N S T R I

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Using a LWR SMR for Desalination and Petrochemical Process Heating Cogeneration

By:

Ebrahim Abedi

Introduction

- One of the main and future increasing fields of energy consuming is the providing process heat and water for various types of industries.
- There are huge amounts of fossil fuels have been consumed to providing heat, steam and process water for the industries throughout the world.
- Petro-chemical industries are one of most consumers of process heat and steam.

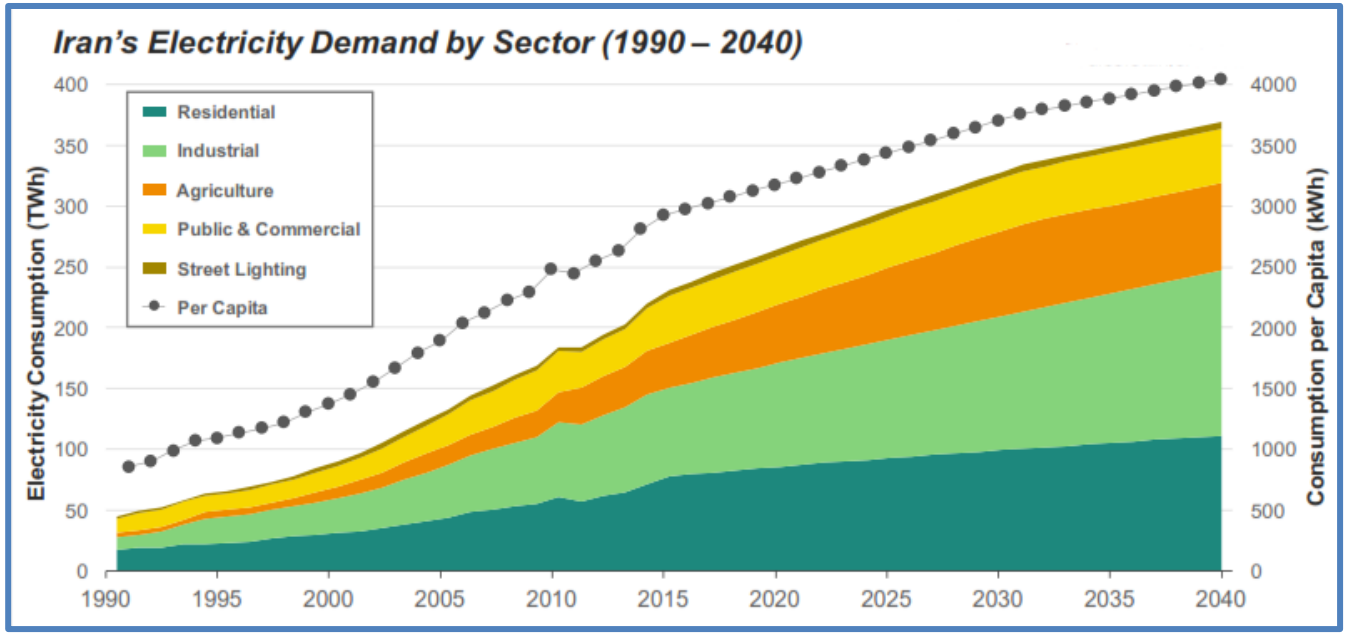


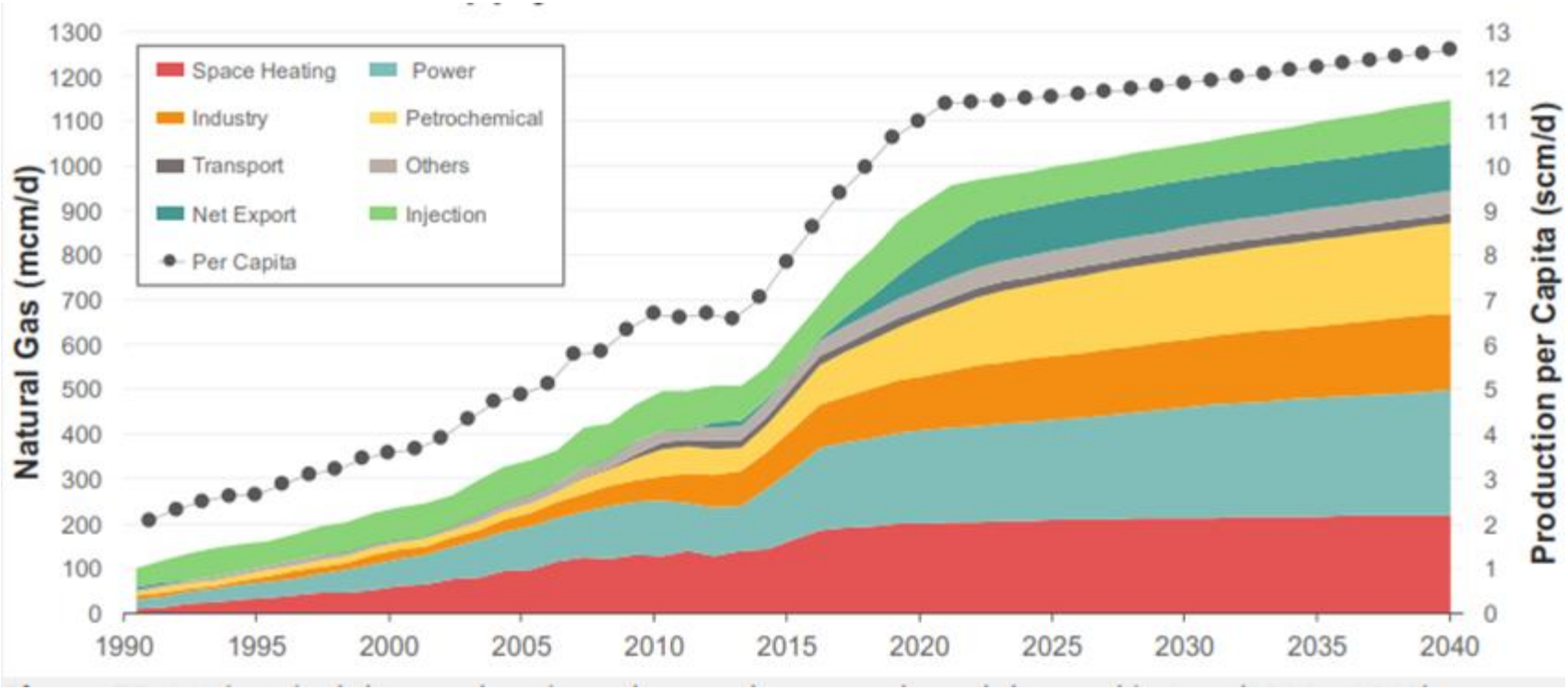
TABLE I. TEMPERATURE NEEDS OF VARIOUS TYPES OF INDUSTRIAL PROCESSES

Industrial Process	Approximate Temperature Range (Centigrade)
Home and building heating	100 – 170
Desalination	100 – 130
Vinyl Chloride production	100 – 200
Urea synthesis	180 – 280
Process Steam	200 – 400
Paper and pulp production	200 – 400
Oil refining	200 – 600
Oil shale and oil sand processing	300 – 600
Crude oil desulphurisation	300 – 500
Petroleum refineries	450 –550
Production of synthetic gas and Hydrogen from natural gas or naphtha	400 – 800
Steel making via direct reduction	500 – 1000
Iron industry	600 – 1600
Production of styrene from ethyl-benzene	600 – 800
Production of ethylene from naphtha or ethane	700 – 900
Hydrogen production by thermo-chemical reaction	600 – 1000
Coal processing	400 – 1000
Coal gasification	800 –1000

Reference:

Natural gas supply and demand in Iran

As an example, Iran uses about 130 mcm/d natural gas for petro-chemical plants that more than 30% of it fired for process heating and steam production



Various power plants financial and technical info.

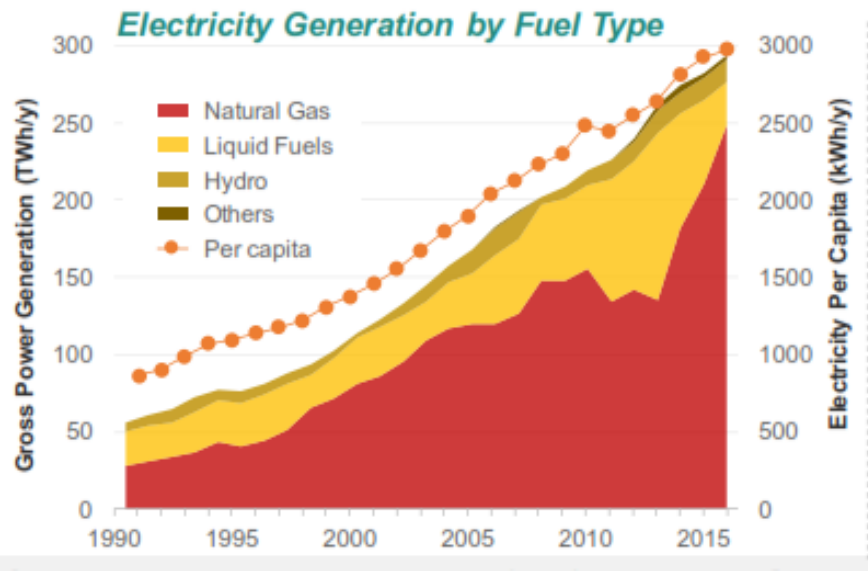
Power plant type		Overnight cost ($/kW)	Fix OMC ($/kW-Y)	Variable OMC ($/MWh)	Capacity factor	Fuel cost ($/MMBtu)	Heat rate (Btu/kWh)	Life time (Year)
Steam turbine	Min	650	6	3	0.64	1	9,626	30
	Max	1,500	25	26	0.71	2	9,626	
Gas turbine	Min	650	6	3	0.26	1	11,628	20
	Max	1,500	25	26	0.35	2	11,628	
Combined cycle	Min	554	5	1	0.50	1	8,029	20
	Max	1,172	17	3	0.61	2	8,029	
Coal-fired	Min	1,549	19	2	0.85	2.6	8,870	30
	Max	5,350	37	9	0.85	2.6	8,870	
Nuclear	Min	3,206	12	0	0.9	0.67	10,400	40
	Max	7,550	90	10	0.86	0.67	10,400	
Hydro power	Min	1,239	14	2	0.07	-	-	40
	Max	3,226	15	5	0.32	-	-	
Wind turbine	Min	1,206	12	0	0.21	-	-	30
	Max	2,341	49	6	0.35	-	-	
Geothermal	Min	1,664	66	0	0.95	-	-	40
	Max	3,901	160	28	0.7	-	-	
Photovoltaic	Min	5,058	7	0	0.26	-	-	30
	Max	6,000	34	0	0.1	-	-	
Solar thermal	Min	3,623	54	0	0.5	-	-	30
	Max	5,899	66	0	0.24	-	-	

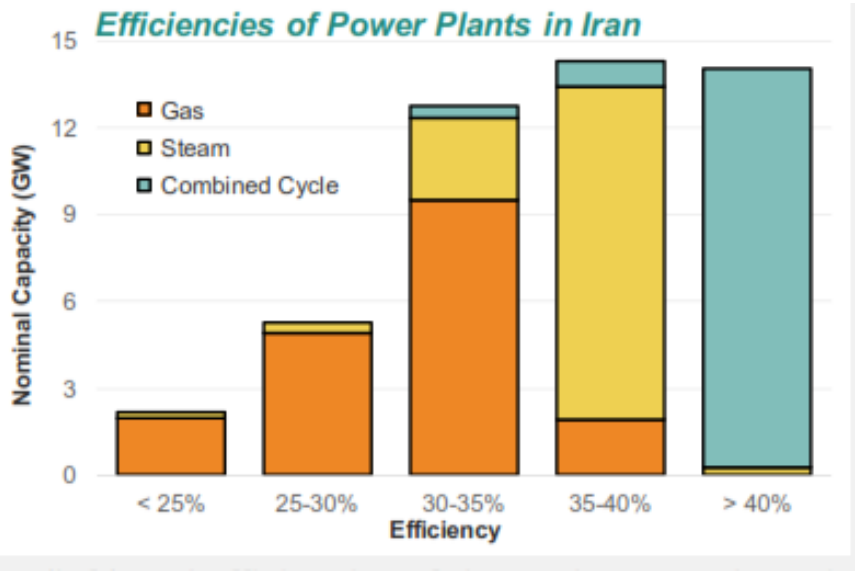
Average fuel consumption per unit of electricity generation

Fuel type	Steam turbine	Gas turbine	Combined cycle	Diesel engine
Natural gas (m^3/kWh)	0.1841	0.2910	0.2019	-
Diesel (l/kWh)	0.0008	0.0602	0.0220	0.2981
Fuel oil (l/kWh)	0.0785	-	-	-

The data extracted from Iran thermal power plant

Electricity production efficiency of different types power plants



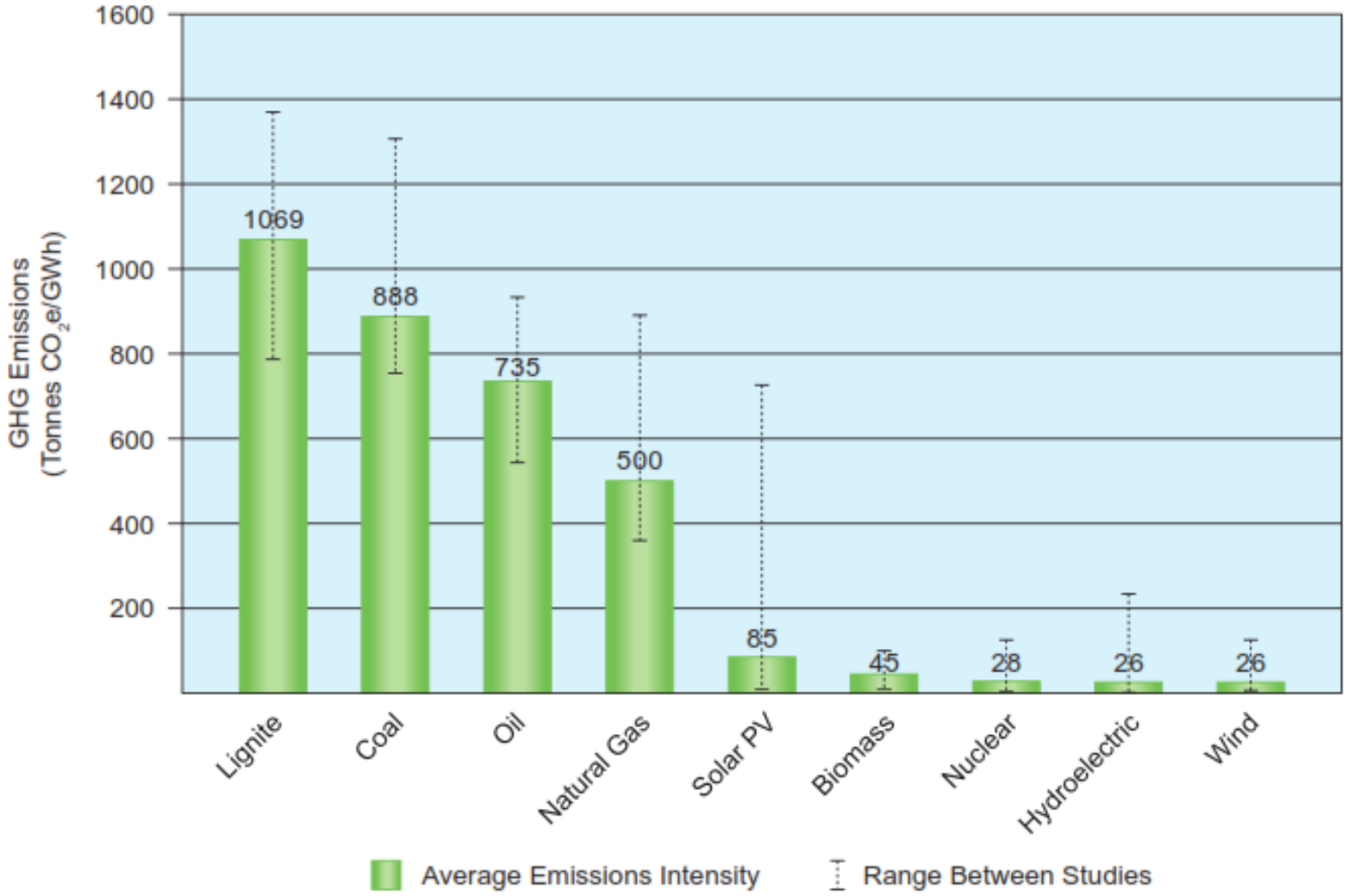


- Nowadays the efficiency of natural gas fired power plants is about 37-40% for gas turbines and 42-45% for combined cycles. These values can be up to 45% and 60% respectively, at state of art using advanced turbines technologies .
- On the other hand, the efficiency of either commercialized today large LWR NPPs or near future SMR plans (regardless the high temperature or LMFRs) is between 25 to 33% .
- So there is a gap of at least 10% between Nuclear LWRs and Natural gas fired combined cycle PPs

The carbon emission values for different fuel used power plants

Technology	Mean	Low	High
	tonnes CO_2e/GWh		
Lignite	**1,054**	790	1,372
Coal	**888**	756	1,310
Oil	**733**	547	935
Natural Gas	**499**	362	891
Solar PV	**85**	13	731
Biomass	**45**	10	101
Nuclear	**29**	2	130
Hydroelectric	**26**	2	237
Wind	**26**	6	124

The carbon emission values for different fuel used power plants



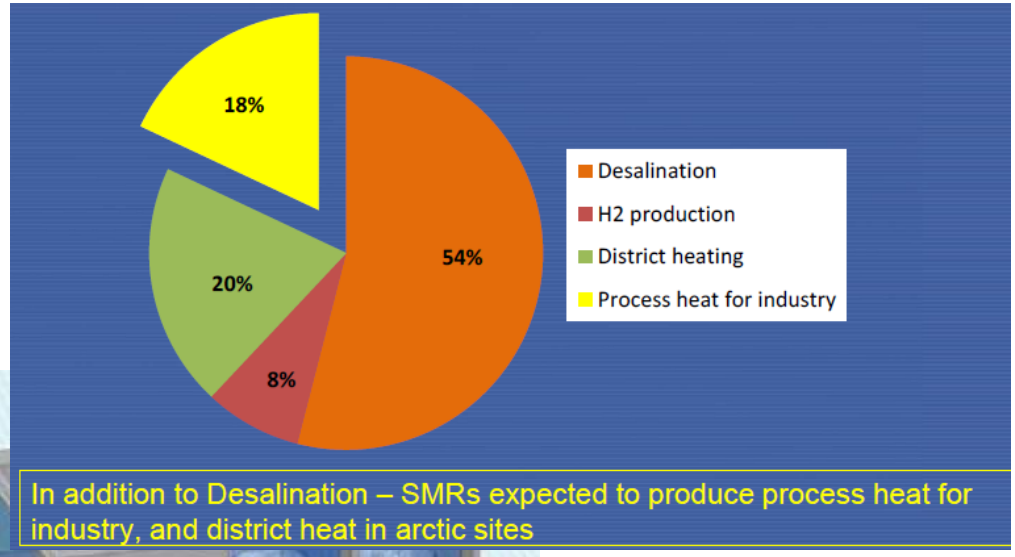
Advances in fossil fuel power generation technologies

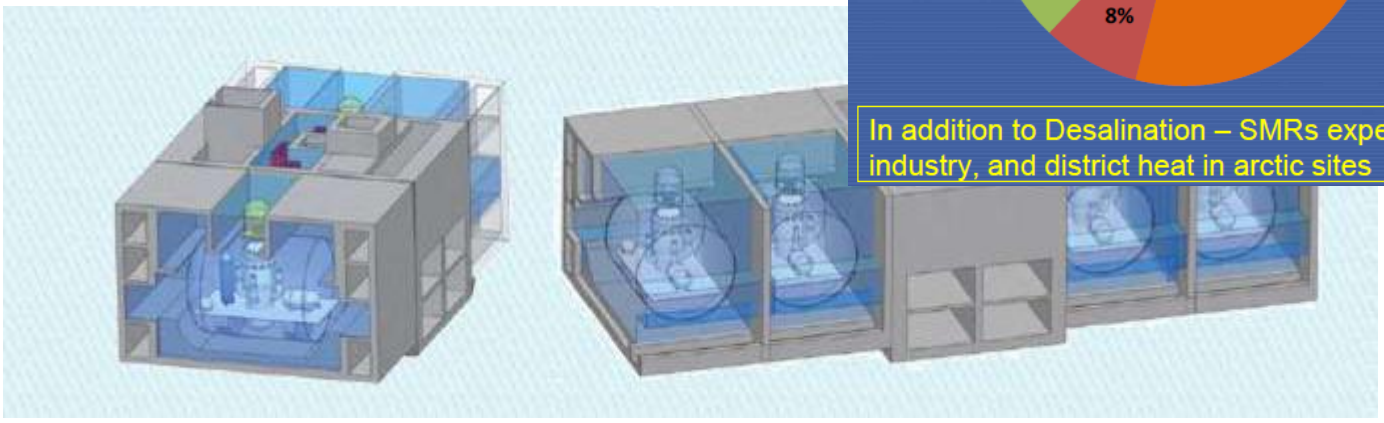
- Increased operating efficiency as well as more efficient CO2 capture and storage (CCS) in the medium term are the types of technology developments leading towards CO2 -free electricity production from fossil fuels. To give an example, Siemens has built a combined cycle power plant for E.ON AG in Irsching (Germany) with a capacity of 570 MW and an electric efficiency of 60.75%. This is the first plant in the world to exceed the 60-percent mark, and it will save over 40,000 metric tonnes of CO2 annually compared with state-of-the-art power plants of existing design with an efficiency of 58%.

- In coal-fired power generation, for example, efficiencies above 46% are being reached today with the aim to come close to the 50% level in the next few years. Although the state-of-the-art technology is at such high levels, the average efficiency of gas and coal fired plant across the world is approximately 41% for gas and 34% for coal. Looking at the coal fired power plant fleet, it becomes obvious that there is a huge efficiency potential. The total installed capacity of steam power plants in Europe is around 2,300 GW (2011) and 40% of them will be retired in the next two decades. That means roughly 1,000 GW of capacity needs to be replaced. In the USA, due to the availability and low costs of shale gas, old coal plants could be substituted by high efficiency combined cycles.

What's the Idea..?!

- The idea is simultaneous decreasing the carbon foot print and increasing electricity power generation through exploitation of a NPPs (preferably a SMR) as a industrial power plant to deliver heat, steam, desalination water to a (or if possible several) petrochemical plant and therefore possessing more natural gas to use for power generation.





A Petro-chemical Utility Facility case study

Output service	unit	Produced volume	remarks
electricity	MWh	4,500,000	Gas turbine
Process steam	M tone	9,500,000	200-420C
potable water	M3	14,000,000	MED
Demin. water	M3	19,000,000	Mixed Bed
Boiler feed-water	M3	12,500,000	MED

- *Mobin petro-chemical plant in south of Iran*
- *The values belong to 2017*
- *The values have rounded to 500,000*

The facility emitted more than 2,250,000 tone annually CO_2 to deliver their products.

What happens if a SMR used..?!

- A LWR SMR maximum steam(heat) output temperature could be 290-300˚C so where the higher temperature steam would be required the steam temperature must increased, maximum up to 420 ˚C (about 120 ˚C increase)
- if we make suppose 50% of produced steam must be super heated, so it produced 450,000 tone CO_2 annually.
- So the plan potentially could reduce about 1,800,000 tone CO_2 footprint.
- On the other hand using saved CO_2 in a combined cycle power generation plant with a 10% higher efficiency than SMR steam cycle lead to 1,200,000 MWh electrical power generation.

Advantages of using SMRs as industrial process heating and water sources

- They could be optimized in size to comply with industrial facility via their modular design.
- There is no safety and environmental concerns associated with locating nuclear facility near the urban areas.
- There is no such high sensitivity about transport of heating water or steam to the consumer location.
- The heat waste amount that increased severely with distance could be diminished.

References: