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Catalyst Technology for Green & Sustainable Chemistry

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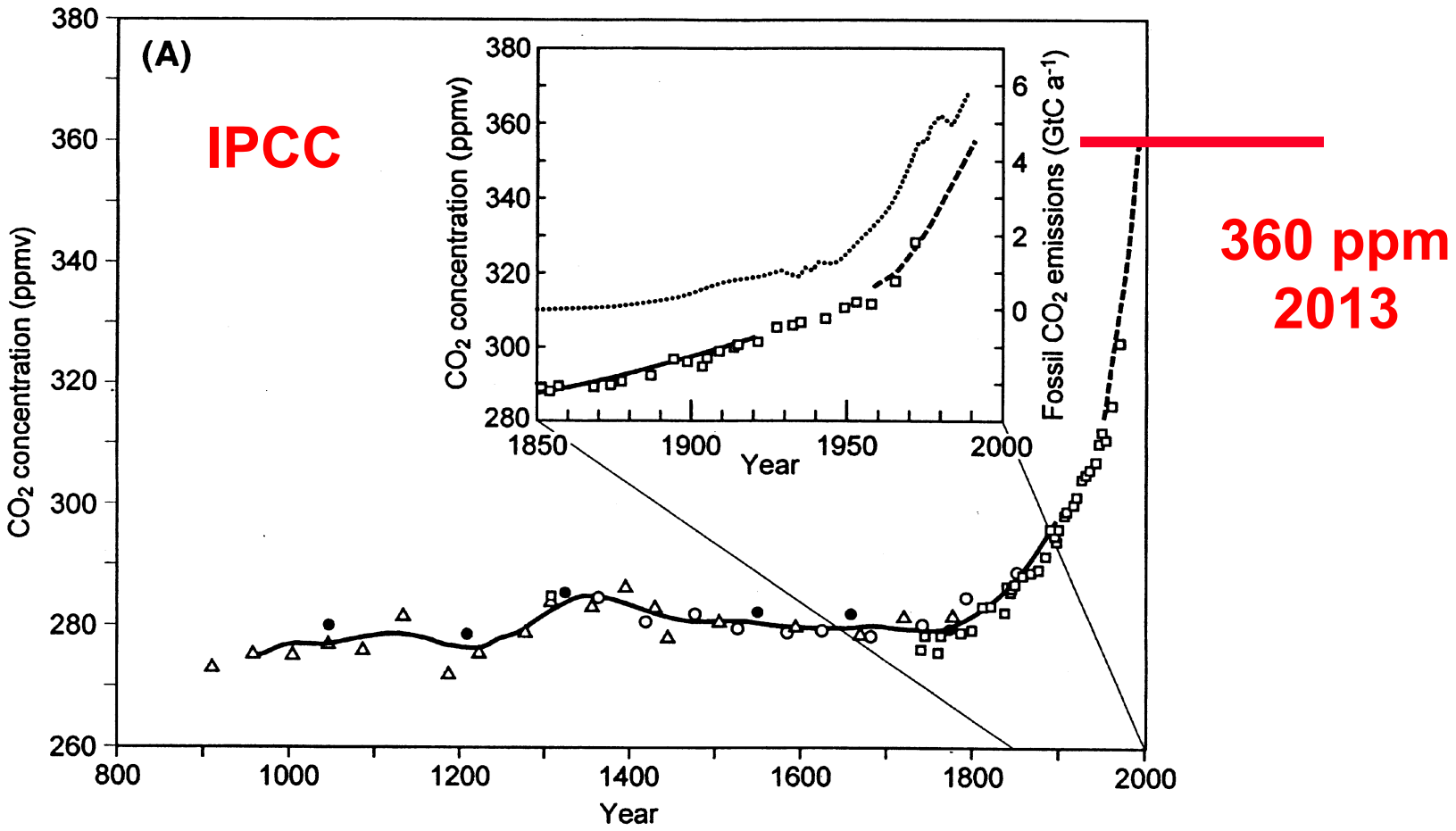
Club of Rome
"Limits of Growth (1972)"

- Its fundamental conclusion is that if rapid growth continues unabated in the five key areas of population, food production, industrialization, pollution, and consumption of nonrenewable natural resources, the planet will reach the limits of growth within one hundred years.

- The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.

CO_2 Concentration over the Past 1000 Years



Environmental acceptability: the E-factor

Industry segment	Product tonage	E-factor kg waste /kg product
Oil refining	10^6 -- 10^8	-- 0.1
Bulk chemicals	10^4 -- 10^6	1 -- 5
Fine chemicals	10^2 -- 10^4	5 – 50
Pharmaceuticals	10 -- 10^3	25 – 100+

Roger A. Sheldon, *Chemtech*, 1994

What is
“Green and Sustainable Chemical Process”?

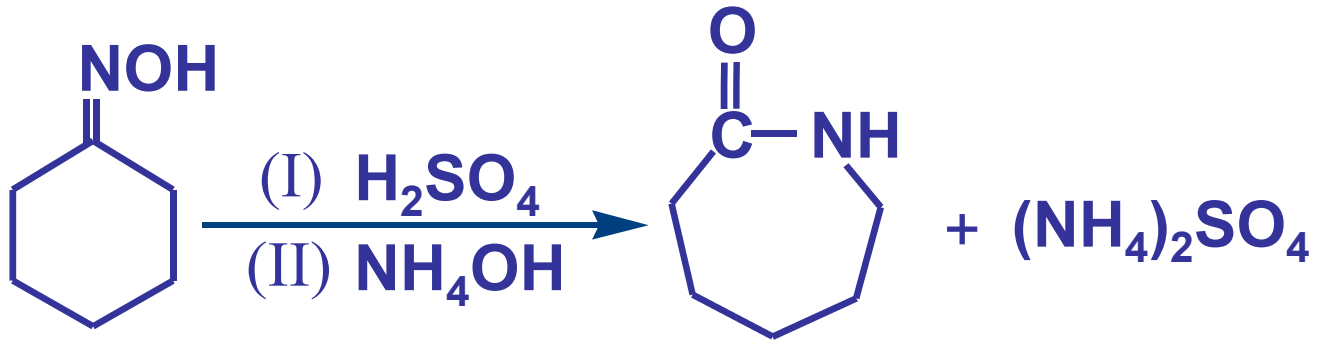
- Atom Efficiency (E-factor, Atom utilization)
- Energy Efficiency/Economical Efficiency
- Environmental Friendliness
- Engineering Efficiency

Potential Environmental Problems of Chemical Industry which we should improve by Catalyst Technology

- Catalytic Processes discarding large amount of waste
- Catalytic Processes treating dangerous substances
- Catalytic Processes consuming large amount of energy

Catalytic process discarding large amount of waste

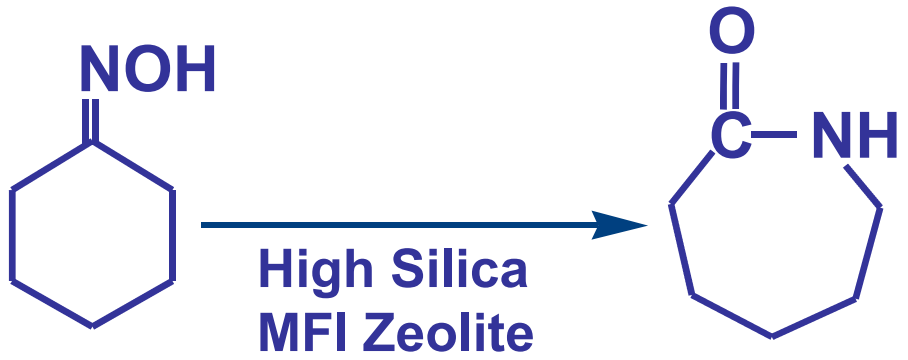
Current catalytic process for Beckman rearrangment



1 ton 1.8 ton

New Catalytic Process for Bechmann Rearrangement without Discharging Industrial Waste

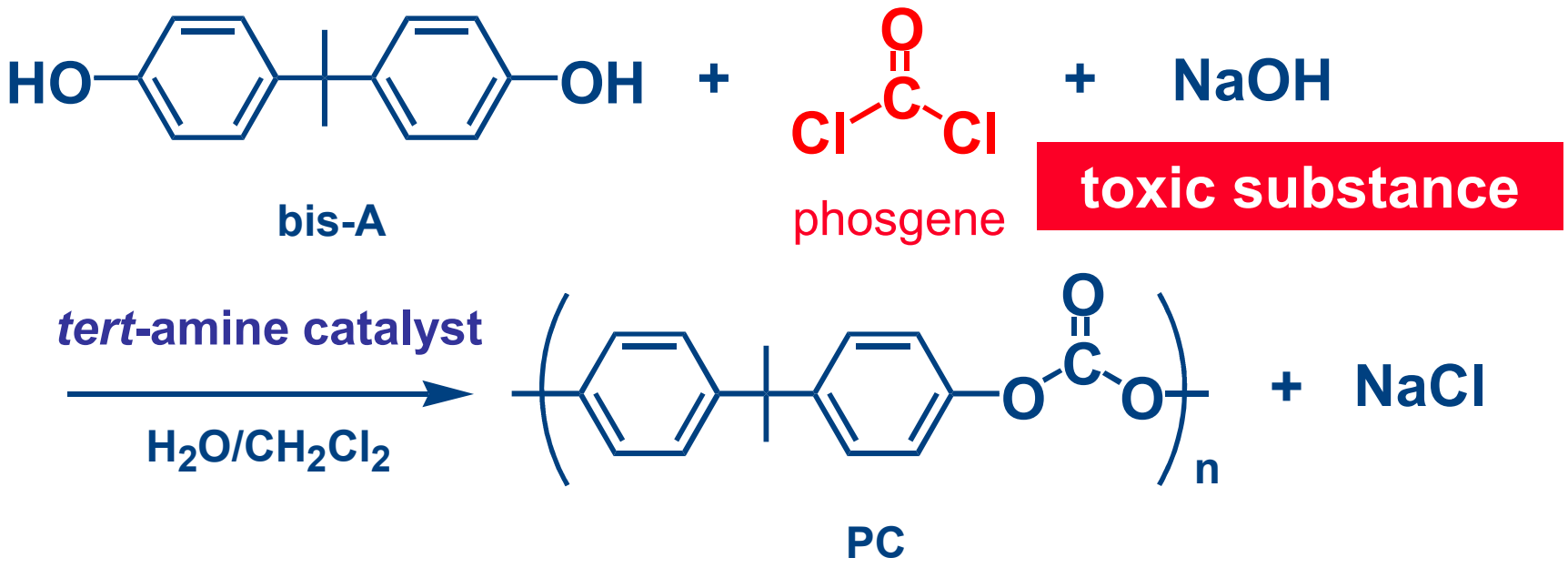
Green and Sustainable Chemistry Award (2003)



newly developed catalyst

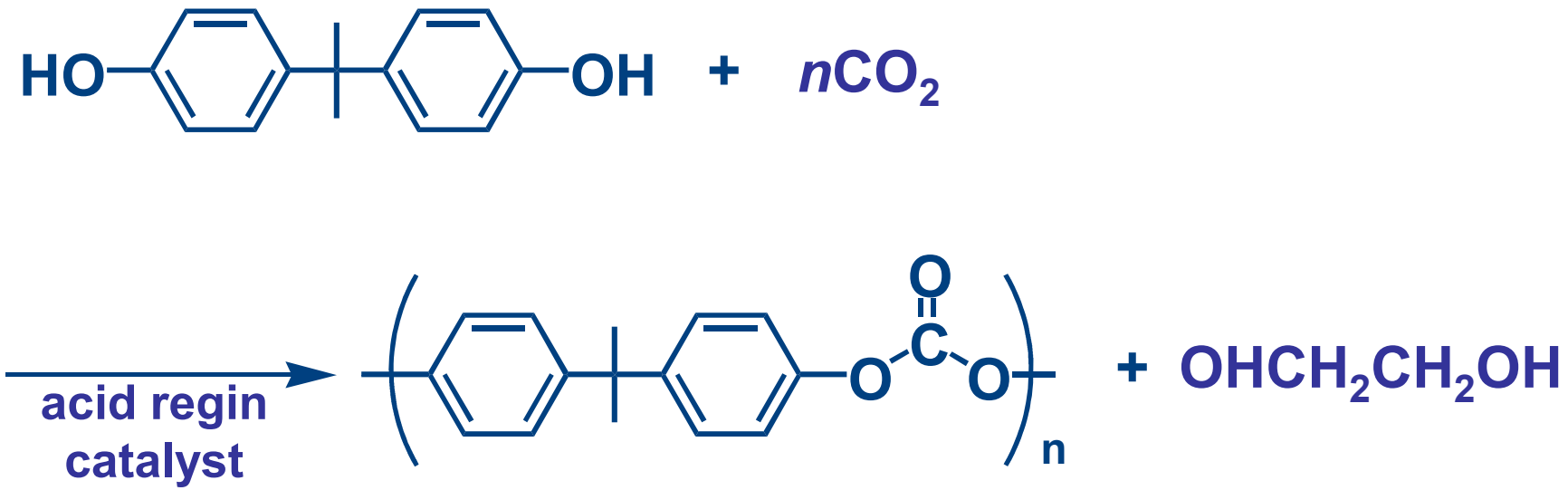
Catalytic processes treating dangerous and toxic substances

Current Process for Polycarbonate production by phosgene process



Newly Developed Catalytic Process
Novel non-phosgene polycarbonate production process using by CO_2 as starting material

Green and Sustainable Chemistry Award (2002)

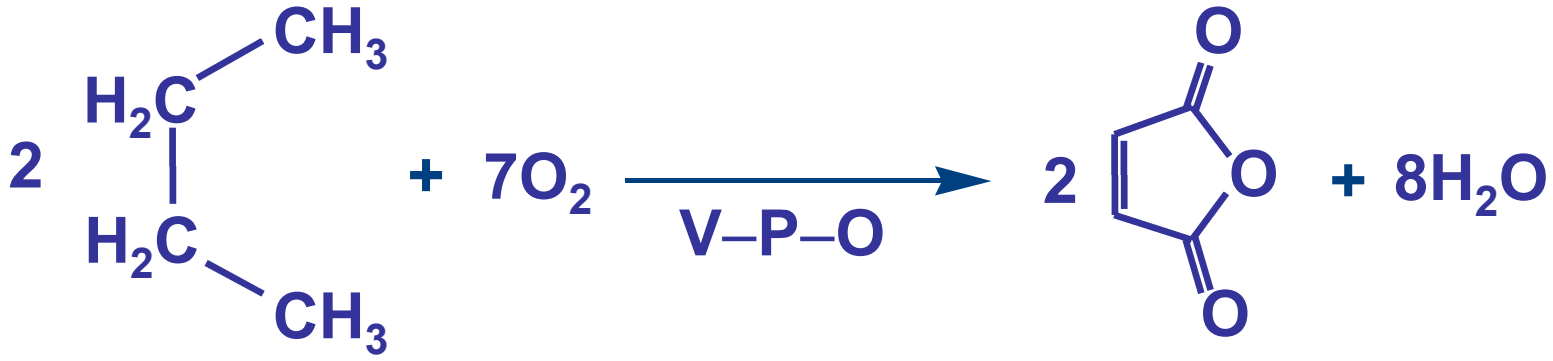


Catalytic processes consuming large amount of energy

Production of maleic unhydride by catalytic oxidation

Current process

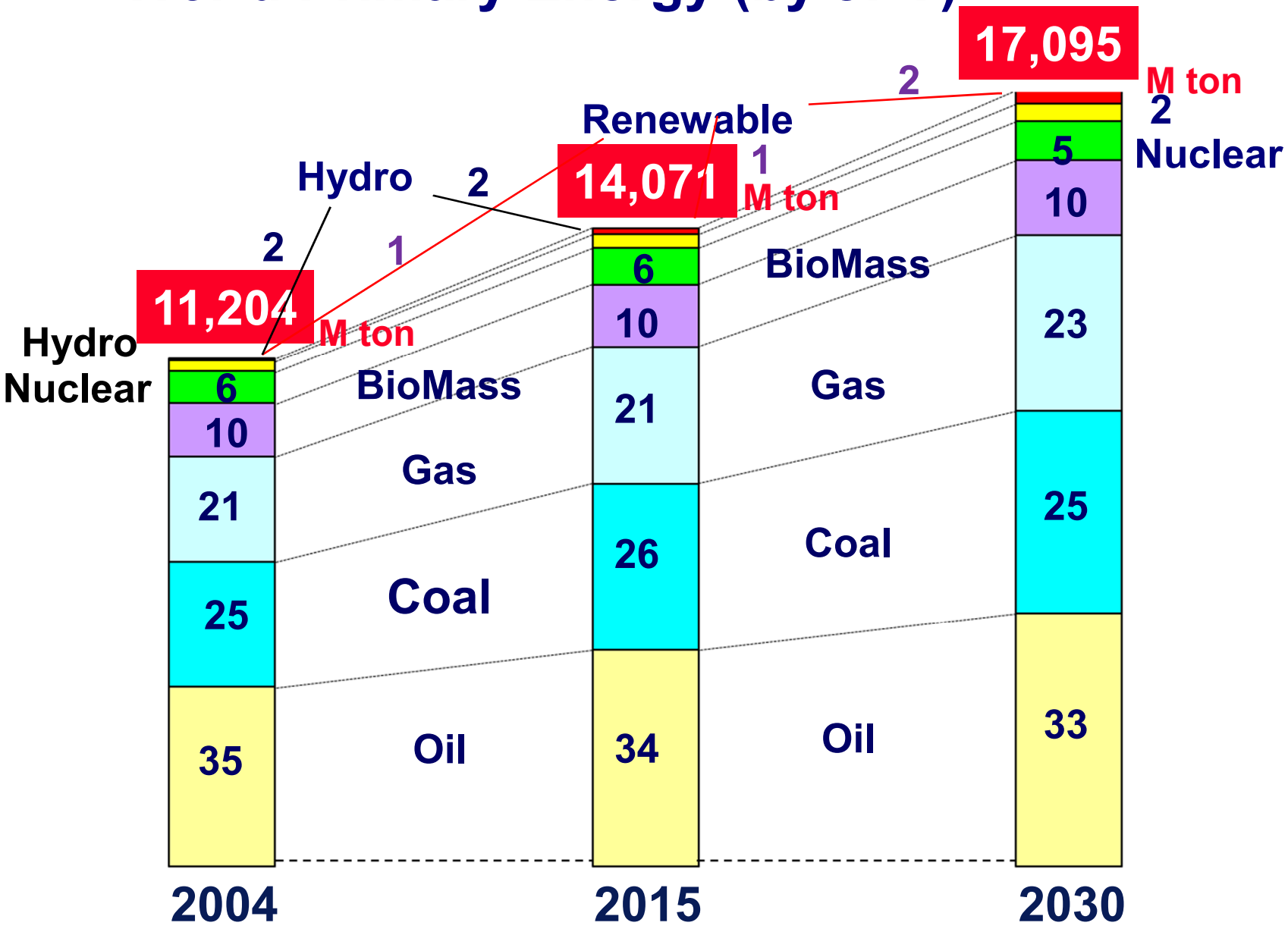
Nelwly developed process



Production of Maleic Anhydride

Maleic anhydride from benzene				Maleic anhydride from butane			
New Process	Material unit (t/t) (A)	CO_2 emission (B)	(A)X(B)	Current process	Material unit (t/t) (A)	CO_2 emission (B)	(A)X(B)
Benzene	1.14	293.4	1668.0	Butane	1.17	293.4	343.3
Steam	-5.83	250	-1457.5	Steam	-6.67	250	-1667.5
Electric power	500 kwh	0.55	275.0	Electric power	847 kwh	0.55	465.9
CO_2 emission			1948.2	CO_2 emission			1517.8
Total CO_2 (kg/t)			2433.7				659.5

World Primary Energy (by JPY)



Environmental Ethics

We who live now have the strong responsibility to use the world's energy resources prudently and to make sure that coming generations of human beings will have a wide range of energy choices.

Production of acrylic acid

Current process

New process

Production of acrylic acid

	Acrylic acid from propene				Acrylic acid from propane		
New process	Material unit (t/t) (A)	CO_2 emission (B)	(A)X(B)	Current process	Material unit (t/t) (A)	CO_2 emission (B)	(A)X(B)
Propene	0.68	768.2	522.3	Propane	1.06	293.4	311.0
Steam	- 0.20	250	- 50.0	Steam	- 0.50	250	- 125.0
Electric power	115 kwh	0.55	63.3	Electric power	587 kwh	0.55	322.9
CO_2 emission			175.0	CO_2 emission			575.0
Total CO_2 (kg/t)			710.6				1083.9

Production of acrylonitrile

Current process

$$+ NH_3 + 3/2O_2 \xrightarrow[\text{Bi-Mo}]{} CH_2{=}CH\text{-}CN + 2H_2O$$

New process

$$+ NH_3 + 2O_2 \xrightarrow[\text{New Cat.}]{} CH_2{=}CH\text{-}CN + 4H_2O$$

Production of acrylonitrile

Acrylonitrile from propene				Acrylonitrile from propane			
New process	Material unit (t/t) (A)	CO_2 emission (B)	(A)X(B)	Current process	Material unit (t/t) (A)	CO_2 emission (B)	(A)X(B)
propene	1.09	768.2	837.3	propane	1.49	293.4	410.8
ammonia	0.44	2622.7	1154.0	ammonia	0.63	2622.7	1652.3
steam	- 3.33	250.0	- 832.5	steam	- 5.93	250.0	- 1401.8
Electric power	23 kwh	0.55	12.7	Electric power	48 kwh	0.55	26.4
CO_2 emission			689.0	CO_2 emission			799.0
Total CO_2 (kg/t)			1860.5				1486.7

Conclusion

The most obvious concern for the extensive utilization of limited or depleting resources is the fact that, by definition, they can run out or become exhausted.

To do the same inevitability, therefore, is not regarded as sustainable either from an environmental or an economic point of view.

One definition of sustainability is the ability to maintain the development of the quality of life while not compromising the ability of our efforts.

Therefore, if our generation were to consume natural resources to the extent that they were no longer a viable and usable option for future generations, this would violate the goals of sustainability.