

Converting Low Level Nuclear Waste to Fuel

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Situation

In modern times, the use of nuclear energy has increased due to the depletion of petroleum and fossil fuels. However, the nuclear power plants produce hazardous nuclear waste that adversely affects the environment[1]. These wastes are classified by their radioactive contamination level:

- **High level Waste (HLW)**
- **Intermediate-Level Waste (ILW)**
- **Low-level Waste (LLW)**



Figure 1: HLW, ILW, and LLW [2]

HLW and ILW are efficiently stored in deep grounds; however, LLW is stored in shallow landfills which is risky. Therefore, only LLW is used in this project.

Problem

- Low-level nuclear waste is disposed of in shallow landfills. The landfills contain **Isosacharric acid (ISA)** that may react with the low-level nuclear waste. This reaction may radioactively contaminate nearby groundwater and water sources[1]
- The waste is rather disposed of or stored; therefore, it is not utilized efficiently



Figure 2: Illustration of How LLW May Contaminate Water Sources [3]

Solution

- The EMDP team suggests a solution that will utilize the LLW efficiently by converting the waste to methanol fuel through the processes of neutralization and combustion.

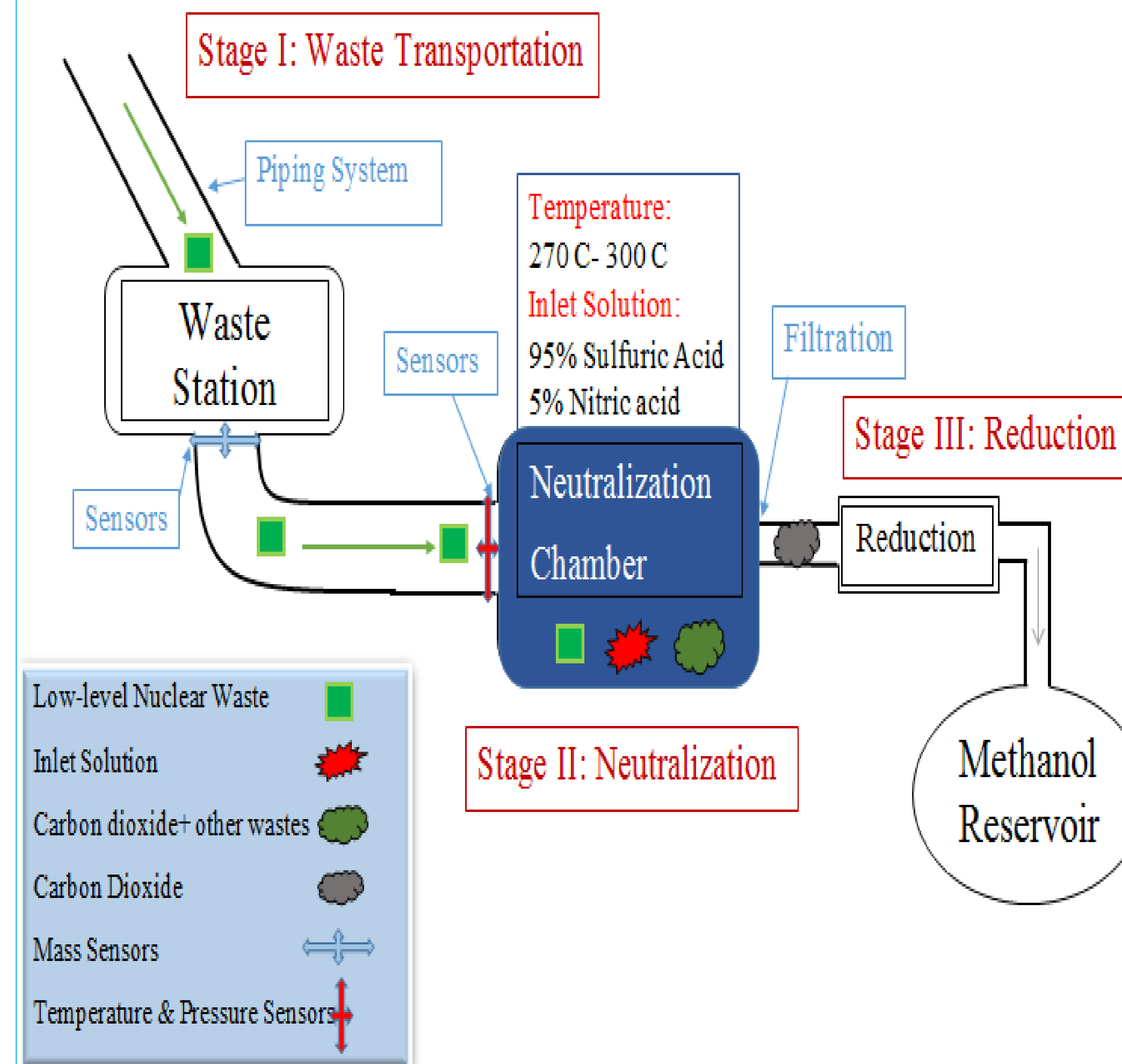


Figure 3: The Three Staged Process of Conversion

- Stage I: The waste is transported to the Waste station by the Steel-Concrete coated pipe system that insulates radioactivity and ISA..

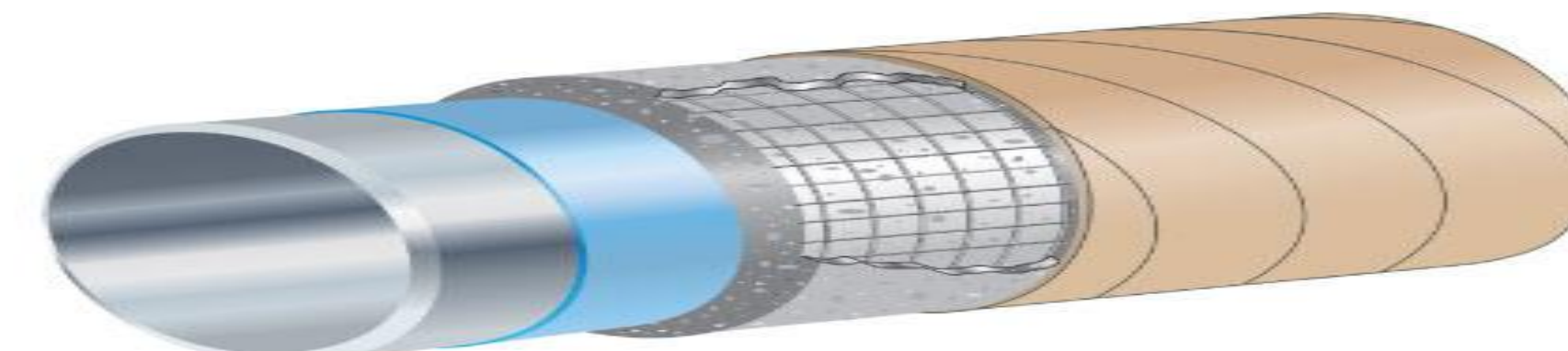


Figure 4: Steel-Concrete Coated Piping System [4]

- Stage II: The waste is chemically digested and neutralized in the neutralization chamber by Sulfuric Acid (H₂SO₄) and Nitric Acid (HNO₃) [5]
- Stage III: CO₂ is filtered from other wastes, and is then reduced to Methanol by the reduction reaction: CO₂+ H⁺ -> CH₃OH (Methanol) [5]
- Methanol can be used as an alternative fuel, or can be added to Gasoline in order to operate in vehicles.

Sensors are used to know the exact amount of waste going in the chamber. Moreover, it monitors the temperature and pressure to control the process and ensure safety.

Types of Sensors:

- Mass Sensor
- Temperature Sensor
- Pressure Sensor

Evaluation

- Neutralization has not been implemented in modern industry
- The current method of disposal cost: \$250,000,000 since 1996 [6]
- Sulfuric and Nitric Acids are expensive

Table 1: Cost analysis for Inlet solution, Waste Neutralized, and Pipes[7][8]

	Cost of Inlet Solution	Equivalent Mass of Waste Neutralized	Cost of Concrete Pipe Per Meter
Per Day	\$10,500	5kg	\$257.96
Per Month	\$315,000	150kg	\$257.96
Per Year	\$3,780,000	1800kg	\$257.96

Table 2: Cost analysis of Temperature and Pressure Sensors [9][10]

	Cost of Sensor
Temperature Sensor	\$71 per piece
Pressure Sensor	\$33 per 100 pieces

References

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 - [2] Realscience.Lancsngfl.ac.uk, 2016. [Online]. Available: http://www.realscience.lancsngfl.ac.uk/images/library/waste_header.jpg
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- Other references available upon request*