

- The safe stop of plant activity takes 24 to 48 hours.
- Usually, it takes a few weeks to close the facility. shutdown takes from 1 to 2 weeks. Even in case of complete shutdown, it is preferable to keep some activities hot, cool or running (for example hot asphalt moving through pipelines (when it gets cold it can dry and destroy pipeline), some chemical reservoirs required to stay cold (temperature increase can cause an explosion))
- There are specific activities to proceed for the complete shutdown of the plant. These activities are specified in plants' hurricane policies and this document updates based on experiences of each event. (28th

- Preparation for hurricane season starts in May. In response to Harvey new policies and procedures have been put in place. In some plants, new chapters related to flooding have been added in hurricane preparedness guide.
 - To manage water flush in a more efficient manner plants improved their drainage system.
 - Production facilities and equipment raised to minimize potential flooding damage.
 - As a response to Harvey, new weather stations created and more stations planned to be established in the future for more accurate predictions of rainfall/wind events.
 - Establishing a more detailed local weather network could assist the industry to prepare and respond to emergencies. There is a need for real-time rainfall measuring stations and weather stations and more accurate flood forecasting models.
 - For better measurement of floodwater and rain, water sticks placed in the key locations of the plants in order to measure flood levels more accurately and manage the crisis more efficiently.
 - A simple solution to overcome the threat of loss of the city's water was to use fire water to run air conditioners.
 - Most of the plants didn't lose power. Utilities (power and steam) were kept running at all times during Harvey and Imelda.
 - Pumps become demanded during hurricanes and storms. The pump rental will help to manage to floods better.
 - Shared satellite service for all refineries in the hurricane period can be a better solution than having those phones active all year. (researchers' suggestion).
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- Restarting refinery's activity takes

- The magnitude of Harvey was too big which caused a deficit of spare parts. Plant inventory and local suppliers couldn't meet post-Harvey demand. (hundreds of motors had to be replaced or repaired after Harvey. Year after there is still corrosive damage of equipment throughout the plant)
- Most of the spare parts have been delivered to Houston, but transportation channels from Houston to Beaumont were not active.
- It took about 7 days to get back to normal operations after Imelda vs 4 weeks in the case of Harvey.

- Now suppliers and plants have more inventory, even though keeping more inventory generates additional costs and inventory also is under risk to be damaged during hurricanes.
- Implement post-hurricane plant restart training for employees as preparedness.
- Spare parts shipment hub in the Beaumont airport area can be the best solution to fix the issues related to post-hurricane recovery for the entire industry.
- In some cases, large supplies and machinery were transported by helicopter from other plants to the Montagne Center.
- Zoned maintenance helped to address issues quickly.
- Flexible production practices can help to identify which production can be restarted in which time with the different levels of operations (in case of Harvey jet fuel production started earlier than the production of other products as they had enough inventory in tanks).
- Budgeted funds to purchase necessary supplies during the recovery period.

- Refinery shut down and especially recovery needs extra manpower.
- Hiring new employees is a time-consuming procedure in the oil and gas industry due to safety training and background check.
- A road closure is another challenge as it's the main way to get employees to work.

- Nearly half of the employees of the oil and gas industry impacted personally.
- Due to personal damage and lack of their ability to report for work many employees couldn't show up when refinery opened.

- Personnel on-site was not able to leave to go home, while personnel off-site was not able to get to the refinery and chemical plant.
 - Strict guidelines and safety protocols add additional time in hiring new temporary personnel and this slows down the recovery.
 - High demand for workers to recover from previous hurricanes in the same year affected the job market.
 - It became difficult to identify vendors to supply food to employees on site.
 - Medications for employees on-site became an issue.
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- Remote work for those employees who could complete their tasks from distance helped to manage human resources more efficiently
 - During recovery, there is no need for one part of employees to be on the worksite. Some companies used their workforce efficiently offering them opportunities to help to fix houses of other employees and communities.
 - Employees hosted in temporary housing near refinery to avoid transportation problems. However, there is a need for more reliable housing solutions other than just staying in hotels that have available rooms and plants of office buildings.
 - One of the oil and gas companies has a centralized response team that takes over the emergency response on-site (the emergency response team allows to go back to normal operations quickly).
 - Since Hurricane Rita, plants have implemented better and accurate communication with employees. Many channels have been used to ensure instant communication including text alerts and social media postings by oil and gas companies, communication by city. A future step can be creating real-time logistics maps to facilitate employees' and suppliers' access to production sites.
 - Reduce bureaucracy and red tape regarding the use of drone technology.
 - Practice to set up medical and financial teams to handle employees' immediate needs during a crisis.
 - Additional hotels/temporary housing solutions for workers are needed during these events.
 - Pre-certification and pre-security screening can shorten the time for new temporary workers to rapidly start working on refinery's recovery.
 - Some oil and gas companies

