Bunker Fuel Outlook and IMO Implications

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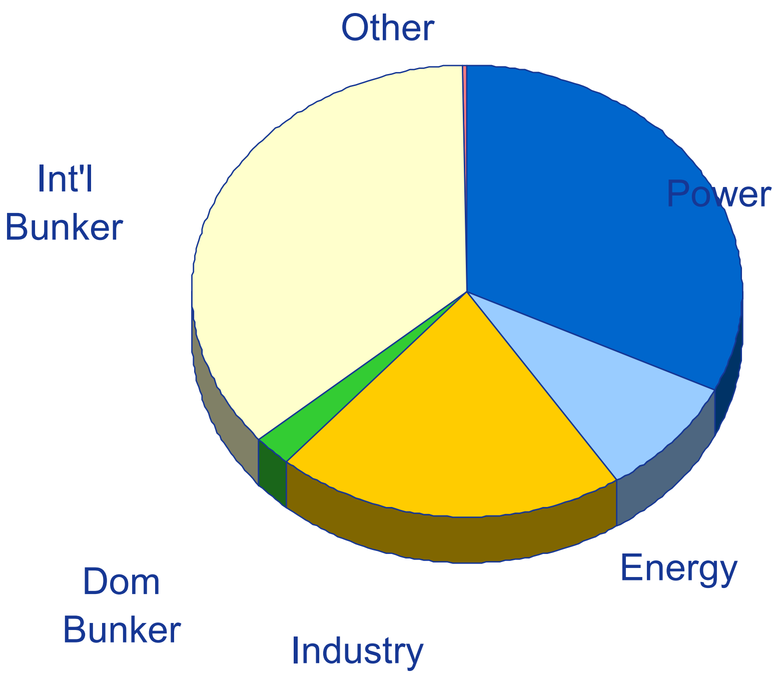
Most residual fuel oil is used in non-bunker applications.



- Domestic and international bunker accounts for about 200 million tonnes per year.
- Non-bunker applications represent about 320 million tonnes per year.

Power applications

- About 170 million tonnes per year are consumed in power plants and utility applications.
- Sector consumption is falling about 5% per year.
  - Large power installations can be built to use either inexpensive coal or energy-efficient gas in lieu of oil.
  - Oil is used in many locations as a fuel of last resort.

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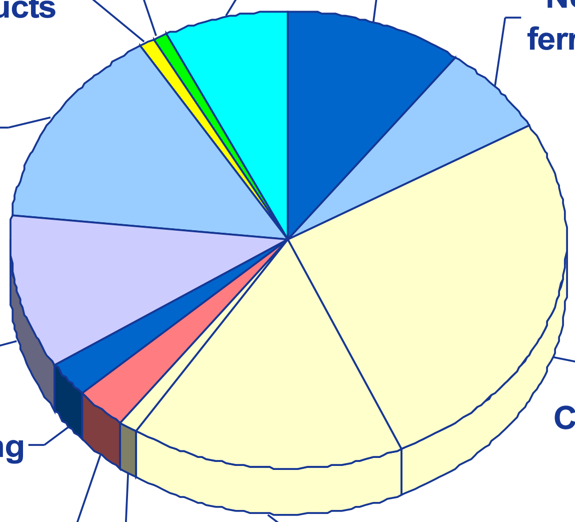
Energy applications are mostly refinery fuel.

- Many oil refineries consume fuel from crude oil to drive the refinery process. This category excludes feed stock uses of fuel oil.
- Refiners are usually able to consume high viscosity fuels since fuel is consumed mostly in furnaces or boilers under very stable operating conditions.
- Refineries consume about 45 million tonnes per year of fuel oil, a figure that is declining as gas displaces oil.

Global industrial fuel oil use is to provide process heat or steam.



- Chemicals, non-metallic minerals and pulp & paper account for large fractions of global industrial fuel oil consumption.
- Many other applications are quite small.

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- Residual fuel applications
- IMO's new initiatives on bunker sulfur emissions
- Medium term and long term impact
- Possible ways to meet new bunker specifications.

Important new initiatives have been adopted for bunker fuel-derived sulfur emissions.

- Marine bunker fuel has had no sulfur emissions regulations.
- New sulfur emissions limitations have been adopted that will impose new costs.
- The nature of bunker fuel may change.

- Shore-side, stationary sulfur emissions have been regulated for many years.
- No major change in these regulations is anticipated.
- Clean fuels as well as flue gas desulfurization (FGD) are used for compliance.
- Low sulfur fuel oil is used in some areas.

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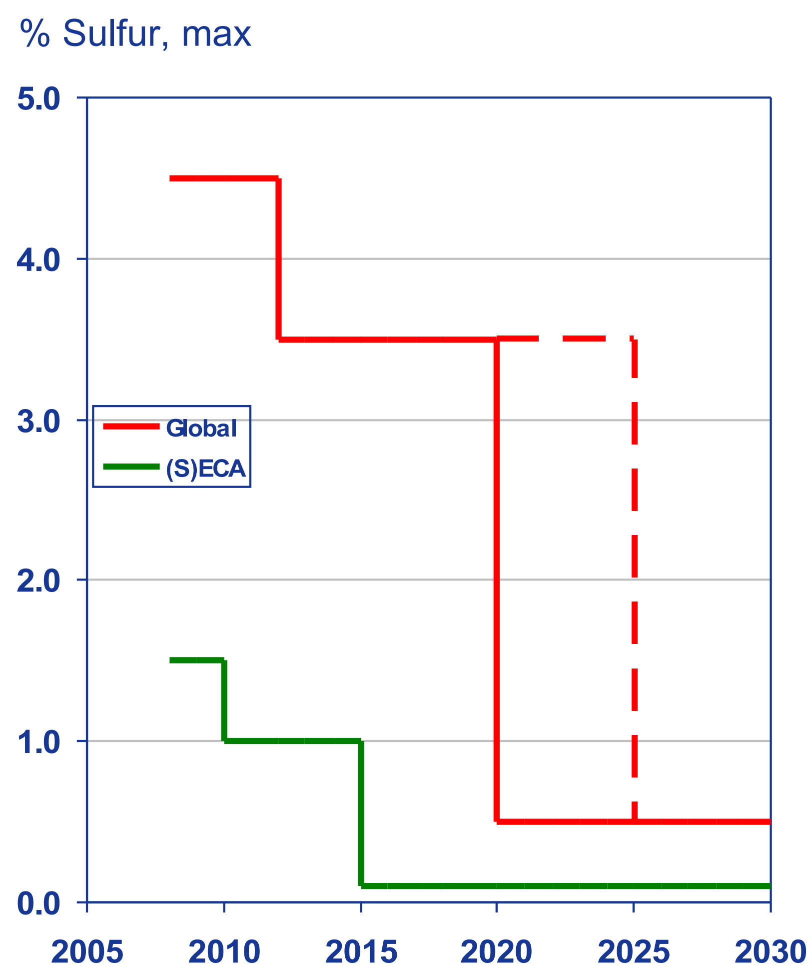
Proposed IMO regulations will significantly reduce sulfur emissions from bunker fuel consumption

- **In April 2008, the IMO proposed and approved amendments to the MARPOL Annex VI**
  - **Proposal was adopted in October**
  - **Country-level regulations to be propagated**
  - **Global bunker fuel sulfur reduced to 0.5% by 2020/2025**
- **SOx Emissions Control Areas, (S)ECAs, have lower limits**
  - **Current (S) ECAs established in the North Sea and Baltic Sea**
  - **North America is probable to implement (S) ECAs north of the Mexican border**



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New technologies in vessel emission controls may aid in compliance, mitigating the fuel quality impact.

- IMO has approved the use of "equivalence technology", such as flue gas treatment, in place of low sulfur fuel
- On-vessel scrubbers are not proven commercially but several pilot testing programs report good results
- Retrofitting cost and suitability is uncertain
- Technology addresses sulfur and perhaps PM emissions but not NOx or CO_2
- On-vessel flue gas treating could provide a lower cost solution in some cases
  - Adoption will depend on route, service, vessel age and other factors

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Medium term solutions for SECA fuels will not be revolutionary for the refining industry.

- Low sulfur fuel oil demand has fallen globally in the past decade.
- Feed stocks and equipment that made that fuel likely can be diverted to low sulfur bunker fuel in moderate volumes without disrupting refineries or appreciably impacting cost differentials.
- Locations of fuel supply may not match SECA demand locations.

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Bunker fuel qualities are generally below current IMO global requirements of 3.5% sulfur in 2012 …

IFO 380 Quality

Sources: Port of Long Beach, PGI

- But IMO's requirements of 0.5% sulfur in 2020 / 2025 will significantly impact both ship owners and refiners.

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Ship owners are faced with two fundamental alternatives.

Fuel Sulfur Reductions

- Progressive reductions in fuel.
- Perhaps use lowest sulfur fuel only in selected areas.
- Exposed to fuel price increases.

Exhaust Gas Scrubbing

- Technology will probably work.
- Permitting for sensitive areas not clear.
- O&M costs are as yet uncertain.
- Concentrates some objectionable materials into waste streams that must be disposed of in port.

The refining industry is faced with three fundamental alternatives.

Reduce Marine Fuel Sulfur

- **Heavy investments in desulfurization or conversion technology.**
- **May produce low sulfur MDO or MGO in lieu of IFO.**

Drop Fuel Oil as a Product

- **Invest in more advanced processing**
- **Focus refining on lighter, higher valued fuels.**

Do Nothing

- Continue to make high sulfur fuel oil.
- Focus on stationary applications of fuel oil.
- Sell marine fuel only if exhaust gas scrubbers allow.

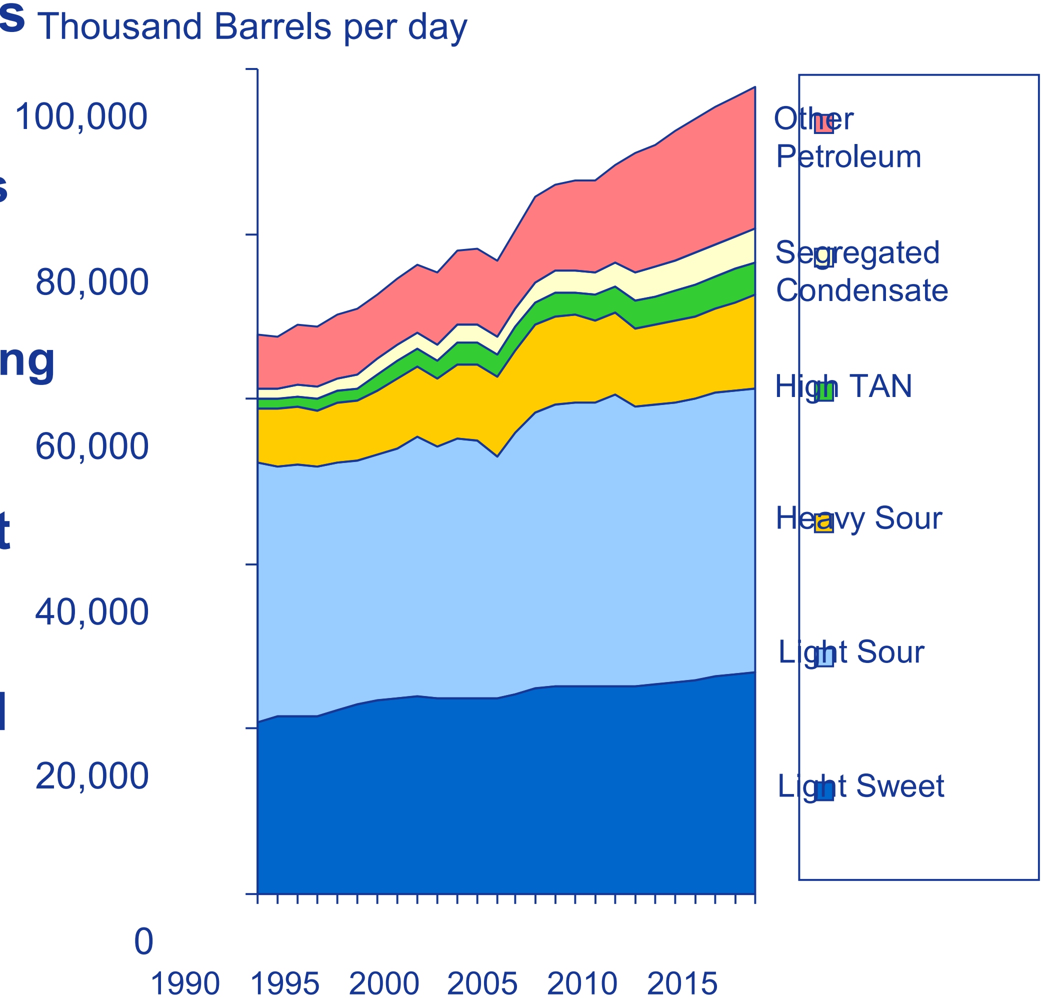
How can refiners make low sulfur bunker fuel?

At least four process routes are possible.

- **Process only low sulfur crude oil.**
- **Remove sulfur from the bunker fuel from higher sulfur crude oils.**
- **Convert bunker fuel components to MGO-range lighter products and remove the sulfur from those.**
- **Convert bunker fuel components into high speed diesel (HSD)-range products and remove the sulfur from those.**

Shifting crude oils is not a promising solution.

- **Supply of sweet crude oil is not rising much.**
  - **Existing sweet crude oil is devoted mostly to making LSFO for onshore applications and to cracking operations.**
- **Only some refiners at most could use this route.**
- **Bunker fuel/fuel oil derived from growing sour crude production must be upgraded.**



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Removing sulfur directly from bunker fuel is technically possible but expensive.

- Processes for removing sulfur from fuel oil have existed for decades.
- These processes were developed to make low sulfur fuel oil for utility generators, most commonly in Japan.
- The processes are very expensive to install and to operate.
- These are referred to as ARDS—Atmospheric Reside Desulfurization and VRDS—Vacuum Residue Desulfurization.
- Generally these result in internationally uncompetitive low sulfur fuel oil in today's market environment.

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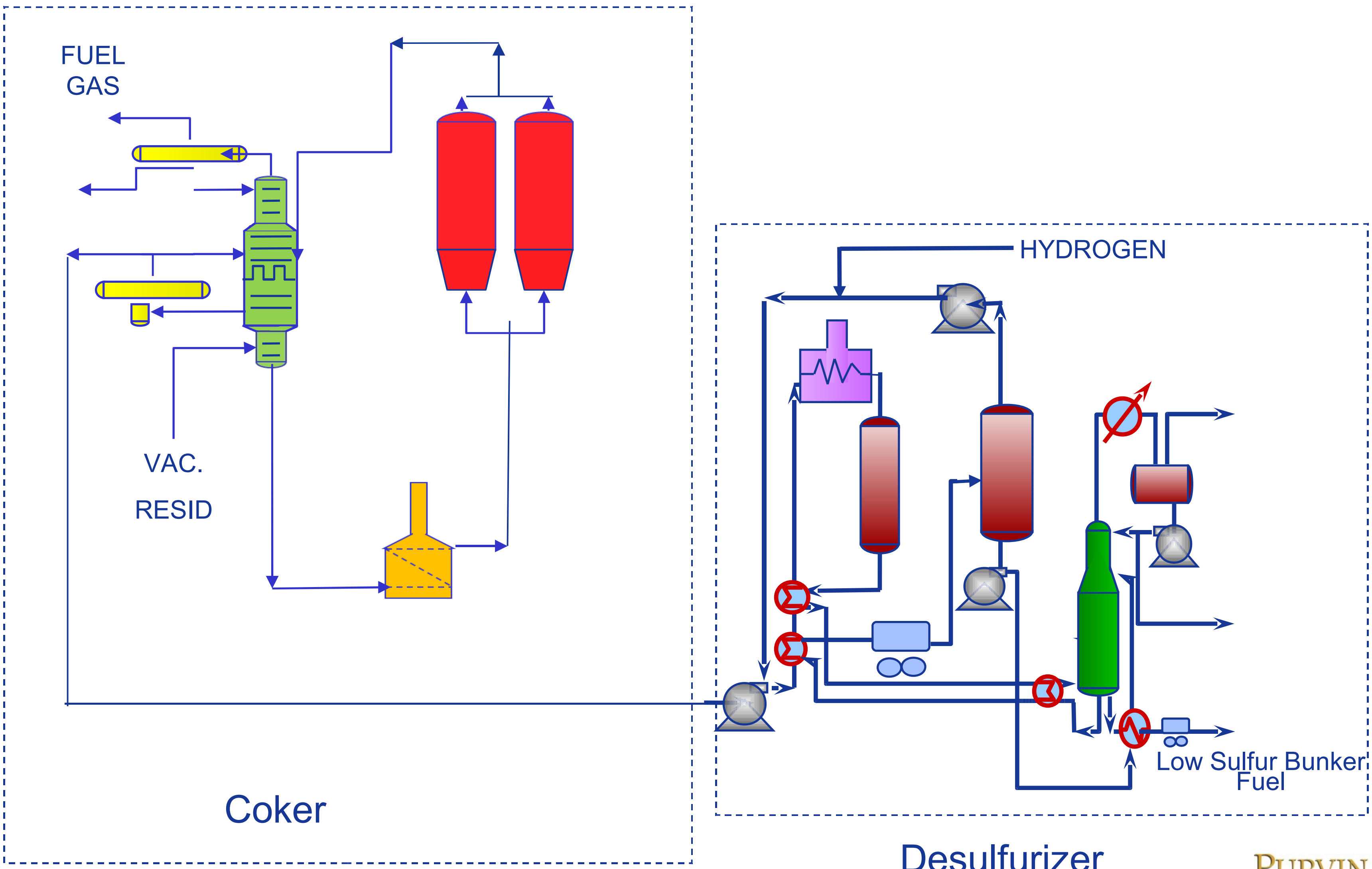
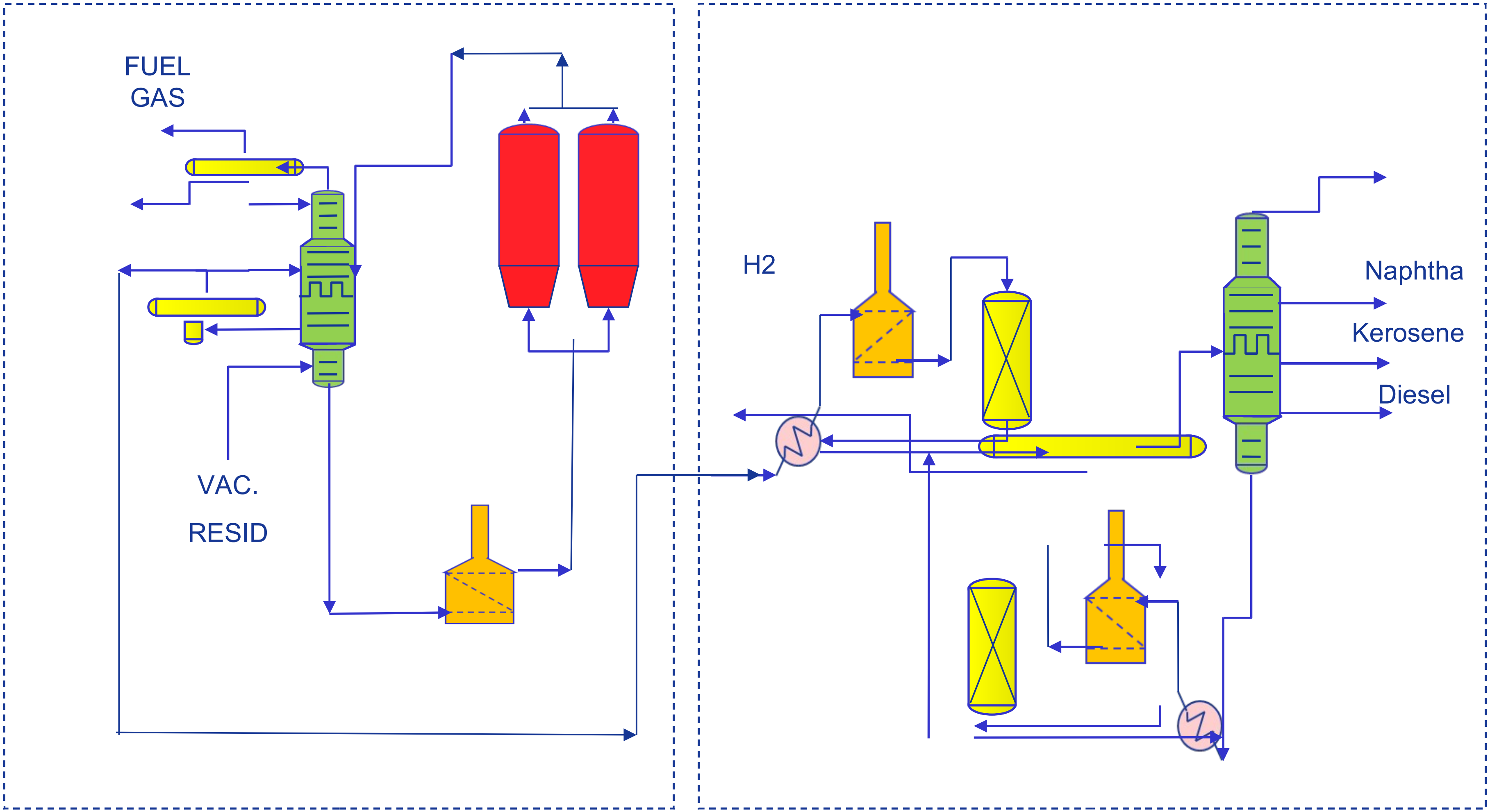
Coking and desulfurizing makes a low sulfur MGO-type material at good yield.



Coking/desulfurizing results in high sulfur bunker destruction and good yield of marine fuel.

- Resulting marine fuels are lighter than RM-grade fuels as they are all distillate.
- Viscosity will be greater than conventional MGO, perhaps 30-50 cst.
- Low sulfur marine fuels yield will be about 65% of the high sulfur bunker fuel destroyed.

Coking and hydrocracking together produce HSD, kerosene and naphtha from VR/bunker fuel.



Coker

Hydrocracker

Coking/hydrocracking results in high sulfur bunker destruction and good yield of light products.

- No stream that is marine fuel gravity results in this case. All production is conventional high speed diesel or higher quality.
- This approach is effective at destroying bunker fuel but not highly effective at producing low cost marine fuels.
- If the refining industry adopts this approach, marine fuels would be mostly conventional high speed diesel.

The refining solution to IMO sulfur regulations likely will be expensive.

- Technically the challenge of low sulfur fuel in high volumes can be met.
- Costs will be high and low sulfur fuel premium is likely to rise from current levels in the long term case.
- Conventional refining cases are unlikely to be cost competitive with scrubbing in a full-time low sulfur environment.

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