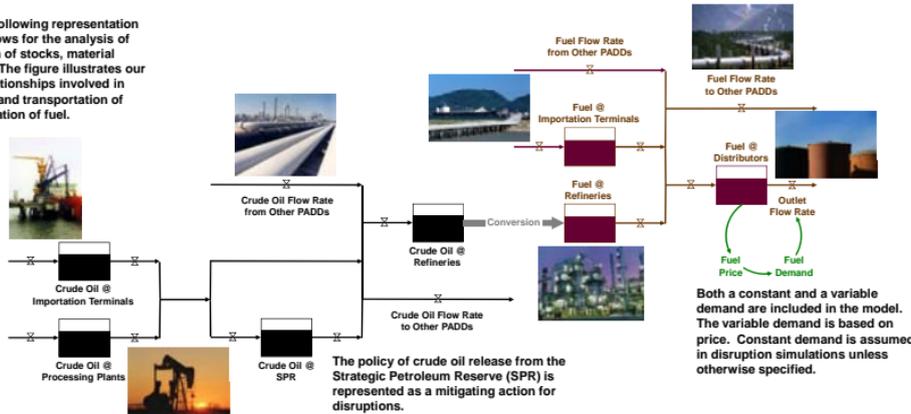


Model Structure

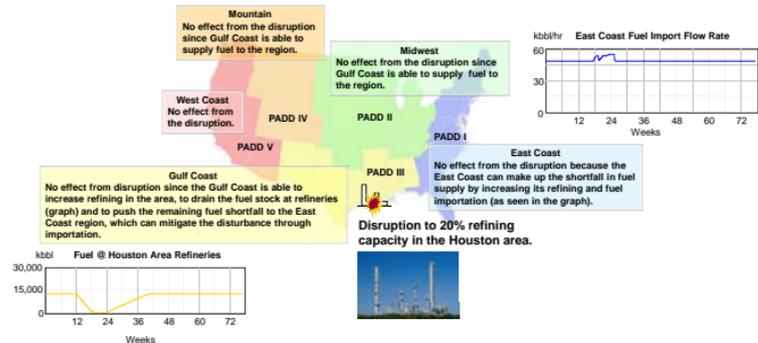
We modeled the petroleum industry with the following representation of stocks and flows. This model structure allows for the analysis of dynamics behaviors caused by the interaction of stocks, material flows, informational delays, and disruptions. The figure illustrates our understanding of complex processes and relationships involved in the production, processing, storing, refining, and transportation of crude oil as well as the storage and transportation of fuel.

In the model, these processes and regional interactions respond to a simulated market. In order to reflect demand-supply-price relationships, we modeled the market's allocations of crude oil and fuel among the regions in the United States. The result of these crude oil and fuel market allocations can be seen in the disruption scenarios presented.



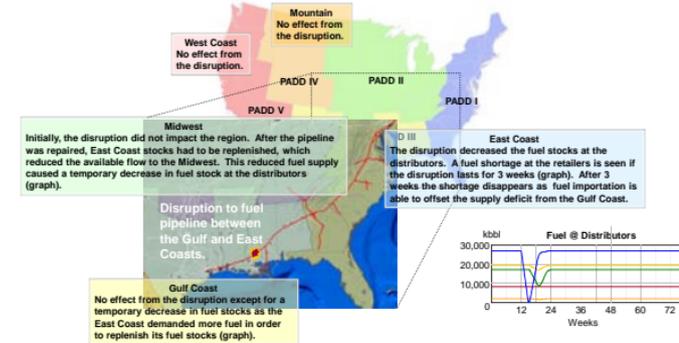
Refining Capacity Disruption

In this disruption scenario, a 12-week loss of 20% of refinery capacity in the Houston area was simulated. The impact of the disruption is primarily felt by East Coast distributors/refiner, who can cover their deficits (from the Gulf Coast) with imports. No fuel shortages are caused by this disruption.



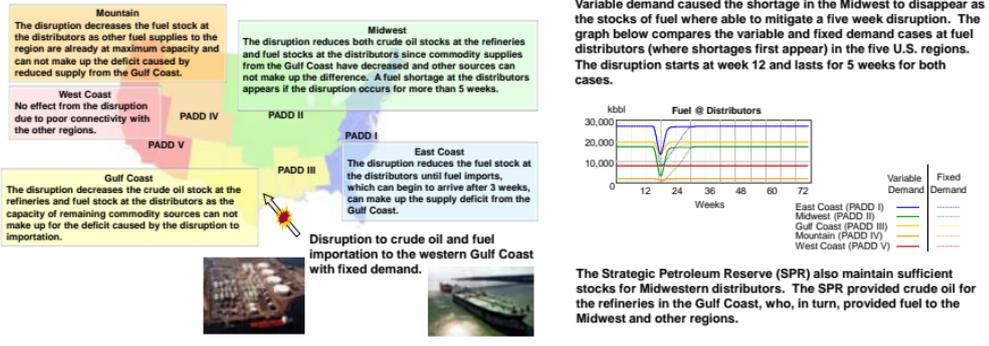
Pipeline Disruptions

A pipeline connecting the Gulf Coast to the East Coast was disrupted for 3 weeks. The East Coast distributors experienced fuel shortages. After the disruption, the Gulf Coast and the Midwest experienced a decrease in fuel stocks as the East Coast replenished its stocks.



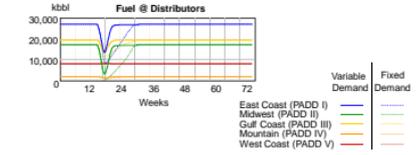
Importation Disruption

A five-week disruption to crude oil and fuel importation in the western Gulf Coast (Louisiana and Texas) was simulated. We examined three cases: fixed demand (base case), demand that varied with price (price-demand elasticity), and crude oil released from the Strategic Petroleum Reserve. In this scenario, each region uses its stocks of crude oil and fuel in order to buffer the disruption. Based upon EIA data, Midwestern fuel stocks are not sufficient to support the five-week disruption.



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Variable demand caused the shortage in the Midwest to disappear as the stocks of fuel where able to mitigate a five week disruption. The graph below compares the variable and fixed demand cases at fuel distributors (where shortages first appear) in the five U.S. regions. The disruption starts at week 12 and lasts for 5 weeks for both cases.



The Strategic Petroleum Reserve (SPR) also maintain sufficient stock for Midwestern distributors. The SPR provided crude oil for the refineries in the Gulf Coast, who, in turn, provided fuel to the Midwest and other regions.

A pipeline connecting the Gulf Coast to the Midwest was disrupted for 7 weeks. The Midwestern distributors experienced fuel shortages. After the disruption, the Gulf Coast and the East Coast experienced a decrease in fuel stocks as the Midwestern region replenished its stocks.

