WHY MODULAR?
For 37 years, modular equipment has been manufacturing and delivering to customers. Modular construction is, in our opinion, the best way to build an oil refinery, particularly in capacities under 50,000 BPD and in cases where the intended final capacity is to be built in stages.

The first point to be made is that “modular” just refers to the way of construction, where the refining equipment of the various process units is put on platforms or “skids” by the manufacturer, and then shipped to the refinery location, as opposed to shipping the equipment to the refinery location and then building it on site. The resulting refinery, in terms of technology and equipment used, is exactly the same as a conventionally-built refinery. Thus it is just as efficient and long-lasting as a conventional refinery, but with two important advantages: The modular way contributes important savings in investment cost for the process units, while yielding a much faster overall construction schedule of the refinery. The combination of these two advantages invariably shows an important increase in the overall profitability of the refining project. At a smaller capacity, a modular refinery would thus be competitive with the larger conventional one, but most importantly in many cases, of course, a smaller refinery will be considerably easier to finance.

There was a time when modular process units and refineries were small in size, limited in technology, and not applied to capacities above 2,000-5,000 BPD. They were thus limited to very specific local applications, next to producing wells of difficult access, in the dry desert, the cold tundra or in a deep jungle. However, today, this scenario is changing, and modular refineries can be supplied up to a capacity of 50,000 BPD (limited by the transportation limitations), and include desulfurization units, catalytic reformers, catalytic isomerization units, or hydrocrackers.
In other words, they are complete, modern refineries, and highly competitive with those built by conventional construction. Conversion refineries up to 200,000 BPD can be offered on a modular basis, and can be built, depending on the requirements, at a lower cost and in a shorter time. These modular units are thus generally small, but there is obviously no technical difference between manufacturing and building a 10,000 BPD unit and a 50,000 BPD.

Modular construction imposes several limitations, both on the maximum capacity of the units which is practical to build and transport, and on the type of refinery process units that can be “modularized”. For example, the largest crude oil distillation unit which can practically be built and transported (and this as long as the site has easy access to a port) is probably 50,000 BPD. The limitation derives from the equipment size itself, and affects other process units which may require very large or heavy pieces of equipment. An example of this would be the hydrocracking unit, where the unit’s reactors, even at a relatively moderate capacity, such as 20,000 BPD may be too large to build alongside the modular rest of the unit. Also, the conversion technical option under modular construction is limited to Hydrocracking, since the construction of modular Fluid Catalytic Cracking, Thermal Cracking or Coking units is not viable at this time. Hydrocracking is, of course, an excellent process, producing high-quality jet fuel and Diesel products directly, while its naphtha is sent to octane upgrading in the refinery’s catalytic reformer. FCC, usually considered a good option by refinery planners because its lower investment cost, requires a host of additional process units around the conversion process unit, including desulfurization of charge or products, polymerization, alkylation, or butane isomerization to meet modern fuel specifications. This defeats to a large extent its lower investment advantage.

With the use of a Hydrocracking scheme, in these days of lower aromatic specifications in gasoline, particularly in Europe and North America, as shown below, we will take a number of processing decisions on the full range naphtha, so that we meet octane requirements at low aromatics content.
The above considerations point to the two issues to be discussed in deciding the refinery configuration: A choice for the conversion scheme, and a choice for the generation of octane.

Usually, we need conversion of the atmospheric residue, because it typically accounts for fully half of the crude feedstock, and hydrocracking is our choice route to achieve it. If we need to go for an absolutely maximum conversion of that residue, we add a Solvent Deasphalting (SDA) unit on the vacuum residue. The “lift” of a solvent deasphalted oil (DAO) would be an additional variable, but although it is technically possible to lift much more, lifting more than 30% of DAO from the vacuum residue makes the quality of the hydrocracker feed progressively worse, and runs the risk of making the hydrocracker’s operation very difficult, shortening the hydrocracking catalyst life.

The second issue is that of the production of a high gasoline octane within the aromatic specifications: Meeting the latest world specifications in the gasoline will require the refinery to lower the aromatics content of the gasoline below 35%, which means that we will face difficulties making our gasoline octane by just increasing the severity of the Catalytic Reformer. The addition of an Isomerization unit to improve the paraffinic octane in the lighter fraction, even adding normal-paraffin recycles will achieve the highest possible octane of the light naphtha fraction. Another process solution will be to add a small benzene saturation unit to the isomerization loop. This unit will not destroy much of the octane contributed by the benzene, since its conversion products (cyclohexane and methyl-cyclopentane) are also high-octane. Another decision we can make is to cut the end point for the naphtha at 155ºC, both for the straight run naphtha from the Crude Unit, and for the naphtha produced by the Hydrocracker. This increases the refinery yield of kerosene, but some of the kerosene shown could be shifted to the Diesel oil product, so this should not be a problem.

Other minor considerations for the refinery configuration will be the choice for treating kerosene (mercaptan oxidation or hydrotreating) and the need for an asphalt oxidation unit.
With these ideas in mind, a possible overall refinery configuration is shown below:
One of the key advantages of modular construction, in addition to low investment and fast project implementation, is its adaptability to factors such as market development growth, or financing availability. In planning a large refinery capacity, in order to be competitive, while at the same time keeping a reasonable construction time, and finding the financing solution for the expenditure such a project requires, adding modular trains of 50,000 BPD, with construction times of only 2-3 years would allow a lower initial investment, with subsequent capacity additions taking place while the initial refinery project is already generating revenue. A lower overall investment for the same capacity allows the refinery to be more competitive in export markets than a conventionally-built refinery would be.

The controversy about the advantages of modular construction versus conventional construction continues in international meetings. International contractors (and because of their prestige in the industry, consultants, and refining customers alike) have been minimizing for years the enormous advantages of modular construction, in terms of both investment and time on-stream. Because modular construction only requires from the general contractor the preparation of concrete slabs where the modular process units are assembled, the bulk of the value of the refinery units now shifts to the modular supplier. In other words, of the “EPC” project value, Engineering and Procurement would be now both the responsibility of the modular supplier, leaving to the conventional contractor only the Construction portion. Obviously, this is not a satisfactory arrangement for contractors (they traditionally derive most of their profit from the equipment procurement), so the modular approach is one which the conventional contractor is bound to dismiss, fight and criticize.

A final, very important, additional advantage of the modular approach is that the contractor does not need to be experienced in building the process units in question. All it needs to do with respect to the modular units is to prepare the concrete slabs to receive the modular units from the manufacturer. Most local contractors have therefore, the technical expertise to build the project, thus greatly widening the range of contractors able to build the refinery.
This has successfully designed, fabricated, delivered, and installed modular refineries and gas plants across the globe since 1978. With conventional foundation-mounted refinery equipment, each piece of equipment is placed on its individual foundation at the refinery site and welders pipe the equipment together. This “stickbuilt” conventional method, even under ideal conditions, requires significantly longer construction time than modular fabrication. In remote locations, or places unfamiliar with industrial construction, the differences in time and efficiency of construction can be dramatic: In modular construction, rather than assembling all of the components at the refinery site, the facility’s structure is reduced to smaller elements that are assembled efficiently and rapidly at the fabrication plant. By performing most or all of the fabrication and assembly at manufacturing facility, the modules, as well as the workers that put them together, are not subjected to environmental dynamics like heat, wind, or rain. Modularization also minimizes inclement weather delays. Controlled working conditions yield a higher-quality product, the metal is less prone to expand and contract from temperature fluctuations, and welding equipment runs on a steady voltage from the local California power grid.
The above explains the advantage of the modular construction in terms of time, which leads to an earlier on-stream date, and earlier revenue from the investment, decisively increasing profitability to the client. However, as important as achieving operating revenue sooner is, speed of construction by the modular approach intrinsically reduces investment, since it drastically reduces the labor factor of the “material and labor” costs: Typically, in far-away places M&L costs split 40-60%, or even 30-70%, while by modular construction, the split is more nearly 50-50%. Thus, modular construction means costs between 70% and 80% of traditional “stickbuilt” construction. In modular construction, high-cost field work hours are transferred to the shop. Building with modules reduces the need to maintain a skilled construction crew on or near the refinery site, which can cost $150 or more per day per worker just for housing. Fabricating modular processing facilities away from the refinery's final site reduces the impact of construction on the customer's site, a significant advantage when the installation site already is an operating plant. Modular construction also minimizes lay-down space, an important consideration when the field site is small or congested. In-air work is minimized, and foundation requirements are often simplified.
Pre-fitting components onto a module permits correction of any fitting errors prior to shipment to a customer's plant, with less re-work needing to be performed on-site. Procurement also is simplified, especially when the installation site is located where raw materials and equipment are expensive or difficult to obtain. Removing the need for highly skilled labor onsite offers an added advantage in areas where skilled labor is either costly or unavailable.

All modules are hydro-tested as part of the weld inspection, particularly any pipe that is to be painted and insulated before leaving the facility. Installation time is then very fast. It’s skid-mounted modular equipment for placement on concrete slab foundations. A module leaves the fabrication plant nearly complete, with most of its support structure, pipe, instrument stands, electrical wiring, grating, fireproofing, insulation and other components built in and ready for operation, once connection is made to the refinery’s systems. All modular equipment is transported by truck, rail or ship to the refinery site where the modules are assembled with the advice of an experienced installation team. When the equipment arrives, it is set on the concrete slab foundations. Final skid placement and elevations are checked against the drawings and skids are shimmed and adjusted accordingly. All piping, instruments, and electrical connections are made among the skids and tested. After completion of testing, the
equipment is disassembled, packed, shrink-wrapped, and shipped. All equipment is shipped by truck from the Bakersfield, California, or the Houston, Texas fabrication facility to the destination port. Local project management can also provide as necessary.

After the equipment is in place, assembly of the interconnecting spools begins. The equipment is literally bolted together. Little welding is required. The process equipment can usually be assembled and ready to start up within thirty days. All rotating equipment, instrumentation, and electrical equipment require preparation for operation. Piping is pressure tested and/or vacuum tested. The equipment is purged and made ready for startup. The twenty-four hour test run confirms the design of the process equipment. Our advisors advise the operating personnel about the proper operation of the equipment to achieve the intended results.