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The Potential of Biogas Energy from Tropical Organic Wastes and the Improvement of Environmental Situation for Urban Citizen

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Bali: Fact, figure, and the map

Udayana University at Jimbaran Hill

Facts and figures:

Area: 5,600 square kilo meter (2,162 square mile;

(the size of Brunei)

Population: 4 million

Main religion: Hindu (over 90%)

Economy:

Tourism and agriculture

Campus of Udayana University

The main campus is located in Jimbaran Hills peninsula.

It occupies 200 hectares of land with views over looking the peninsula and the sea.

The southern part of Bali, including Jimbaran peninsula, is the prime area for Bali's tourist development.

Brief Timeline of Udayana University

1962

2015

Established in 1962 with Faculty of Letters

Today 13 Faculties to reflect local, national, and global trends and demands:

Agriculture
Agricultural Technology
Animal Husbandry
Economics (Management, Accountancy)
Engineering and Architecture (Civil, Electrical, Mechanical, Informatics, Architecture)
Fishery and Marine Science
Mathematic and Natural Science (Biology, Chemistry, Physics, Pharmacy, Computing)
Medicine and Health Sciences
Law
Letters and Culture (Anthropology, Archeology, Ancient Java, Bali, English, History, Indonesia, Japan)
Social and Political Sciences
Tourism
Veterinary Sciences

Student Body in Udayana University

Courses	Current	New
Undergraduate Regular	8,288	3,105
Undergraduate Evening class	4,092	846
Diploma	436	204
Matriculation	136	93
Master	1,343	598
PhD	148	139
Specialist for Clinical Doctor	279	73
On leave	65	

Typical annual students body: 22,000 – 24,000

International Students in Udayana University

International citizens who study in Udayana University:

Australia, Austria, Brazil, China, Finland, Germany, Japan, Malaysia, Timor Leste, United State of America, United Kingdom

Background

The emerging country Indonesia has a huge biomass energy potential is about 50 GW, from Indonesian Ministry of Energy which 1.5 MW are currently (2010) used

Beside energy problems, Indonesia and Bali faces an environmental pollution problem. Municipal wastes accumulate in huge landfills emitting greenhouse gases; lechate waters pollute coastal mangrove forests or waste is burned locally, causing air pollution and ecological damage.

Sustainable solutions on waste management and renewable energy are immediate needed. Research focused improving skills and knowledge in biogas as much about the technology is required to develop biogas technology in Indonesia.

Biogas Potential

Rural and Urban Organic waste available in Bali
~ 800 m^3/day

~ Produce methane

Biogas Effluent to be used as organic fertilizer

50 GWh
of potential energy Source!

100 million ton
of fossil fuel import potentially avoided!

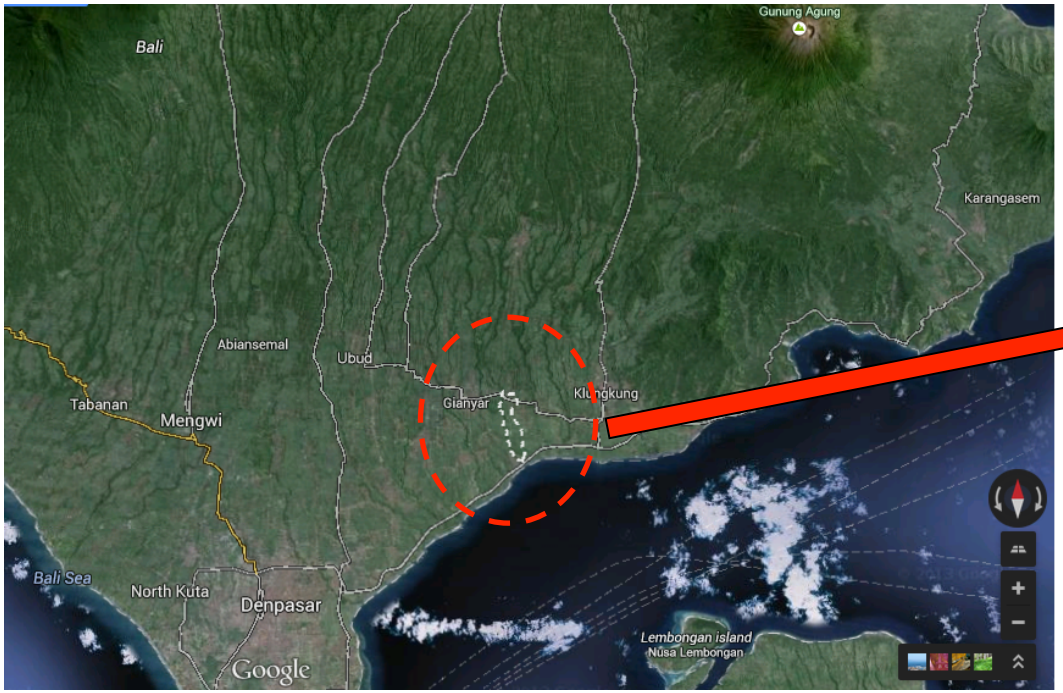
Urban Municipal Organic Wastes

- Largest landfill in tourism area Denpasar, Bali
- Waste generation is 800 m^3/day
- Open dumping wastes treatment and plastic selected by hands
- Some wastes burned locally

Rural area burned locally

Open dumping area

Temesi Aeration Composting



Wastes production in Gianyar area 50 tons/ day
Organic and anorganic wastes separated by manual
Organic wastes to produce compost with aeration system

Existing biogas plant

In Indonesia, the biogas capacity is limited to the construction of small Chinese-type fixed dome digesters on small agricultural sites actually only fed with animal manure.

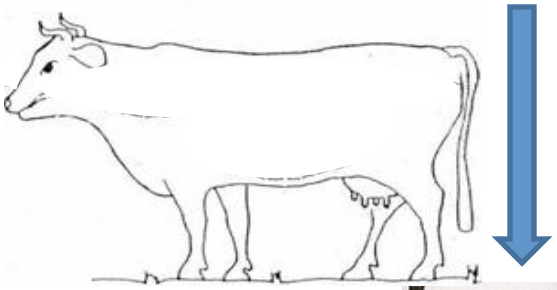
- **SIMANTRI and BIRU Biogas plant**
- **Capacity: 3 – 8m^3**
- **Input: Manure**
- **CO_2 : 38 – 48%**
- **Feeding from 15 – 25 cows manure**
- **Using for cooking and lighting.**

Integrating biogas in organic waste

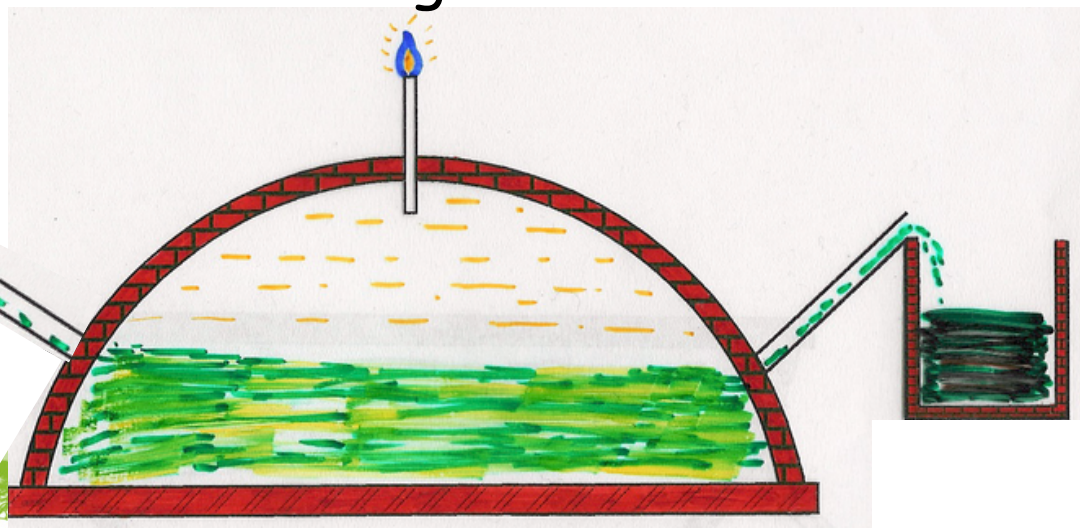
New concept:

Adding organic wastes to increasing biogas production

Temperature, loading rate, and solid content need to be carefully monitored

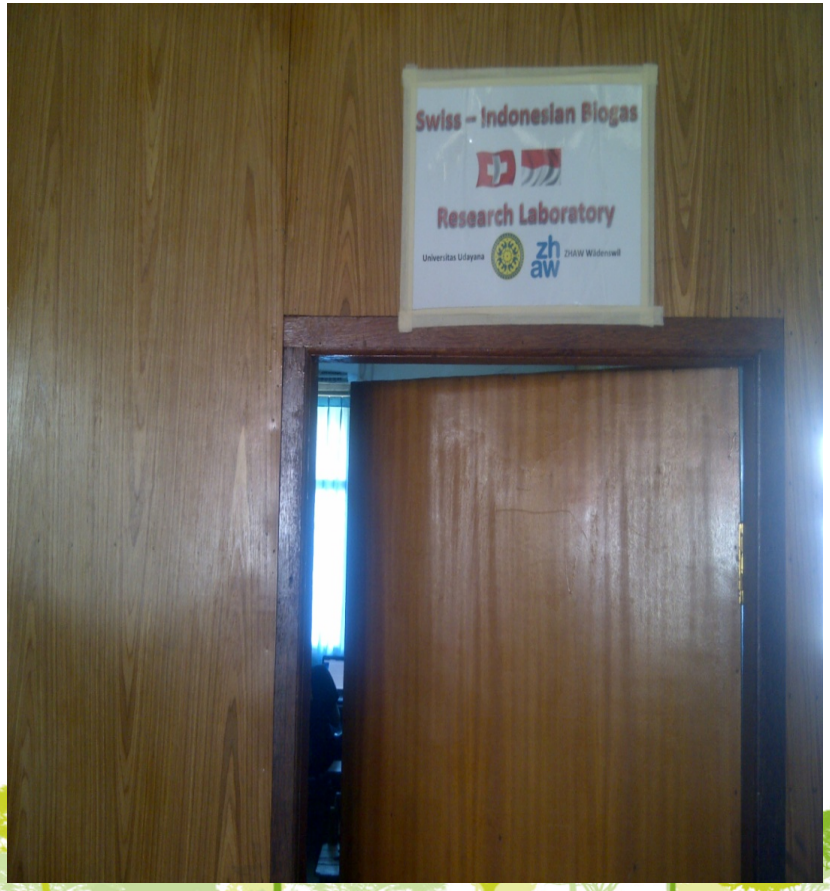


The Biogas Plant



Preliminary Study

- In 2012, the ZHAW Center of Environmental Technology initiated a research collaboration with the Technical Engineering Dept. of Udayana University in Bali
- Build up biogas laboratory at Campus Bukit Jimbaran



FOS/TAC Analysis

- **The term FOS/TAC refers to the proportion between Flüchtigen Organischen Säuren (Oganic Volatile Acids) and the Total Alkalischen Carbonaten (Total Alkaline Carbonates)**
- **The more organic acids is contained in the fermenter (acetic and propionic acid) the more the methane producing bacteria are going to be affected**

$$\text{FOS/TAC} = \frac{\text{FOS}\ (((\text{amount of } H_2SO_4 \text{ from pH 5.0 to pH 4.4 x 1.66 / 2.5 x 10}) - 0.15) \times 500)}{\text{TAC}\quad (\text{amount of } H_2SO_4 \text{ from pH X.X to pH 5.0 x 250 / 2.5 x 10})}$$

FOS / TAC	Feeding state
> 0.6	Overfed: decrease the feeding, maybe interrupt shortly
0.5 – 0.6	Overfeeding danger: feed less
0.3 – 0.5	Normal state: keep feeding rate
0.2 – 0.3	Hungry: raise feeding rate
< 0.2	Very hungry: raise the feeding rate considerably

Learning programme in Switzerland

- Two weeks learning programe for professional Udayana student in ZHAW Switzerland.
- Learning including laboratory safety instruction, where perform some practical work in the field of biogas research
- Field trip to industrial scale biogas installations.

Some supporting equipments:

available at Udayana Univ.

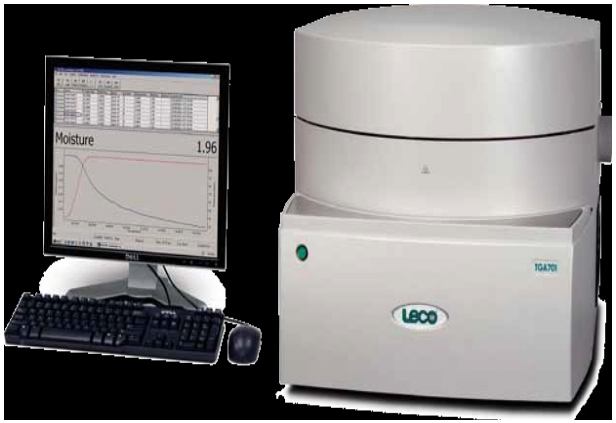
Gas Chromatography

SEM analysis

C H N O S element analysis

Biology Microscope

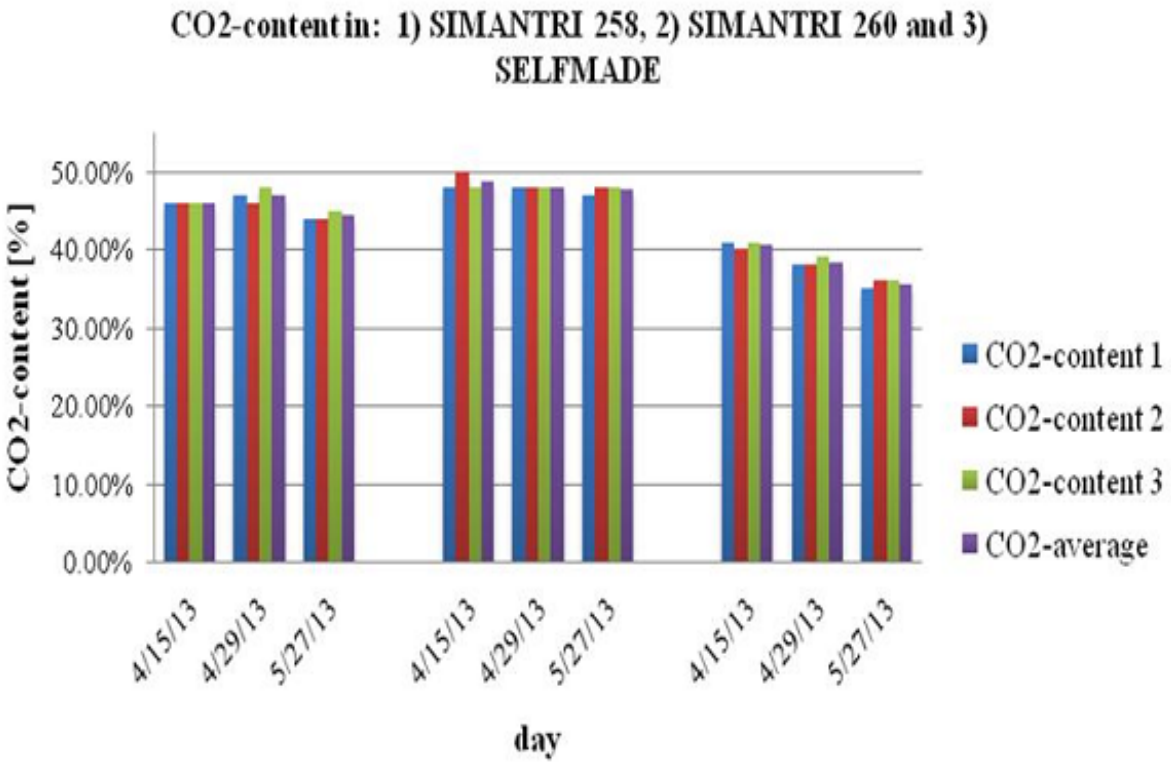
Bom Calorymeter



TGA analyzer

CO_2 and CH_4 content

CO2-content is measured as absorption liquid in the BRIGON CO2-indicator acts a 4 molar KOH or NaOH solution. Assuming that the biogas includes mainly CO_2 and CH_4, the methane content is 100 Vol.-% minus the CO_2-content in Vol.-%.



Digester performance

The sampled fermenter material is analyzed with FOS/TAC test for getting an impression about the biogas plants' performance and easy option to determine the proper feeding to a biogas plant

$$\frac{\mathbf{FOS}}{\mathbf{TAC}} = \frac{(\mathbf{FOS}((\text{amount of } H_2SO_4 \text{ from pH 5,0 to pH 4,4 x 1,66 / (2,5 x 10)} - 0,15) \text{ x } 500)}{\mathbf{TAC}\ (\text{amount of } H_2SO_4 \text{ from pH X, X to pH 5,0 x 250})/(2,5 \text{ x } 10)}$$

> 0,6 overfeed; reduce feeding rapidly
0,5 – 0,6 danger of overfeeding; reduce feeding
0,3 – 0,5 balanced feeding; stay at feeding level
0,2 – 0,3 hungry; increase feeding
< 0,2 very hungry; increase feeding rapidly

FOS/TAC Result

Name of biogas plant	Date	FOS/TAC average
SIMANTRI 258	15.04.2013	0.23
	27.04.2013	0.39
	28.04.2013	0.26
SIMANTRI 260	15.04.2013	0.93
	27.04.2013	1.19
	28.04.2013	2.08
SELFMADE	15.04.2013	0.24
	27.04.2013	0.17
	28.04.2013	0.27

As SIMANTRI 258 is hungry and balanced fed, SIMANTRI 260 is always overfed. In Opposite the self-made biogas plant could use more feed to work much better.

DM and oDM co-substrates

Before heating to 105 °C for DM determination

After oDM 550 °C for oDM determination

DM and oDM results

dry matter of "clammy" basic raw material

After input of values please copy the formula of DM down to calculate the new values automaticly

Salak hulls + fruit

Nr.	Date	Time / duration	cup weight (cup)	initial weight (matrerial)	resulting weight (cup + material)	resulting weight (material)	DM	Remarks
			g	g	g	g	%	
S1	07.05.13	9:45	5,440	20,448	8,848	3,408	16,67%	burning time 24 hours
S2	07.05.13	9:45	5,474	20,016	9,248	3,774	18,85%	burning time 24 hours
S3	07.05.13	9:45	5,558	20,088	9,230	3,672	18,28%	burning time 24 hours

Material	DM [%]	oDM [%]
Avocado hull	24,43	96,40
Banana peeling	13,42	76,02
Corn	18,90	96,29
Durian hull	14,22	91,73
Manggo hull	19,99	95,00
Nangka hull	16,60	92,77
Orange peeling	13,19	95,39
Pineapple peeling	9,99	91,07
Rice straw	37,46	74,87
Snake fruit / Salak	17,93	92,71

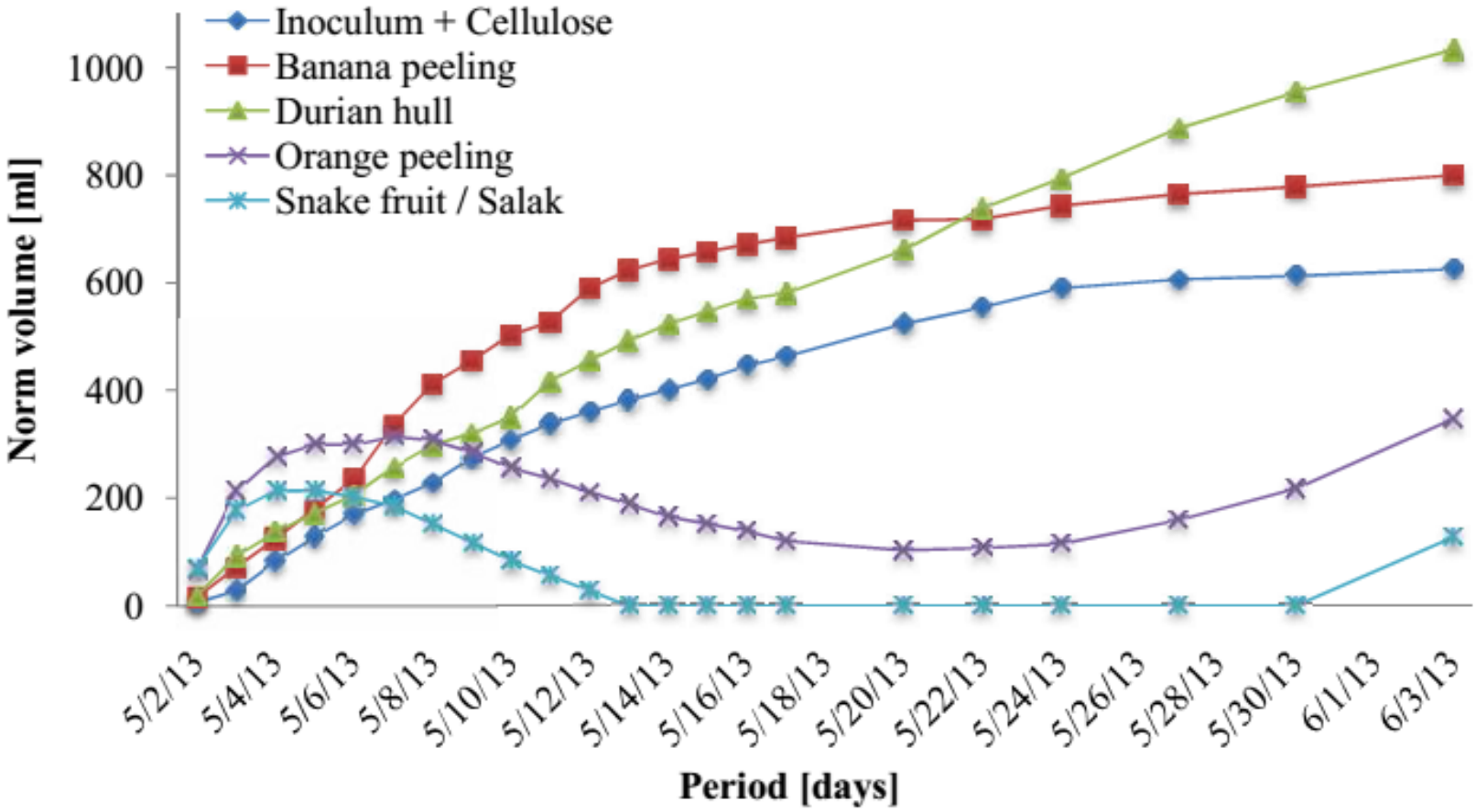
Batch bottles measurement

The method is adapted for measurements in gas-tight barred batch-bottles with fixed head volume and pressure measurement. Biogas production is calculated over pressure increase.

$$\textbf{Norm volume [ml]} = \frac{(\text{Head volume [ml]} \times 273.15\ \text{K} \times \text{Bottle pressure [bar]})}{((273.15\ \text{K} + \text{air temperature})) \times 1.013\ \text{[bar]})}$$

$$\textbf{Biogas yield [Nl/}\boldsymbol{kg\ oDM}\textbf{]} = \frac{(\text{net volume of sample [ml]} * 10\text{^}2)}{(\text{sample mass[g]} * \text{oDM of sample [\%]})}$$

Biogas yield co-substrates



Banana peeling and Durian hulls show a very good performance and increase the biogas yield. Orange peeling and Snake fruit show at the beginning good improvement of the biogas yield but it decreases afterward

Conclusions

- **All known biogas plants in Indonesia/Bali are only fed with mainly cattle manure and sometimes with pig or a mixture of cattle and pig manure.**
- **FOS/TAC-determination showed that the knowledge for feeding and running a biogas plant is missing.**
- **The huge number of different fruits gives a good opportunity to use their wastes**
- **It was found using co-substrate such as Banana peeling and Durian hulls could increase the production of biogas.**

BIOGAS Technology development: *Subtrat and Upgrading Process*

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Thank you