Sustainability in the chemical industry by 2050

(The outlook for a sustainable chemical industry in 2050)

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It was Albert Einstein who, long before the awareness of depletion of ores and fossil fuels and pollution of the environment gathered momentum, had already stated that: "The world we created today as a result of our thinking thus far faces problems that cannot be solved the way we thought when we created them".

Everybody agreed with him at that time although the message was hardly understood. But in the early seventies the consciousness grew that conservation of energy and protection of the environment deserved particular attention, thanks to the Report of Rome and Dennis Meadows' doomsday scenario in "Limits to Growth".

Of course, there were other problems Einstein warned about, but we should concentrate on the two issues that were emphasized by Meadows.

Especially environment established its place in the new thinking. Only in the early seventies was energy an issue when the Organization of Oil Exporting Countries (OPEC) was able to raise the price of a barrel of oil to a level above US$ 40. Later the price stabilized at a much lower level and price worries subsided.

It was not until 1992, that the Dutch government launched an initiative for a "Sustainable Technology Development" and asked for *the* guidelines. The basis of their questions to an interdepartmental program group was: What will the world look like in about fifty years time?" and "Are there any avenues that should be taken into now in order to arrive without major shocks in the society of 2050?".

It was realized by the program group that these simple questions had many aspects for areas as diverse as: water, housing, transport and food.

One area was chemistry, recognizing the fact that chemistry is the major driving force in all life processes and a major contributor to many products that enhance the quality of life. Think of fibers, plastics, coatings, food-ingredients, pharmaceuticals, paper, detergents and many others.

The mission for "DTO-Chemie", the group responsible for working out the chemistry contributions part, was two-fold:

- Sketch the contribution chemistry could make to a sustainable society in the middle of next century by looking back from 2050. This "looking-back" with backcasting Techniques was crucial in the approach to answering the questions.
- Formulate the avenues of developments and changes that have to be taken at this very moment.

The goal was evident: Increase the quality of life with the help of chemistry.
The study initially centered on the availability of energy carriers. That is: finding substitutes for oil, petrol, kerosene, coal, natural gas and promoting the use of electricity based on solar radiation from a chemical point of view.
Another study dealt with the possibilities of raw material supplies for the production of chemicals with particular notice to the large polymers: polyethylene, polypropylene and PVC. At present, these polymers are responsible for half of the global output of industrial organic products.
Also, in dematerialization (reduction of material use) chemistry should play an important role. For instance, in lighter materials in transport vehicles in order to save energy; and in more efficient reaction technology in order to reduce emissions to water and air. Or in the construction of laminates in solar cells in order to trap solar energy for conversion into electricity.

Every proposed technology should be:

- Environmentally neutral as well as
- CO_2 neutral

The process was started by asking groups consisting of representatives from industry, science, politics, government and banks;

- What will be the shape, the motivation and the need of the world in the year 2050?
- Will industry and science be capable to fulfil the needs of that world?
- Which conditions should be satisfied from now on to implement all the necessary activities?

The backcasting sessions supplied many expectations and, of course, many uncertainties. However, some conclusions for the year 2050 were supported by nearly everyone involved.

- There will be roughly 10 billion people living on our planet.
- The energy consumption will, despite major energy conservation, at least have doubled compared with that of 2000. The share of electricity in the energy supply will be much larger than in the preceding century.
- The economy will have grown exponentially.
- A much larger part of the global population will be living in cities.
- The mobility of the people will have strongly increased.
- The strong individualism of people will lead to many more personal vehicles.

The parties that must satisfy these conditions are: government, industry, universities and development institutes world-wide.

The members of the backcasting groups stated that the parties should work in close cooperation but also realized that their possibilities especially for the long term, would be limited.

The driving force will be the realization that fossil reserves are finite and that prices will go up. Moreover, one wants to become less dependable on distant suppliers.

Before we reach that point large quantities of oil, natural gas and coal are going to be used. This will initially result in a further increase of the CO_2 content in the atmosphere till the years 2020-2030. According to the calculations of the IPCC (International Panel on Climate Control) this will have a modest impact on the rise of the sea level and the global temperature.

After 2030 a gradual stabilization of the CO_2 content by an increased use of electricity

from wind and photovoltaic cells and by using liquid fuels from biomass conversion will taken place. In the second part of the next century the CO_2 concentration will decrease. This will be the result of the scrubbing effect of the oceans as mentioned before.

An activity that will precede the CO_2 reduction is removal of detrimental quantities of certain persistent organic pollutants in the atmosphere by better controlled chemical processes. Not only moral considerations but also financial reasons will lead to reducing the spilling of these chemicals.

In the more developed countries legal constraints will have an accelerated modifying effect.

Last but not least the coating industry with their emissions of solvents.

There is already enough knowledge developed to switch to either waterbased coatings or to high-solid paints with only a fraction of the solvents used in more antiquated coating materials. Another technology is the take-up of monomers, used as solvent, in the coating recipe.

It is only a matter of time to bring about the needed cleaning effect in the atmosphere. Too drastic actions now could be counter productive.

In a changing society in which sustainability is going to play an increasing role the effects of an increase in land use for agriculture to produce food and energy, should not be overlooked.

Plants have their own emissions and too large plantations of a particular crop can be detrimental to human and animal health.

Another issue that deserves attention is the water vapor content in the atmosphere. It is too easily accepted that all water vapor coming from combustion is going to condense soon afterwards.

In the equilibrium situation that existed before the industrial revolution this was hardly a problem. Evaporation of sea and landwater and the closed loop of biomass burning were the major processes in water vapourforming. Water vapor however, that originates from combustion of large quantities of natural gas is not part of the equilibrium system.

It can be imagined that especially water vapor originating from natural gas burning could increase the average relative humidity of the global atmosphere by a few percent.

If this should be the case, and there are hardly any measurements to check this

assumption, the greenhouse effect would be influenced as much by this fossil water vapor increment as by the increment of CO_2 from the same natural gas. The greenhouse effect of water vapor is namely around 30 times stronger than that of CO_2.

I informed you about the program that we proposed to the Dutch government. It is not at first sight a quantum leap in completely new technologies. The inventions that will be leading to a large leap forward should be following as a matter of course when this program is going to be tackled with vigor. What is new is the connection of the different avenues.

Chemical products are dependent on energy carriers and agriculture plays at long range the key part. Cooperation between agriculture and the chemical industry in this field cannot be avoided. New studies of the methodology of chemical processes play an essential role in this scenario.

I want to finish by expressing my optimism that through intensified programs for sustainability, especially aimed at energy supply and methodological studies of chemical processes, air pollution will be greatly reduced too.