relieve pressure but on March 12, due to the high temperature, the cooling water levels decreased and exposed fuel rods. A hydrogen explosion occurred at reactor 1 and the concrete outer structure collapsed. On March 14, a second, hydrogen explosion occurred in Unit 3 with similar effects. On March 15th a third explosion occurred in Unit 2. The explosion damaged the steel containment of the reactor core with much larger releases of radiation. A fourth explosion damaged the floor area of the reactor and the spent fuel pool.

At the beginning, the Japanese government underestimated the dangers from radiation releases. On 12 March, the Chief Cabinet Secretary said the reactor would not leak a large quantity of radiation, and that people outside a 20 km radius are not exposed. Within two weeks, the government asked people living between a 20 and 30 km radius of the disaster to voluntarily vacate. In late April, the government extended the evacuation zone up to 50km.[156]Over 160,000 people were evacuated.[157]

150- Report.« UN Says Worsening, Effects «Chernobyl Clare. Kapp, The Lancet 355,no.9215 (6 May 20000)doi:10.1016/s0140-6736(05)72535-6 1625.

151- Vidal, John. "UN Accused of Ignoring 500,000 Chernobyl Deaths." The Guardian. March 25, 2006. Accessed June 24, 2019. https://www.theguardian.com/environment/2006/mar/25/energy.ukraine

152- Gill, Victoria. "Chernobyl Zone Shows Decline in Biodiversity." BBC News. July 30, 2010. Accessed June 24, 2019. https://www.bbc.com/news/science-environment-10819027

153- Ibid, TORCH report

154- CHERNOBYL., WISE Interna- OF EFFECTS HEALTH THE AT LOOK COMPARATIVE CRITICAL, A tional, October 2003, accessed June 2019, https://wiseinternational.org/nuclear-monitor/594/critical-comparative-look-health-effects-chernobyl.

155- LIVE 20 YEARS, 20 - CHERNOBYL, WISE International 2006, Accessed June 2019, https://wiseinternational.org/nuclear-monitor/645-646/chernobyl-20-years-20-lives.

156- Lessons from Fukushima. Greenpeace International. February 2012. Accessed June 24 2019. https://www.nrc.gov/docs/ML1234/ML12340A561.pdf

157- "Situation of the Evacuees." Fukushima on the Globe. November 06, 2015. Accessed June 24, 2019. http://fukushimaontheglobe.com/the-earthquake-and-the-nuclear-accident/situation-of-the-evacuees

Fig (24): Japanese Nuclear Crisis- Fukushima [Chernobyl Guide]

About 8,000 workers per month were involved in decommissioning work. Radiation levels remain very high inside the reactors and make human intervention impossible. A robot was introduced into unit 2, but it got stuck in debris.[158]

In 2013, The Japanese Environmental ministry announced that 300 tonnes of contaminated water from Fukushima Daiichi is still seeping over barriers into the Pacific.[159]Every day, still over 200 m3 of water are injected into the three reactor cores to cool the molten fuel. The highly contaminated water runs out of the cracked contaminants into the basement where it mixes with water from an undergroundriver.[160]

By the end of March 2017, the sum of 22 thousand residential areas, thousands of hectares of land had been decontaminated. The effectiveness of these measures remains questionable, especially in the case of wooded areas near homes. The future of tens of thousands of evacuees, the assessment of health consequences of the disaster, the management of decontamination wastes remain big challenges.[161]

Health and Economic consequences

Great controversy is still going around health effects with official estimates much milder than estimates from independent scientists and groups.

158- Ibid, The World nuclear Industry

159- McCurry, Justin. "Toxic Fukushima Fallout Threatens Fishermen's Livelihoods." The Guardian. August 09, 2013. Accessed June 24, 2019. https://www.theguardian.com/world/2013/aug/09/fukushima-fallout-threatens-fishermens-livelihoods

160- Ibid, 'The World Nuclear Industry.'

161- Ibid, 'The World Nuclear Industry.'

Ultrasound screening in the Fukushima area demonstrated a high detection rate of thyroid cancer in young individuals.[162]The number of cancer cases found in children is about 30 times that of the national average, yet the official survey consistently stated that "it cannot be concluded whether or not the thyroid cancer cases found are due to exposure from the Fukushima accident."[163]

Some reports predict an estimated 5,000 fatal cancer cases from radiation exposures in future, plus similar numbers of other related diseases. Between 2011 and 2015, about 2,000 deaths from radiation related evacuations due to ill-health and suicides occurred.[164]

In 2016, the official cost estimate for settling all problems caused by the Fukushima accident was about ¥22 trillion (US$200 billion).[165]The Japan Center for Economic Research (JCER) proposed a cost between ¥50 trillion (US$453 billion) and ¥70 trillion (US$635 billion).[166]

162- Yamashita, Shunichi et al. "Lessons from Fukushima: Latest Findings of Thyroid Cancer After the Fukushima Nuclear Power Plant Accident." Thyroid : official journal of the American Thyroid Association vol. 28,1 (2018): 11-22. doi:10.1089/thy.2017.0283

163- Ibid, 'The World Nuclear Industry.'

164- Ian Fairlie. Summing the Health Effects of the Fukushima Nuclear Disaster. Accessed June 24 2019. https://www.ianfairlie.org/wp-content/uploads/2015/08/Summing-up-the-Effects-of-the-Fukushima-Nuclear-Disaster-10.pdf

165- Ibid, 'The World Nuclear Industry.'

166- Tatsuo Kobayashi, Tatsujiro Suzuki and Kazumasa Iwata. Public Financial Burden of the Fukushima Nuclear Accident. Japan Center for Economic Research. March 7 2017. Accessed June 24 2019. https://www.jcer.or.jp/eng/research/policy.html

Chapter Six: The Decline of Nuclear Power

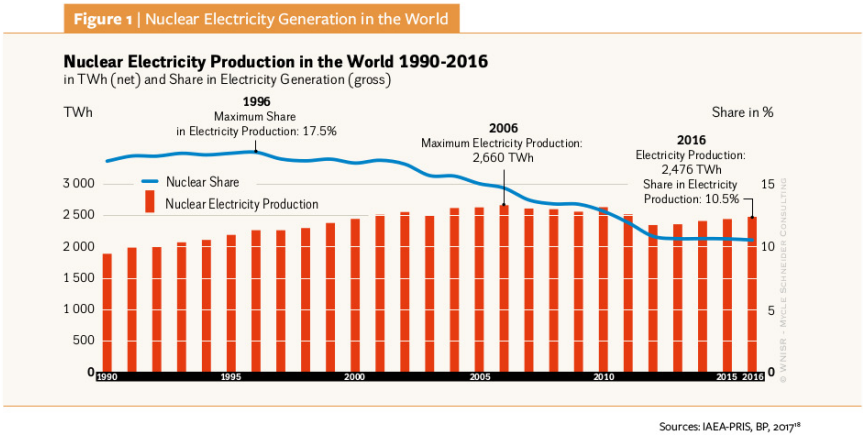
1- Summary of the Chapter

Since the 1990s, nuclear energy has been on a continuous downward trend. Now nuclear power supplies only 10.5% of total world electricity. Nuclear energy has never been very widely spread, only 31 countries in the world use nuclear power for electricity, with the "Big Five" countries generating 70% of the total. Many western countries are phasing out of nuclear power and this is shifting the market to developing countries. With the exception of China, very few countries are constructing new nuclear plants. The future forecast for nuclear energy is not promising.

2- The downward trend of nuclear power

Since the first nuclear power generation started on 27th of June 1954 at Obninsk in the Soviet Union, there have been two major waves of nuclear startups. The first peaked in 1974 and the second peaked in 1985. But by the nineties the number of reactor shutdowns outweighed the number of startups, and since then nuclear energy has been on a continuous downward trend.[167]The nuclear share of the world's power generation is limited to 10.5%. It has dropped from a historic peak of 17.5% in 1996 to 10.5% in 2016,[168]with a total net installed power capacity of 391 GW.[169]

Fig (25): Graph showing Nuclear Electricity Production in 2016 [source: International Atomic Agency]



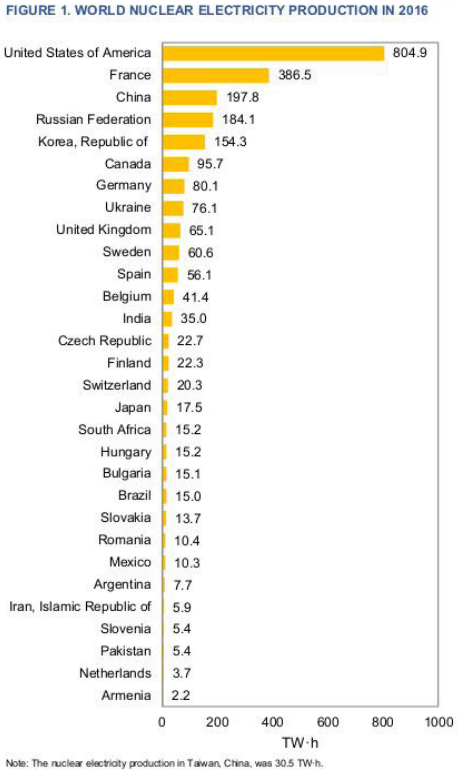
167- Ibid, 'The World Nuclear Industry.'

168- Ibid, 'The World Nuclear Industry.'

169- Energy, Electricity and Nuclear Power Estimates for the Period up to 2050. Reference Data Series No. 1. 2017 Edition. International Atomic Energy Agency. Vienna, 2017. Accessed June 24, 2019. https://www-pub.iaea.org/MTCD/Publications/PDF/17-28911_RDS-1%202017_web.pdf

Only 31 countries in the world are operating nuclear power plants.[170]The "Big Five" nuclear countries are the U.S., France, China, Russia, and South Korea. They generate 70% of the world's nuclear electricity. These 31 countries operate a total of 447 nuclear reactors. Some assessments count only 403 reactors-excluding the reactors with Long-Term Outages (LTOs).[171]

Fig (26): A Graph showing the shares of the top producing countries for electricity from nuclear energy [Source: Energy, Electricity and Nuclear Power Estimates for the Period up to 2050]



Nuclear is losing its lustre:

Nuclear power is increasingly becoming unpopular especially in its homeland. Many of the countries which used to form the traditional nuclear market are rejecting and phasing out nuclear power.

> ***"Germany decided to phase out of nuclear power and to shut down its 17 operating reactors by2022.[172]***

170- "Electricity Supplied by Nuclear Energy." World Nuclear Association. Accessed July 29, 2019. https://world-nuclear.org/nuclear-basics/electricity-supplied-by-nuclear-energy.aspx.

171- Ibid, The World Nuclear Industry"

172- Fertal, Duroyan. "Germany: Nuclear Power to Be Phased out by 2022." Green Left Weekly, Issue 882. June 4, 2011. Accessed June 24, 2019. https://www.greenleft.org.au/content/germany-nuclear-power-be-phased-out-2022

Belgium,[173]and Switzerland[174]are also phasing-out of nuclear power. France, one of the top-five nuclear countries, with 58 reactors, is decreasing its nuclear share of electricity from three quarters to one half.[175]South Korea, the fifth top country, closed one plant and suspended the construction of two more. [176]US, the top nuclear leader has only one construction project "[177]

This clamp down on nuclear power in Western Europe and North America shifted the nuclear market to the developing world. Now with 53 reactors under construction, all, except 6, are in Asia or Eastern Europe, with almost a third in China alone.

Fig (27): Table showing number of reactors under construction worldwide as of 2017 [Source: The World Nuclear Industry: Status Report 2017, p.30]

Table 1 | Nuclear Reactors "Under Construction" (as of 1 July 2017) [30]

Country	Units	Capacity (MW net)	Construction Starts	Scheduled Grid Connection	Behind Schedule
China	20	20 500	2009 - 2016	2017 - 2021	11
Russia	6	4 359	1983 - 2010	2017 - 2019	6
India	6	3907	2004 - 2017	2018 - 2023	5
UAE	4	5380	2012 - 2015	2018 - 2020	1
USA	4[a]	4 468	2013	2019 - 2020	4
South Korea	3	4 020	2009 - 2013	2018 - 2019	3
Belarus	2	2 218	2013 - 2014	2019 - 2020	1
Pakistan	2	2028	2015 - 2016	2021 - 2022	?
Slovakia	2	880	1985	2018 - 2019	2
Finland	1	1600	2005	2018	1
France	1	1600	2007	2019	1
Japan	1	1325	2007	?	1
Argentina	1	25	2014	2019	1
WORLD	**53**[b]	**52 310**	**1983 - 2017**	**2017 - 2023**	**37**

Sources: WNISR, with IAEA-PRIS and WNA, 2017

3- Nuclear Power Future

By mid- 2017 Over half of the total number of reactors in the world were more than 30 years of age, and 64 of them were more than 40 years. At least 100 reactors will most probably be closed

173- "Belgium Maintains Nuclear Phase-out Policy." World Nuclear News. April 4, 2018. Accessed June 24, 2019. http://www.world-nuclear-news.org/Articles/Belgium-maintains-nuclear-phase-out-policy

174- Kanter, James. "Switzerland Decides on Nuclear Phase-Out." The New York Times. May 25, 2011. Accessed June 24, 2019. https://www.nytimes.com/2011/05/26/business/global/26nuclear.html?_r=1

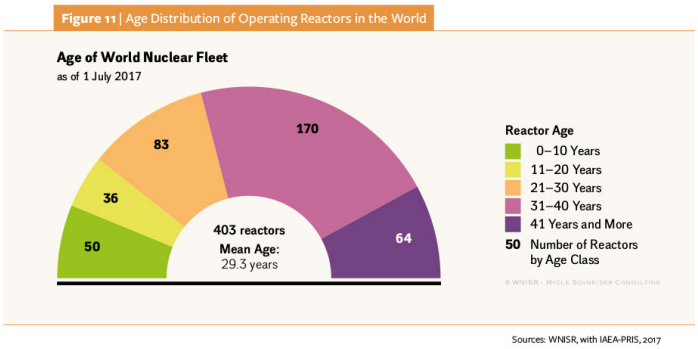
175- Ibid, 'The World Nuclear Industry.'

176- Pearce, Fred. "Industry Meltdown: Is the Era of Nuclear Power Coming to an End?" Yale E360. May 15, 2017. Accessed June 24, 2019. https://e360.yale.edu/features/industry-meltdown-is-era-of-nuclear-power-coming-to-an-end

177- Ibid, Ibid, 'The World Nuclear Industry.'

over the next 10-15 years due to aging.[178]The number of newly constructed reactors is unlikely to replace all the aging ones that will be out of service. Even if all reactors are to be licensed for 60 years, the number of operating reactors would still increase by only five, adding 16.5 GW in 2020. By 2030 closure of 163 reactors due to aging will occur leading to losing 144.5 GW.[179]

Fig (28): Graph showing distribution of reactors by age [Source: The World Nuclear Industry: Status Report 2017, p. 37]



Despite these indicators of declining nuclear power, a number of energy organizations forecast that nuclear power production will increase in the coming decades. For example, the IEA's World Energy Outlook suggests that by 2040 the total power output from nuclear will increase by about 50 percent. This is a somewhat unlikely achievement, given the very low level of construction in the traditional markets and the ageing nuclear fleets and with many countries phasing out and few are coming in.

178- Dittmar, Michael. "Taking Stock of Nuclear Renaissance That Never Was." The Sydney Morning Herald. August 18, 2010. Accessed June 24, 2019. https://www.smh.com.au/business/taking-stock-of-nuclear-renaissance-that-never-was-20100817-128ky.html

179- Ibid, 'The Would Nuclear Industry..'

Chapter Seven: Better Alternatives Exist

1- Summary of the Chapter

There are numerous options available to meet the world needs for electricity that are better than nuclear energy. On top of these options are renewable energy sources which are cheaper, cleaner, safer and sustainable. While uranium and fossil fuel will be depleted in a couple of decades, renewable sources are infinite and abundant. Wind and solar Photovoltaic cells (PV) are leading the growth of renewable power. By the end of 2017 Levelized Cost of Electricity (LCOE) showed that wind followed by solar PV were the cheapest of all sources of energy. Affordable storage solutions are expected in near future, this will overcome the variability and interruption of wind and solar powers.

Egypt is endowed with abundant wind and solar energy resources. IRENA's (International renewable energy agency) renewable energy map analysis performed in 2018 showed that Egypt has the potential to supply 53% of its electricity from renewable mix by 2030, which would result in a reduction in total energy costs by 900 million US$.

2- Renewable Energy sources are better alternatives

Renewable sources are infinite and plentiful

Nuclear power is finite. Uranium, at least the economic uranium, is going to last for a couple of decades and so fossil fuel too. Wind, solar, hydro, geothermal, biomass and other renewable energy sources are infinite because they are produced from sources that either do not deplete or can be replenished within a human lifetime.[180]

> ***"Every hour the sun sends energy to Earth more than needed to satisfy global needs for an entire year.[181] Wind energy can satisfy more than 40 times the world's needs of electricity and more than five times the world's needs of energy.[182]***

Renewable sources are the cheapest

By the end of 2017, the Levelized Cost of electricity (LCOE) from onshore wind was (US$30-60/MW/h) and from solar PV was (US$43-48/MW/h).

These costs were below costs of:

- **Combined gas cycle (US$42-78/MW/h),**
- **Coal (US$60-143/MW/h), and**

180- Frewin, Chris. "Renewable Energy." Student Energy. Accessed June 24, 2019. https://www.studentenergy.org/topics/renewable-energy

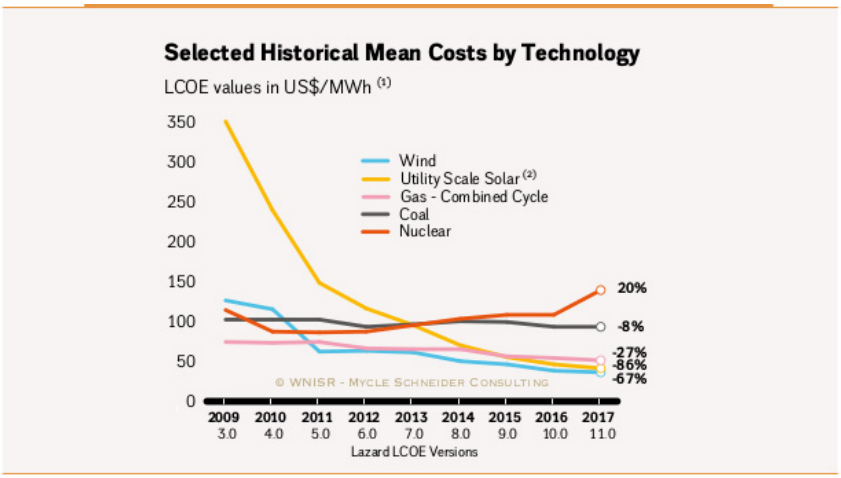
181- Imboden, Otis. "Solar Power Has Benefits as a Source of Alternative Energy." Solar Power Information and Facts. September 15, 2017. Accessed June 24, 2019. https://www.nationalgeographic.com/environment/global-warming/solar-power/

182- Lu, Xi, and Michael B. Mcelroy. "Global Potential for Wind-Generated Electricity." Wind Energy Engineering, 2017, 51-73. doi:10.1016/b978-0-12-809451-8.00004-7

- **Nuclear (US$112-143/MW/h).**[183]

"Wind and Photovoltaic cells are the cheapest sources of power"

Fig (29): Historical Mean Cost by Technology as of 2017



Source: Lazard Estimates,2017[773]

Technology improvements triggered huge and rapid reductions in prices of renewable energy. These drops are unmatched by any other source of energy.[184]Competitive auctions are spreading around the world for wind and solar, and record-low prices are being set.[185]

"Between 2009 and 2017, large scale PV costs went down by 86% and wind by 67%"

The reduction in prices is not only for wind and solar but for most renewable sources. By 2020, all the renewable power generation technologies in commercial use will fall within the fossil fuel cost range.[186]

Generating electricity from a variety of renewable sources is much more economical than using nuclear power.

183- Mycle Schneider, Julie Hazemann, Tadahiro Katsuta, Andy Stirling, Ben Wealer, Antony Froggatt, Phil Johnstone, M.V. Ramana, Christian von Hirschhausen, Agnes Stienne. The World Nuclear Industry: Status Report 2018. A Mycle Schneider Consulting Project. September 2018. Accessed June 24 2019. https://www.worldnuclearreport.org/IMG/pdf/20180902wnisr2018-lr.pdf

184- Ibid

185- Ibid, Henze

186- IRENA (2018), Renewable Power Generation Costs in 2017, International Renewable Energy Agency, Abu Dhabi. Accessed in June 24 2019. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018.pdf

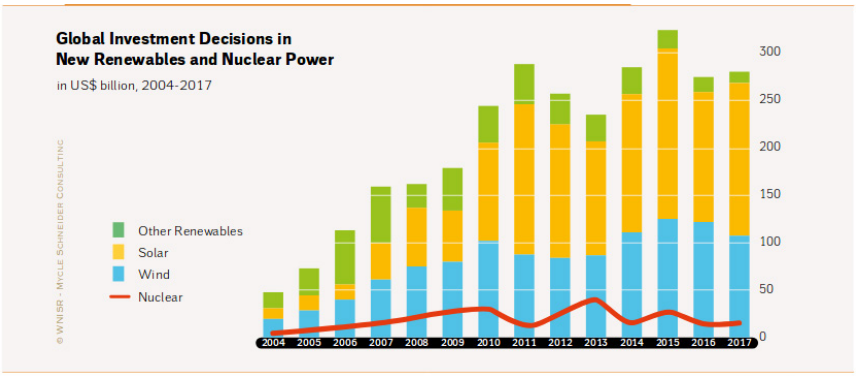
"In 2014 an important study showed that across the EU, end consumers can save up to 37% on their electricity costs – in some member states even up to 74% – when plans to build nuclear power plants are shelved in favour of renewables."[187]

3- Future of Renewable Energy

Falling renewable power costs signalled a shift in their competitiveness.[188]In 2017, The reported investments for the construction of nuclear projects were 16 billion US$. While investments in wind reached over US$100 billion and in PV 160 billion US$. [189]New investments are important indicators of the future power mix

"Globally renewables are the fastest-growing sources of generating electricity. Renewables now are providing 19% of the total installed capacity, and expected to reach 30% in 2040.[190]

Fig (30): Global Investment Decisions in New Renewables and Nuclear Power



Source: FS-UNEP/BNEF 2018 and WNISR Original Research

Affordable energy storage in near future

The main drawback for wind and solar power is the intermittent and variable production. That is why storage is important. Storage batteries used to be very expensive, but now the cost of batteries is decreasing rapidly. Since 2010, 79% decrease in lithium-ion battery costs occurred. Battery storage

187- Gabriele Mraz, Andrea Wallner, Gustav Resch, Demet Suna. Renewable Energies versus Nuclear Power: Comparing Financial Support. Wiener Umwelt Anwaltschaft/Vienna Ombuds-Office for Environmental Protection. Vienna, November 2014. Accessed June 24 2019. http://www.wua-wien.at/images/stories/publikationen/renewable-energy-versus-nuclear-power-summary.pdf

188- Ibid, 'IRENA (2018)'

189- Ibid, 'The World Nuclear Industry.. 2018'

190- International Energy Outlook 2017. September 14, 2017. U.S. Energy Information Administration. Accessed June 24 2019. https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf

is starting to compete in price with other options such as pumped hydro.[191]

4- Egypt's Renewable Energy Potential

"Egypt has abundant sources of renewable energy especially wind and solar which are not fully exploited yet."

Egypt is one of the most suitable regions for exploiting solar energy. The country enjoys between 2,900 and 3,200 hours of sunshine annually, with annual direct normal intensity of 1970-3200 kWh/m2 and a total radiation intensity between 2000 and 3200 kWh/m2/year.

Egypt is also endowed with abundant wind energy resources, particularly in the Gulf of Suez area due to the high and stable wind speeds. At a height of 100 meters the speed reaches on average of

8-10 m/s. Other promising new regions have been discovered east and west of the Nile river.[192]

Egypt›s current total installed capacity of renewables amounts to 3.7 gigawatts including 2.8 GW of hydropower and around 0.9 GW of solar and wind powers. The Egyptian government has set renewable energy targets of 20% of the electricity mix by 2022 and 42% by 2035.

"According to a recent IRENA analysis in 2018, Egypt has the potential to supply 53% of its electricity mix from renewables by 2030. This increased deployment of renewable energy would result in a reduction in total energy costs of USD 900 million in 2030."

In addition the reduction in external costs from air pollution would add as much as USD 4.7 billion in 2030.

The IRENA report commented that the recent Egyptian Energy Strategy, developed in 2014, does not reflect the rapid economic and technological changes taking place at the national and regional levels.

"The IRENA report concluded that by properly developing its energy strategy Egypt can reduce and even eliminate the need for coal and nuclear thus strengthening the country's energysecurity"[193]

191- Henze, Veronika. "Tumbling Costs for Wind, Solar, Batteries Are Squeezing Fossil Fuels." BloombergNEF. March 28, 2018. Accessed June 24, 2019. https://about.bnef.com/blog/tumbling-costs-wind-solar-batteries-squeezing-fossil-fuels/

192- Ibid, "Renewable Energy Outlook: Egypt." IRENA:

193- Ibid, 'Renewable Energy Outlook: Egypt.'

Annex I

Legislative and regulatory framework of Dabaa Project

1- History of Dabaa Nuclear Project

Dabaa nuclear project is located between 149 km and 164 km on the Alexandria-Marsa Matrouh road in Matrouh governorate. Laying between El Alamein city (50 kms) to the east, Marsa Matrouh city (125 kms) to the west. and 6 kms to the north of Dabaa city. The project will be executed on an area of 45 square kilometres, with a length of 15 kilometres on the sea coast.

The site of Dabaa was allocated for the establishment of a nuclear plant by the Presidential Decree No.308 of the year 1981.[194]In 1983, Egypt put forward specifications for the construction of a 900 megawatt nuclear power plant, but the project was halted in 1986 after the Chernobyl accident.

In 2002, The Government announced its intention to revive the project and in 2003 the land of the area was seized and the inhabitants were forcibly displaced, but the project remained suspended.[195]

After the outbreak of the January 2011 revolution, a number of residents from the area took over the territory, till 2013, when the Egyptian authorities announced that they managed to seize control of the land along with paying reparations to the inhabitants.[196]

In 2014, the nuclear project was revived again, six companies from China, France, Japan, the United States, South Korea and Russia submitted proposals to establish the nuclear plant in Dabaa. Later it was declared that the Russian company Rosatom was chosen to build the project.

2- The Russian Agreement

On 19th of November 2015, the Egyptian and Russian governments signed two agreements to build Egypt›s first nuclear power plant, in the presence of the Egyptian and Russian presidents. [197]

The first agreement was signed between the Egyptian Ministry of Electricity and Russia›s state-run company Rosatom to build a nuclear plant in the Dabaa area. The nuclear plant is made up of four nuclear units with a total capacity of 4,800 megawatts. The primary delivery and commercial operation of the first unit will be by 2026 and the second, third and fourth units are expected to be completed by 2028.

194- أحمد عصام عيسى، 7 معلومات عن محطة الضبعة النووية، البوابة نيوز، 4 سبتمبر 2017، تم التصفح 29 يونيو 2019 https:// www.albawabhnews.com/2696012

195- شيماء عزت، محطة الضبعة: طموحات ومخاطر الحلم النووي المصري، 13 ، 24 France ديسمبر 2017، تم التصفح 29 يونيو 2019 https://bit.ly/2J9EBRF

196- تقرير لجنة تقصي حقائق بشأن انتهاكات حقوق الأرض والسكن بالضبعة، تقرير حقوقي من إعداد: شبكة حقوق الأرض والسكن (التحالف الدولي للموئل)، المبادرة المصرية للحقوق الشخصية، والمركز المصري للإصلاح المدني والتشريعي 2012 https://eipr.org/ sites/default/files/pressreleases/pdf/daba_report.pdf

197- محمد الجالي، أسماء مصطفى، أحمد حربي، أحمد عبد الرحمن، محمد شعلان، "السيسي يشهد توقيع اتفاق إنشاء المحطة النووية بالضبعة."، اليوم السابع، 19 نوفمبر 2015، تم التصفح 29 يونيو 2019 https://bit.ly/2LvAked

The second agreement was signed between the Egyptian and Russian Ministries of Finance and included obtaining a Russian loan to finance the project. The loan agreement provides Egypt with a 25-billion-dollars Russian government loan to finance 85% of the value of each contract expected by the authorized institutions in both countries for the necessary works, provided that the Egyptian side secures the remaining amount of funding. The loan is to be used over 13 years with an interest rate of 3% annually to be calculated starting from the first day of instalments. If none of the interests mentioned were paid within 10 working days, the interests are then considered as late payment with 150% interest on the aforementioned interest paid, calculated daily. The loan itself will be repaid over a period of 22 years, beginning in the year 2029.[198]

According to the Minister of Electricity statements, four contracts were signed in the agreement that include contracts of design and construction, supplying the uranium fuel, operation and maintenance consultancy, and spent fuel management. [199]The agreement and the contracts, has not been published in the Official Gazette , It has not been submitted to Parliament either.

On December 24, 2015, the Egyptian president approved the loan agreement with a reservation, subject to ratification by the Parliament.The agreement was published in the Official Gazette on May 19, 2016 six months after the signing. The loan agreement has not yet been presented to Parliament as required by article 151 of the Constitution and although a number of MPs have filed briefings to discuss the agreement. Concerned NGOs have asked the government to publish the details and to present the agreement to parliament.[200]

In February 2016, the Official Gazette No. 40 promulgated the decision of the Chairman of the Nuclear and Radiological Regulatory Authority to determine the value of the insurance or financial security to authorize the construction or operation of a nuclear power plant for the generation of electricity of 60 million pounds (approximately US $ 3.4 million) provided by the operator, the Egyptian Nuclear Power Plants Authority, to cover the damage or losses that are proven to be liable in the event of a nuclear accident at its facility.

On February 7th, 2016, the Attorney General issued a decree banning any publication on the project of the nuclear plant in Dabaa. The decree mentioned that this is to protect investigations carried out by the Public Prosecution, without mentioning anything about the nature of these investigations. The ban included all audiovisual media, national and foreign newspapers and magazines, and other publications, as well as websites.[201]

198- عادل البهنساوي، "انفراد.. 25 مليار دولار تمويلا روسيا للمشروع النووي"، جريدة المال، 30 نوفمبر ، تم التصفح 29 يونيو 2019 https://bit.ly/2X5BejG

199- رحمة رمضان، وزير الكهرباء: نسعى لتوقيع باقي عقود مشروع الضبعة النووي في أقرب وقت، اليوم السابع، 15 يناير 2017، تم التصفح 29 يونيو 2019 https://bit.ly/2FBzZCM

200- المبادرة المصرية تطالب الحكومة بالإفصاح وباحترام الدستور في اتفاقيات محطة الضبعة، المبادرة المصرية للحقوق الشخصية، 17 ديسمبر 2017، تم التصفح 29 يونيو 2019 https://bit.ly/2IUiDTz

201- النائب العالم يحظر النشر في تحقيقات محطة الضبعة النووية، البيان، 7 فبراير 2016، تم التصفح 29 يونيو 2019 https://www.albayan.ae/one-world/arabs/2016-02-07-1.2567535

This resolution raised the objection of some NGOs,[202]and a number of experts[203] mainly because the ban contravenes with the international practices and recommendations that indicate the need for community dialogue to reassure the public and to respond to their fears and inquiries.

In February 2017, the Nuclear Power Plants Authority, as the competent administrative authority, published an invitation on the website to attend a «community dialogue session» to present the results of the environmental and social impact assessment study for the construction and operation of the nuclear power plant in Dabaa, as stipulated by Environmental regulations. On February 25, 2017, the community dialogue session was held in the Dabaa, where a «non-technical summary» of environmental and social impact assessment was prepared by the Australian Worley-Parsons company, the project consultant. The brief summary claimed no unacceptable adverse effects, without giving sufficient details. The festive nature was overwhelming in the session and there was no possibility of good discussion of the information.[204]

3- Evaluating the regulatory and legislative framework

On November 27, 2017, the Egyptian parliament held an emergency public session in which it approved three draft laws on nuclear energy submitted by the government namely, a new law on «Establishment of the executive body to supervise the construction of nuclear power plants» and a law amending certain provisions of the Law on the "Establishment of the Nuclear Power Plants Authority No. 13 of 1976" and a third law amending some provisions of the Law on "Regulation of Nuclear and Radiological Activities No. 7 of 2010".[205]

These laws include provisions that weaken the independence of the nuclear regulatory bodies. Firstly it allows members from the body involved in the establishment of the nuclear plant to be on the board of the nuclear regulatory authority which violates the requirements of the International Atomic Energy Agency and contravenes the provisions of the Egyptian law itself. The amendments also allow the supervisory board to set up companies to invest its funds, which creates a conflict of interests between the economic benefits of the Authority and the integrity and independence of its supervisory role.[206]

The amendments of the law of the "Establishment of the Nuclear Power Plants Authority No. 13 of 1976" provide a huge package of privileges and financial incentives. The law exempts the nuclear plants from all taxes and duties, and exempts everything it imports from the customs and other taxes, and from all taxes on the interest of foreign loans it holds. It also exempts all subcontracted

202- حظر النشر عن مشروع الضبعة النووي.. مزيد من التخويف والشكوك، المبادرة المصرية للحقوق الشخصية، 28 ديسمبر 2015، تم التصفح 29 يونيو 2019 https://bit.ly/2RHtnYm

203- إسلام المصري، إبراهيم العسيري: حظر النشر في الضبعة "غير منطقي"، فيتوجيت، 22 ديسمبر 2015، تم التصفح 29 يونيو 2019 https://www.vetogate.com/1963372

204- هشام عمر عبد الحليم، علي الشوكي، أحمد البحيري، الحوار المجتمعي حول مشروع الضبعة النووي، المصري اليوم، 25 فبراير 2017، تم التصفح 29 يونيو 2019، https://www.almasryalyoum.com/news/details/1094337

205- نورا فخري، البرلمان يوافق نهائيا على مشروع قانون هيئة المحطات النووية، برلماني، اليوم السابع، تم التصفح 29 يونيو 2019، https://bit.ly/2RHUZgb

206- المبادرة المصرية تعترض على القوانين المتعلقة بالطاقة النووية وتطالب بعدم توقيع عقود المحطة النووية قبل مراجعة القوانين، 10 ديسمبر 2017، تم التصفح 29 يونيو 2019 https://bit.ly/2XA5Ei5

bodies and companies and foreign workers of all taxes.[207] The Ministry of Finance has objected to these exemptions, especially since the Commission and the executive branch receive allocations from the State Treasury.[208] The State Council court has also commented on the overlap in terms of authority caused by the Law on the Establishment of the Executive Body to Supervise Nuclear Plants.[209]

Environment NGOs have criticized the weakness of the regulatory bodies and called for strengthening them and demanded more transparency and the launch of a website that would include the publication of reports on its activities and the radiation situation in the country as required by law.[210]

The progress of the project

On December 10, 2017, President Abdelfattah al-Sisi and President Vladimir Putin of the Russian Federation watched over the signature of the document to start the implementation of the contracts of the Egyptian nuclear plant project between Dr. Mohamed Shaker, Minister of Electricity and Renewable Energy, representing the Egyptian side, and Alexey Likhachev, Russian representative of the Russian side[211].

By the end of December 2017, Russian experts received the Dabaa site according to official statements.[212]

In May 2018, an official source said that the Nuclear Regulatory Authority will review all data provided by the Nuclear Power Plants Authority to obtain work permits for Egyptian engineers and technicians.[213]

In May 2018, the Minister of Electricity announced the establishment of a nuclear waste center in Dabaa. Which implies that the waste will remain at the site and that there are still no plans for long-term disposal.[214]

207- Ibid

208- نورا فخري، جدل بالبرلمان بشأن إعفاء ما يستورده "جهاز الإشراف على المحطات النووية"، برلماني، 27 نوفمبر 2017، تم التصفح 29 يونيو 2019 https://bit.ly/2FG884n

209- ولاء جمال، قسم التشريع يوضح ملاحظاته على مشروع قانون "المحطات النووية"، البوابة نيوز، 25 فبراير 2017، تم التصفح 29 يونيو 2019 https://www.albawabhnews.com/2394145

210- راجية الجرزاوي، ليست هذه سكة السلامة إلى الضبعة: حول متطلبات وإجراءات الأمان للطاقة النووية، جريدة الشروق، 31 أكتوبر 2017، تم التصفح 29 يونيو 2019 https://www.shorouknews.com/columns/view.aspx?c-date=31102017&id=bfc4bafa-dd05-40cb-ba78-2281e024fd8a

211- محمد الإشعابي، بداية تحقيق الحلم النووي المصري بالتوقيع على وثيقة بدء إشارة تنفيذ محطة الضبعة، الأهرام، 11 ديسمبر 2017، تم التصفح 29 يونيو 2019 http://gate.ahram.org.eg/News/1734720.aspx

212- رحمة رمضان، المحطات النووية: خبراء 'روساتوم' في الضبعة بصفة مستمرة منذ ديسمبر 2017، اليوم السابع، 17 فبراير 2019، تم التصفح 29 يونيو 2019 https://bit.ly/2DWpXKH

213- محمد صلاح، مصدر ب "روس أتوم": وفد من الشركة يزور الضبعة بعد العيد، مصراوي، 19 مايو 2018، تم التصفح 29 يونيو 2019 https://bit.ly/2ZU3fwf

214- محمد صلاح، وزير الكهرباء: عقود الضبعة النووية هي الأفضل في العالم من حيث السعر والتكنولوجيا وشروط التدريب، جريدة الشروق، 14 مايو 2018، تم التصفح 29 يونيو 2019 https://www.shorouknews.com/news/view.aspx?c-date=14052018&id=6f1b9979-1d97-4351-b1c8-75b889d6685f

In September, 2018, the Deputy Minister for Technical Education inaugurated the Advanced Technical School for Nuclear Energy Technology in Dabaa City, which accepts those who have a basic education certificate. Which also implies that the graduates would form the lower ranking staff for thereactor.[215]

In February 2019, the Nuclear Power Plants Authority received from Rosatom Corporation the preliminary safety analysis report for review, according to an official source in the Ministry of Electricity and Renewable Energy. The source also said the Authority completed the review of the report and it was approved.[216]

On April 8, 2019, the head of Nuclear Power Plants said that the Authority obtained permission of the Site of Dabaa after approval from the Nuclear and Radiological Regulatory Authority in early March2019.[217]

215- ياسمين محمد، نائب وزير التعليم يفتتح مدرسة الضبعة النووية بمطروح بتكلفة 60 مليون جنيه، مصراوي، 30 سبتمبر 2018، تم التصفح 29 يونيو 2019 https://bit.ly/2YjiFK4

216- Ibid, "المحطات النووية: خبراء 'روساتوم'.."

217- محمد صلاح، "إنجاز كبير".. ماذا يعني حصول مصر على إذن قبول اختيار "الضبعة النووية"؟، مصراوي، 8 أبريل 2019، تم التصفح 29 يونيو 2019 https://bit.ly/2KLG7fM

Annex II

Community Dialogue

Established International practices recommend that community dialogue on nuclear energy be opened to reassure the public by providing them with information and latest developments and knowledge or expert opinions.

The project of the nuclear power plant in Dabaa has raised a lot of public controversy.

There were, of course, views supporting the project, whether the holders of such opinions were convinced of the importance and value of nuclear energy, or convinced of the need to support government decisions in general and decisions that have the support of the presidential institution in particular. In the media, the politicization of the project led to it being described as a national achievement, that would fulfil the «nuclear dream» and bring Egypt to the forefront of the developed countries. The support of the «nuclear project» was seen as proof of national loyalty and patriotism.

There were also many opinions and voices that expressed opposition or raised questions and concerns. But instead of opening up broader community dialogue, a legal decision to ban publication was issued effectively killing what might have started in terms of dialogue and discussion.

The following is a brief layout of the main concerns and arguments that were raised.

1. Concerns over economic and strategic reasons.

Such as concerns over the high cost of construction,[218]the lengthy process,[219]and the high price of the generated power compared to other kinds of electricity,[220] especially with the existence of many, cheaper alternatives from renewable energy.[221]

Concerns for strategic reasons[222]were related to the risk of dependence[223] on the outside in the provision of fuel and disposal of spent fuel, and the risks of political considerations curtailing the

218- أيمن رمضان، هاني النقراشي: تكلفة المحطة النووية تعادل 50 من محطات الطاقة الشمسية، اليوم السابع، 15 سبتمبر 2014. تم التصفح 8 يوليو 2019. https://bit.ly/2XwB591

219- "EGYPT'S NUCLEAR POWER PLANT PLANS SUBJECT TO DELAYS." Public Library of US Diplomacy. December 22, 2009. Accessed July 08, 2019. https://www.wikileaks.org/plusd/cables/09CAIRO2348_a.html.

220- راجية الجزراوي، بعد مرور 3 سنوات على توقيع اتفاقية المحطة النووية.. هل مصر الآن بحاجة إلى توليد الكهرباء من النووي؟، الشروق، 24 نوفمبر 2018. تم التصفح 8 يوليو 2019. https://www.shorouknews.com/columns/view.aspx?c-date=24112018&id=48b6c5ba-b69e-4e56-86cc-7534b4864f46

221- نفس المرجع

222- هشام عمر عبد الحليم، رئيس نادي "الطاقة الذرية": يجب إعادة النظر في جدوى المحطة النووية الاقتصادية (حوار)، 3 أبريل 2017. تم التصفح 8 يوليو 2019. https://www.almasryalyoum.com/news/details/1112265

223- عماد الدين حسين، الضبعة والسياحة.. وبينهما روسيا، 16 ديسمبر 2017. تم التصفح 8 يوليو 2019

https://www.shorouknews.com/columns/view.aspx?cdate=16122017&id=b6dfaa75-c5a1-40ba-9437-09c5ee-ba9fb2

freedom of decision-making in Egypt.[224]

Also Concerns related to the loan, which is considered the largest loan in the history of Egypt.[225] There was also opposition from Egyptian businessmen,[226] on choosing the location of Dabaa[227] because it wastes the chances of tourism development.

2. Concerns over the decision-making process and the lack of participation and transparency

These arguments focused on the decision-making process which ended with the signing of the agreement and which was neither clear nor transparent,[228] and it did not entail sufficient consultations within the community or partnership in decision-making, especially with the decline of the roles of state institutions vis-a-vis the presidency and its related institutions.

Other concerns were related to the decline of the role of Parliament, because the loan agreement was not presented to Parliament,[229] in violation of the Constitution, and where three bills were presented and approved at the same session[230] in a hurry and without a real opportunity for discussion.

Also concerns related to the lack of knowledge of the details of what was signed,[231] lack of publication of any economic feasibility studies or of environmental impact assessment, especially that the People›s Conference for Community Dialogue[232] held in Dabaa was managed in a more ceremonial fashion without discussing the details of the project seriously. Some officials in the nuclear bodies themselves objected[233] to the lack of participation of experts and cadres from these bodies on the file and other important files in the nuclear fields.

224- طارق شلتوت، تفاصيل أول بيان رسمي للسفيرة فايزة أبو النجا مستشار الرئيس للأمن القومي، 30 يناير 2019. تم التصفح 8 يوليو 2019. http://www.elmogaz.com/node/526766?fbclid=IwAR37stAmI6w7f37WTdmbexKcYN-G7DIA6tHy1t5SrXuoCkCu3CXq1ABSc7xU

225- السيسي يوقع على قرض روسي يعادل نصف الدين الخارجي لمصر، جريدة المال، 19 مايو 2016، تم التصفح 30 يوليو 2019 https://bit.ly/2ynhA8N

226- Gamal Assam El-Din, A Nuclear Falling Out, Al-Ahram Weekly, 3-9 September 2009, Issue no. 963. Accessed 8 July 2019. http://weekly.ahram.org.eg/Archive/2009/963/eg3.htm

227- Matt Bradely, Egypt's Nuclear Plants Threatened, The National, 30 October, 2009. Accessed 8 July 2019. https://www.thenational.ae/world/africa/egypt-s-nuclear-plans-threatened-1.60758

228- زياد بهاء الدين، بمناسبة مشروع الضبعة.. كيف يتخذ القرار في مصر؟، 18 ديسمبر 2017. تم التصفح 8 يوليو 2019. https://www.shorouknews.com/columns/view.aspx?cdate=18122017&id=eaa630d8-a7e4-4d45-b788-a948339b0468

229- المبادرة المصرية تطالب الحكومة بالإفصاح وباحترام الدستور في اتفاقيات محطة الضبعة. المبادرة المصرية للحقوق الشخصية. 17 ديسمبر 2017 . تم التصفح 8 يوليو 2019. https://bit.ly/2IUiDTz

230- المبادرة المصرية تعترض على القوانين المتعلقة بالطاقة النووية وتطالب بعدم توقيع عقود المحطة النووية قبل مراجعة القوانين. المبادرة المصرية للحقوق الشخصية. 10 ديسمبر 2017. تم التصفح 8 يوليو 2019. https://bit.ly/2XA5Ei5

231- حازم حسني، الضبعة.. والضبة.. والمفتاح!، التحرير، 21 نوفمبر 2015. تم التصفح 8 يوليو 2019. https://bit.ly/2JveUel

232- عثمان الشرنوبي، لهذه الأسباب تراجع أهالي الضبعة عن رفض المشروع النووي، مدى مصر، 1 مارس 2017. تم التصفح 8 يوليو 2019. https://bit.ly/2Xyw7Zp

233- مرجع سابق، "رئيس نادي الطاقة الذرية: يجب إعادة-"

3. Concerns related to lack of expertise and competencies.

These concerns came mostly from experts and researchers. A number of nuclear energy experts, including the former director of the Nuclear Power Plants Authority, objected to the project[234] because Egypt currently lacks trained expertise at all levels and sectors capable of managing complex projects such as nuclear plants. And that the system of higher education in Egypt is unable to fill this shortage quickly. The former head of the Egyptian Atomic Energy Club[235] also objected, saying that Egypt has no experience in operating the nuclear reactors, and that the conditions for building cadres are missing in the current situation, and that there can be no real progress without reforming the educational system and scientific research in Egypt first.

4. Concerns over weak regulatory framework

Some concerns like from the former director of the Nuclear Power Plants Authority,[236] were about the law that does not give sufficient weight to the considerations of nuclear safety, and about that strong influence of the Executive Authority in the Nuclear and Radiological Regulatory Authority, especially since the law fails to refer to international laws and treaties.[237]

It should be noted that Egypt has not ratified the Convention on Nuclear Safety so far, although it signed in 1994. Egypt and Iran are the only countries not bound by the Convention on Nuclear Safety, and are building nuclear reactors.[238]

Environmental researchers,[239]have objected to the weak capabilities of the Nuclear and Radiological Regulatory Authority, even compared to those in neighbouring countries, and doubted its capabilities of carrying out the regulatory duties efficiently. They also objected that the recent amendment of the laws[240] further weakened the already weak nuclear watchdog.

5. Concerns over risk of nuclear accidents

Some writers have published articles on the consequences of nuclear accidents and the nuclear dream that will turn into a nuclear nightmare. These fears have also been a major concern for a wide audience of non-specialists, who have expressed through the social media platforms those fears that they feel justified by poor efficiency and poor management and infrastructure, as well as education and the existence of pervasive corruption.

234- Ibid, "Egypt's Nuclear Plants.."

235- المرجع السابق، "رئيس نادي الطاقة الذرية."

236- Ibid, "Egypt's Nuclear Power Plants.."

237- Ibid

238- "Convention on Nuclear Safety." IAEA. October 20, 2014. Accessed June 29, 2019. https://www.iaea.org/topics/nuclear-safety-conventions/convention-nuclear-safety

239- المرجع السابق، " ليست هذه سكة السلامة.."

240- المرجع السابق، "المبادرة المصرية تعترض."