



ACES21[®] UREA PROCESS by TOYO



TOYO: Leader in Urea Process Technology

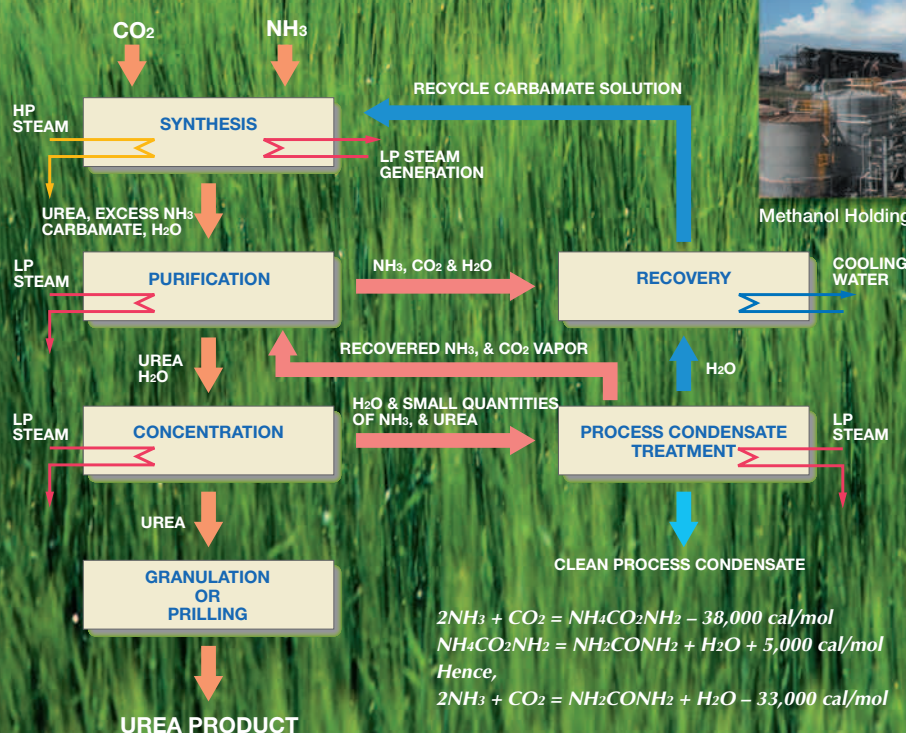
Since its establishment in 1961, Toyo Engineering Corporation (TOYO) has been a leader in the urea industry. TOYO has designed, engineered, constructed and commissioned over 100 urea plants based on the TOYO Urea Process including its urea synthesis technologies and urea granulation technologies.

Using its own expertise, advanced technology and new thinking, TOYO has established the ACES21® Process, which achieves energy saving and plant cost reduction without sacrificing high performance and high efficiency of the urea plant.

ACES21® has been developed together with P.T. Pupuk Sriwidjaja (PUSRI) of Indonesia as a Cost and Energy Saving version of the ACES^(*) Process.

ACES21® is advanced technology to realize low investment cost and low energy consumption for urea production. A major feature of this technology is that it reduces the number of components in the urea synthesis loop to simplify the system. This lessens construction costs with the installation of the reactor on the ground in the CO₂ stripping process (resultantly existing urea reactor can be re-utilized for conventional solution recycle process or ammonia stripping process). In addition, the operation conditions of the synthesis section have been optimized under lower operation pressure than in the previous process. As a result, a remarkable reduction in energy consumption has been achieved.

(*) ACES: Advanced process for Cost and Energy Saving urea production



Methanol Holdings (Trinidad) Limited (Trinidad and Tobago)

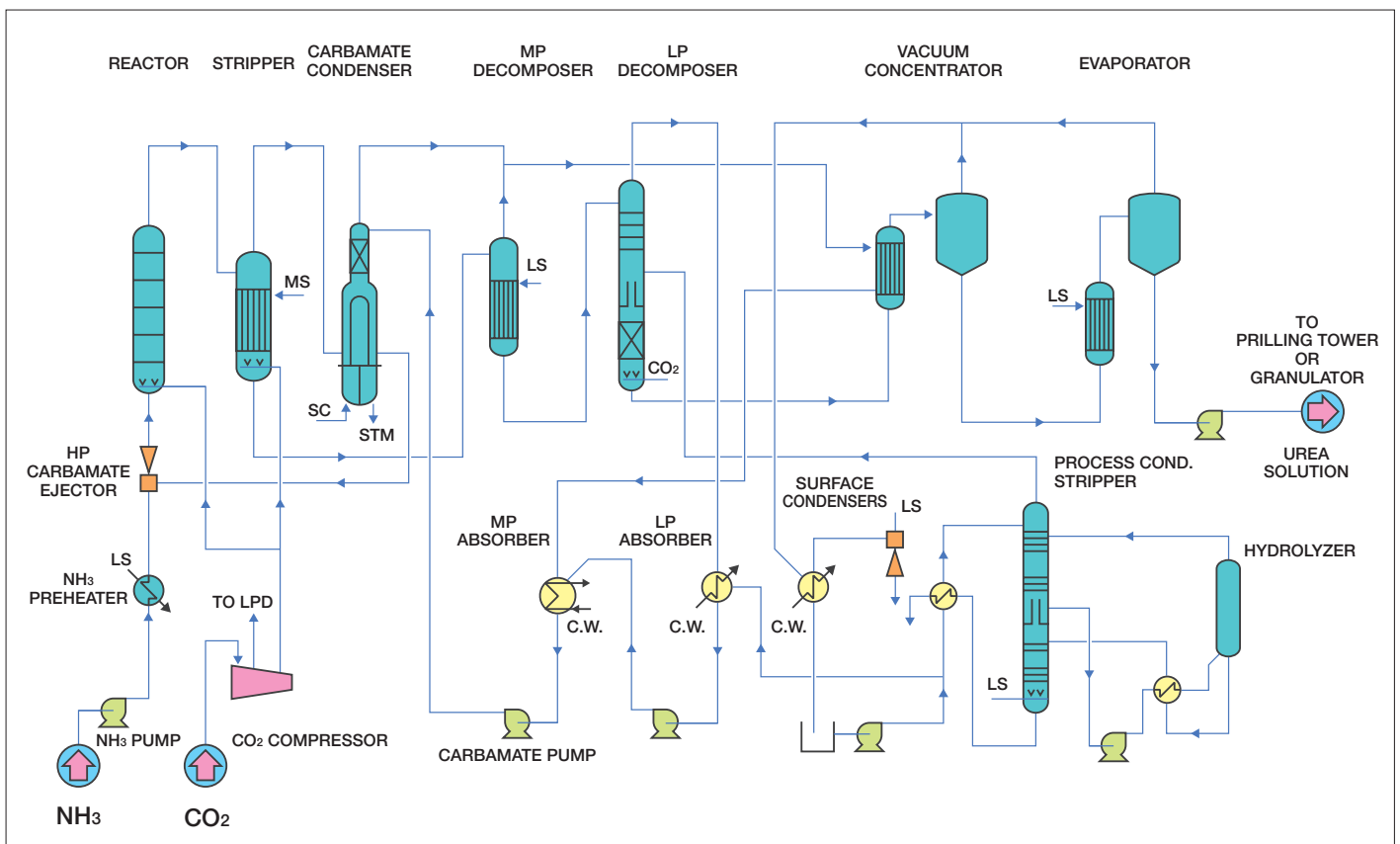
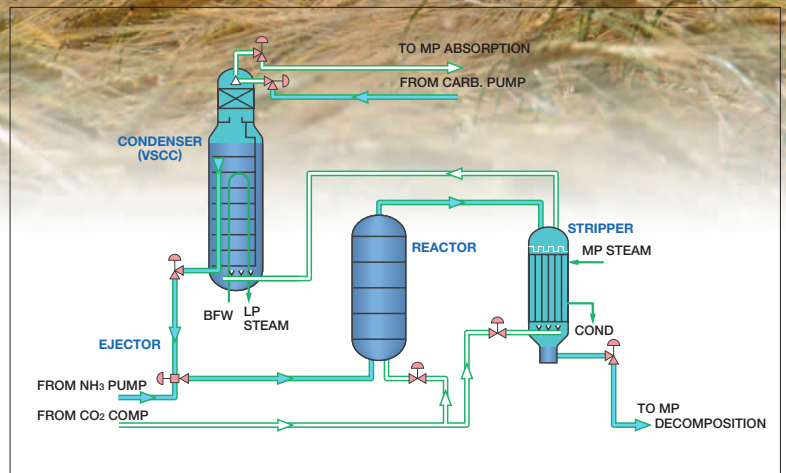
Synthesis

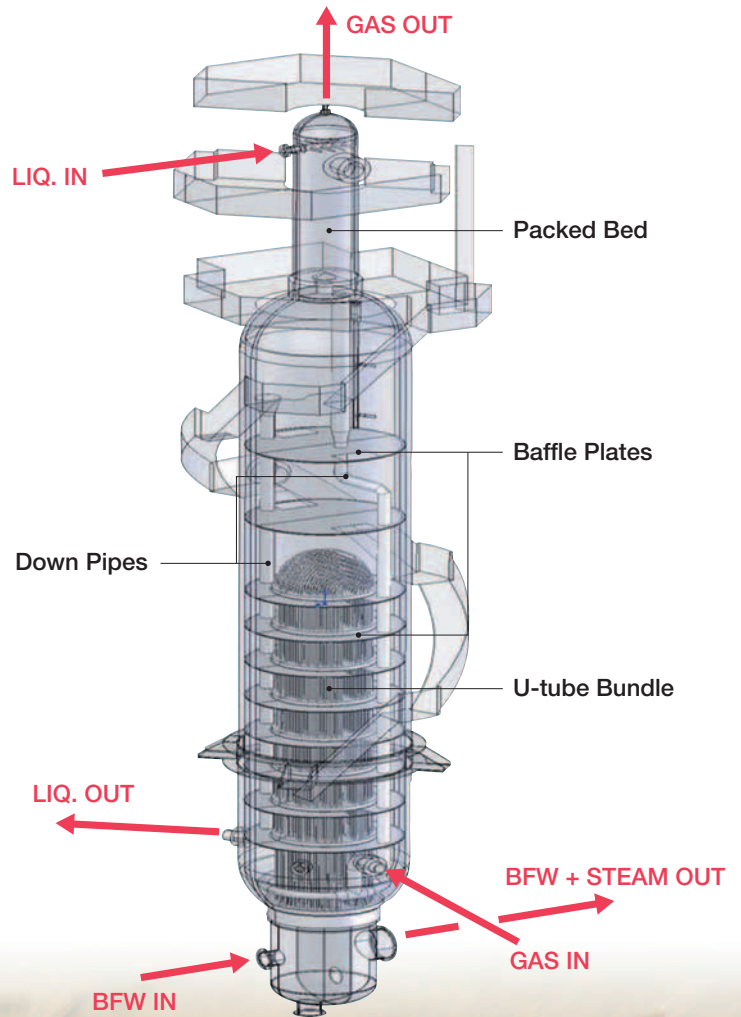
ACES21® process synthesis section consists of a reactor, a stripper and a carbamate condenser. Liquid ammonia is fed to the reactor via the HP Carbamate Ejector which provides the driving force for circulation in the synthesis loop instead of the gravity system of the original ACES. The reactor is operated at an N/C ratio of 3.7, 182 °C and 152 bar. The CO₂ conversion to urea is as high as 63% at the exit of the reactor. Urea synthesis

solution leaving the reactor is fed to the stripper where unconverted carbamate is thermally decomposed and excess ammonia and CO₂ are efficiently separated by CO₂ stripping. The stripped off gas from the stripper is fed to the Vertical Submerged Carbamate Condenser (VSCC), operated at an N/C ratio of 3.0, 180°C and 152 bar. Ammonia and CO₂ gas condense to form ammonium carbamate and subsequently urea is formed by

dehydration of the carbamate in the shell side. Reaction heat of carbamate formation is recovered to generate 5 bar steam in the tube side. A packed bed is provided at the top of the VSCC to absorb uncondensed ammonia and CO₂ gas into a recycle carbamate solution from the MP absorption stage. Inert gas from the top of the packed bed is sent to the MP absorption stage.

Process Description





Process Features

Ground Level Reactor

The sophisticated two-stage synthesis concept employing a VSCC and an HP ejector enables the HP equipment in the synthesis section to be laid-out very compactly in low elevation. The highest level (the VSCC top) is about 30 to 35 m^(*), which is significantly lower than even the traditional solution recycle process in which the reactor is installed on the ground.

(*) Depending on the plant's capacity and configuration

Vertical Submerged Carbamate Condenser

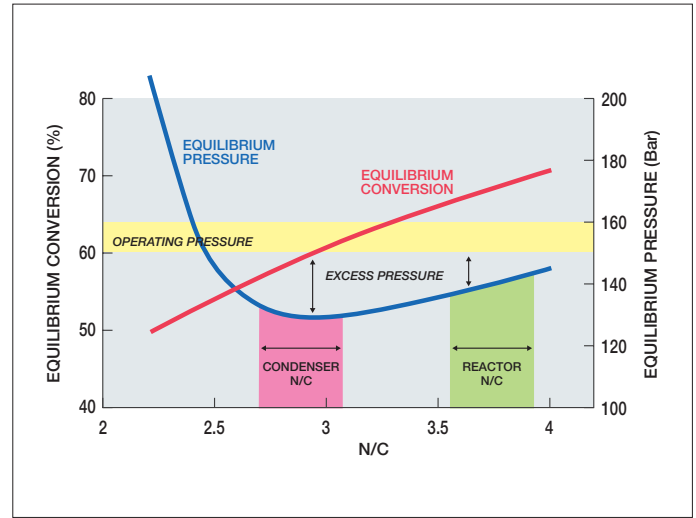
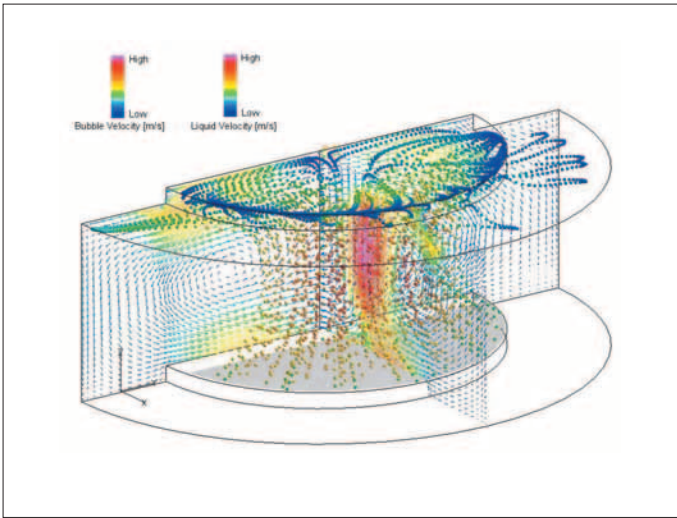
The Vertical Submerged Carbamate Condenser (VSCC) functions to condense NH₃ and CO₂ gas from the stripper to form ammonium carbamate and synthesize urea by dehydration of ammonium carbamate in the shell side, and to remove the reaction heat of ammonium carbamate formation by generating 5 bar steam in boiler tubes.

The advantages of the vertical submerged configuration of the carbamate condenser are summarized as follows:

- High gas velocity, appropriate gas hold up and sufficient liquid depth in the bubble column promote mass and heater transfer.
- An appropriate number of baffle plates distribute gas bubbles in the column effectively without pressure loss.
- A vertical design allows a smaller plot area.

Optimum Selection of Synthesis Condition

In the ACES21[®] Process, the VSCC is operated at an N/C ratio of 3.0 which allows relatively high temperature



Mechanical properties of DP28W™

Grade	Tensile Strength (MPa)	0.2% Proof Stress (MPa)	Elongation (%)	Hardness (Hv)
DP28W™	934	647	42	281
DP12	822	610	42	251
25-22-2(S31050)	676	352	50	173
316L	518	234	52	144

operation of the VSCC, rendering efficient heat transfer between the shell and the tube and higher reaction rate of ammonium carbamate dehydration to form urea. The reactor N/C ratio is selected at around 3.7 to maximize CO₂ conversion with appropriate excess pressure. Resultantly, a high CO₂ conversion of 63% is achieved in the reactor at relatively low temperature and pressure, i.e. 182 °C and 152 bar.

Less Corrosion

TOYO and Sumitomo Metal Ind., Ltd. (SMI) have jointly developed

new duplex stainless steel DP28W™ for urea plant.

The biggest advantage of duplex stainless steel is the excellent corrosion resistance and passivation property in urea-carbamate solution, which enhances reliability of equipment and enables a reduction of the passivation air. In addition, DP28W™ has high mechanical strength which drastically reduces the thickness of the high pressure section components. DP28W™ is the optimal material for urea plants benefiting from the vast flow of feedback stemming from the extensive amassed experience of

TOYO and SMI.

Clean Effluents

The liquid effluents from the urea plant contaminated with NH₃, CO₂ and urea are processed in the process condensate stripper-urea hydrolyzer system.

The process condensate leaving the system is purified to 1 ppm of urea and 1 ppm of NH₃.

The exhaust air from the prilling tower (or granulator) is scrubbed through a packed bed scrubber to reduce the urea dust content to 30 mg/Nm³-air.



Urea prills



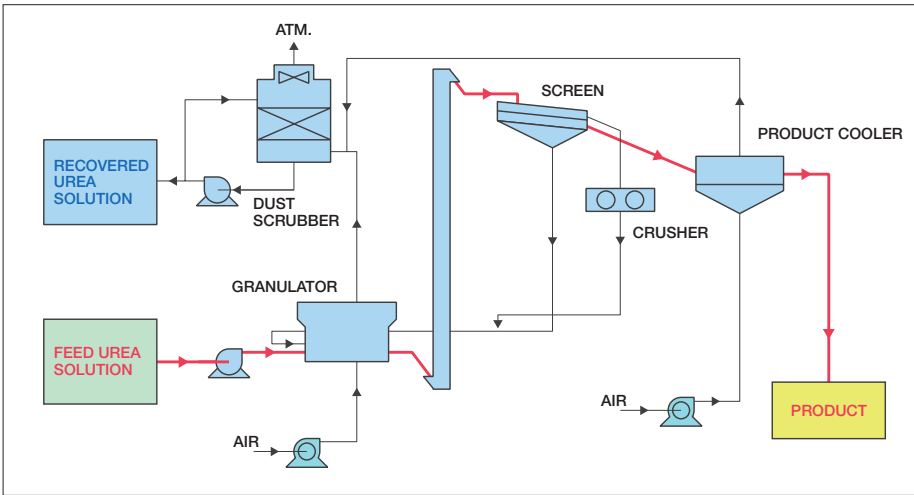
1-3mm Urea Granules



2-4mm Urea Granules



5-8mm Urea Granules



SKW Piesteritz GmbH (Germany)



P. T. Pupuk Iskandar Muda (Indonesia)



Tarim Oilfield Petrochemical Company (China)

Process Variation

TOYO owns or has the right to license various basic technologies to be integrated with the urea plants in addition to the new urea plant construction as a package.

Urea Finishing Technologies

High Purified Industrial Grade Urea Product: Urea crystal, Urea Prills, Urea Granules by Crystal Separation Process

Fertilizer Grade Urea Product: Urea Solution, Urea Prills, Urea

Granules by Vacuum Evaporation Process

Product Forming Technologies

Urea Prilling Process

- Acoustic Vibrating Prill Head
- Spinning Bucket (Tuttle Prilling System)

Urea Granulation Process

- Spout-Fluid Bed Granulator

Pollution Control Technologies

Process Condensate Treatment System

- Urea Hydrolyser
 - Process Condensate Stripper
- Urea Dust Scrubbing System
- Packed Bed Type Wet Scrubber

Supporting Technologies

Anti-caking Treatment of Urea Prills
Melamine Off-gas Recovery System
Integration of Urea-Melamine Plants

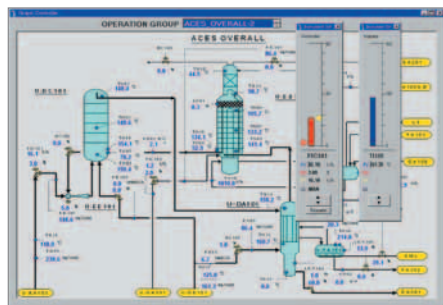
TOYO's Activities and Services

Granting of Licenses and Project Execution

As a licensor of urea processes and related technologies, TOYO offers various types of contracts from a direct license to the client to an indirect license through engineering firms. As the contractor, TOYO supplies the complete urea plant to the client on a turnkey lump-sum basis. Therefore TOYO can control all technologies to be used for the design, engineering, construction and operation of the urea plant without sublicensing agreements. This ensures smoother and simple project execution under single contractual responsibility of the contractor.

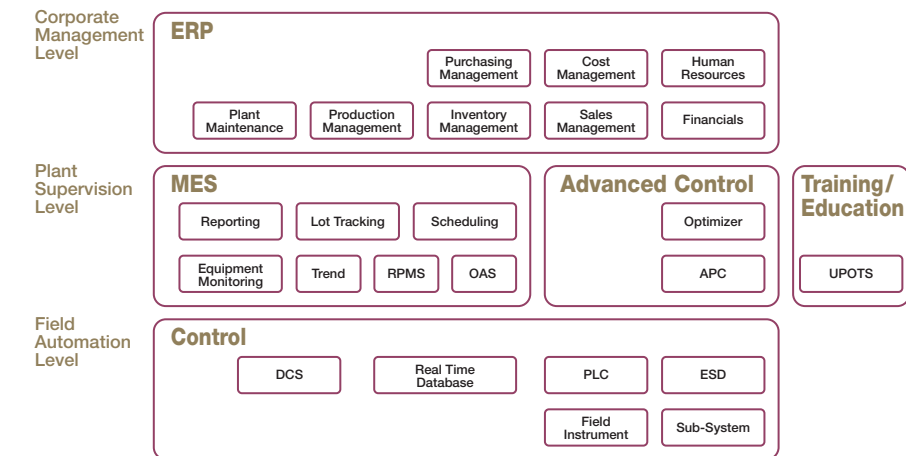
Training of Client's Operators

TOYO's training program usually includes training at TOYO's Engineering Center using a proprietary Operation Training Simulator and Operation Guidance System by which the trainees become familiar with all phases of plant operation including initial start-up and emergency shut-down prior to the in-plant training.



Provision of Plant Lifecycle Solutions

TOYO provides solutions to meet client needs for urea plants such as



Total Solutions by TOYO

operation and maintenance (O&M) services that sustain and enhance the productivity of the client's plant. After the plant is accepted by the client, TOYO's consulting services are available for:

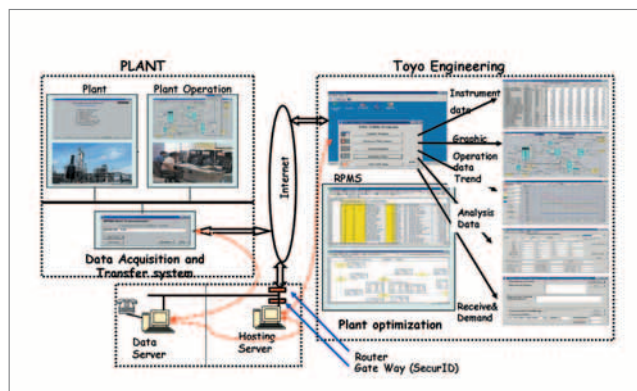
- Improvement of plant efficiency
- Operation optimization
- Trouble shooting
- Pollution control
- Product quality improvement
- Plant maintenance
- Plant retrofitting

One of TOYO's solutions for the maintenance aspect is a Risk Based Inspection and Risk Based

Maintenance (RBI/RBM) system and consulting service for fertilizer complexes provided by TOYO together with ESR Technology Ltd. (UK). The system is expected to enable plant owners to optimize their assets through risk management.

Remote Plant Monitoring System

TOYO offers a Remote Plant Monitoring System (RPMS) service, which connects an actual operating plant and a remote engineering office using DCS, a computer and the Internet to monitor plant conditions in remote offices and provides a feedback of suggestions or recommendations to the plant owner after the evaluation of monitored data utilizing TOYO's professional know-how in the operation and maintenance of urea plants.



Process Performance

Product Quality (Typical)

Nitrogen (N) Content	46.4 wt%
Biuret Content	0.8 wt%
Water	0.2 wt%

Consumption Figure (Typical, Granulation Case)

Raw Material

NH ₃ (100%)	0.563 ton
CO ₂ (100%)	0.731 ton

Note: (1) The loss from Ammonia Pump and CO₂ Compressor is included.

(2) Unit is per metric ton of granular urea.

Utilities (per metric ton of granular urea product)

	Unit	All Motor Driven Case		Steam Turbine Driven Case	
		Steam Export	Steam Self Balance	42 bar	110 bar
Steam Import					
22 bar, 300°C	ton	0.67	0.58		
42 bar, 380°C	ton			0.80	
110 bar, 510°C	ton				0.69
Steam Export					
5 bar, Saturated	ton	0.24	-	-	-
Cooling Water ($\Delta t=10^\circ\text{C}$)	m ³	52	52	81	75
Electricity					
Process	kWh	105	105	21	21
Granulation	kWh	24	24	24	24

Note: (1) All figures above include:

- CO₂ Compression
- Ammonia and Carbamate Pumping
- Urea Synthesis
- Purification and Recovery
- Urea Concentration
- Urea Granulation
- Process Condensate Treatment

(2) The figures above exclude:

- air conditioning, ventilation, air heater, steam trace, etc.
- urea storage and bagging facility

(3) Ammonia Pump and Carbamate Pump are driven by motor.

(4) Local conditions may change the figures above.

(5) Unit is per metric ton of granular urea.



Toyo Engineering Corporation

2-8-1 Akanehama, Narashino-shi, Chiba 275-0024, Japan

Tel: 81-47-451-1111

Fax: 81-47-454-1800

<http://www.toyo-eng.co.jp>