

**The Power of Biomass**  
Turning Waste into Energy  
while Yielding Profits  
with Alex and Abby

Carmen Trandafirescu

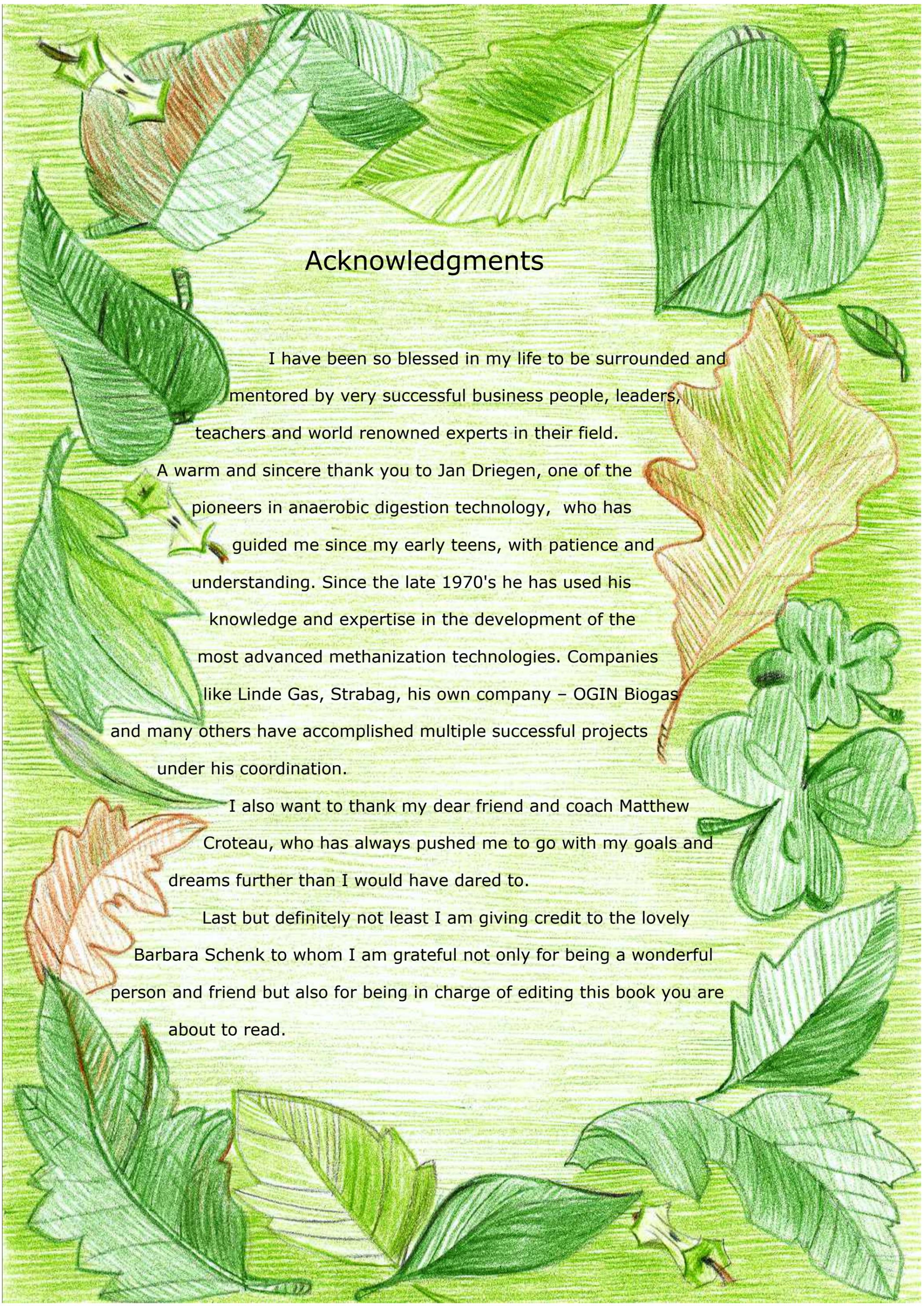


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Illustrated by Ioana DESPA tagabal@yahoo.com



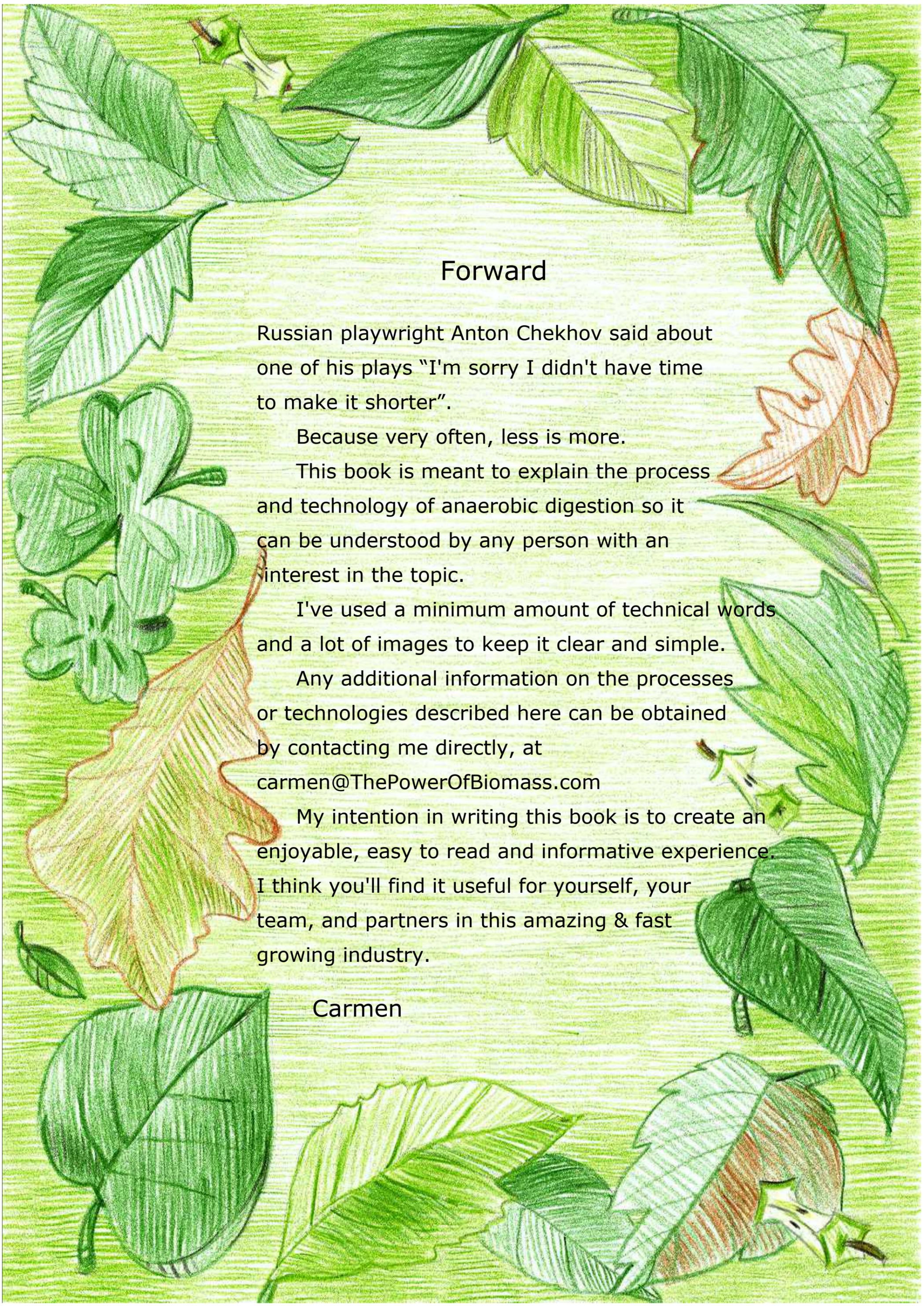
## Acknowledgments

I have been so blessed in my life to be surrounded and mentored by very successful business people, leaders, teachers and world renowned experts in their field.

A warm and sincere thank you to Jan Driegen, one of the pioneers in anaerobic digestion technology, who has guided me since my early teens, with patience and understanding. Since the late 1970's he has used his knowledge and expertise in the development of the most advanced methanization technologies. Companies like Linde Gas, Strabag, his own company – OGIN Biogas and many others have accomplished multiple successful projects under his coordination.

I also want to thank my dear friend and coach Matthew Croteau, who has always pushed me to go with my goals and dreams further than I would have dared to.

Last but definitely not least I am giving credit to the lovely Barbara Schenk to whom I am grateful not only for being a wonderful person and friend but also for being in charge of editing this book you are about to read.



## Forward

Russian playwright Anton Chekhov said about one of his plays "I'm sorry I didn't have time to make it shorter".

Because very often, less is more.

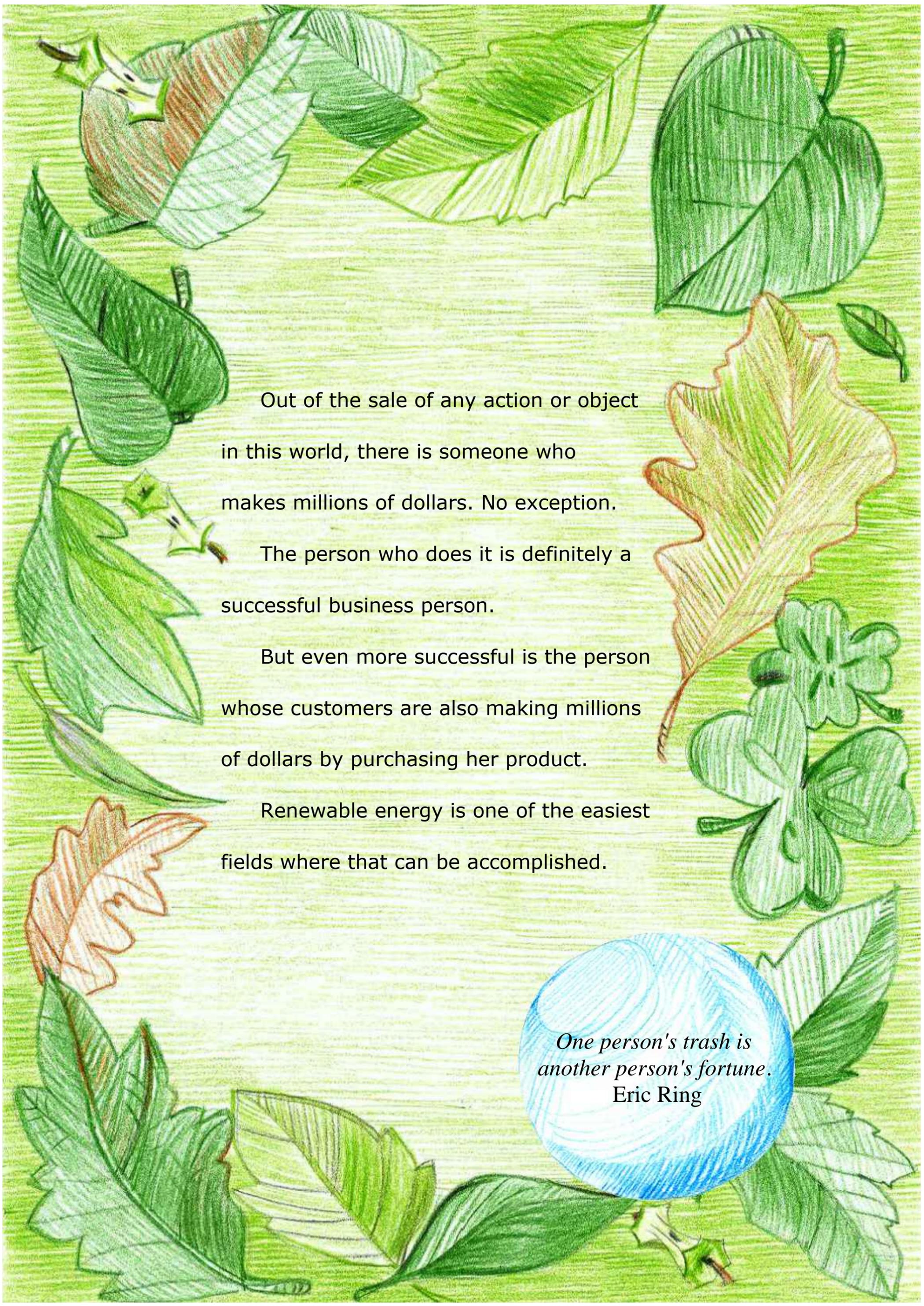
This book is meant to explain the process and technology of anaerobic digestion so it can be understood by any person with an interest in the topic.

I've used a minimum amount of technical words and a lot of images to keep it clear and simple.

Any additional information on the processes or technologies described here can be obtained by contacting me directly, at [carmen@ThePowerOfBiomass.com](mailto:carmen@ThePowerOfBiomass.com)

My intention in writing this book is to create an enjoyable, easy to read and informative experience. I think you'll find it useful for yourself, your team, and partners in this amazing & fast growing industry.

Carmen



Out of the sale of any action or object  
in this world, there is someone who  
makes millions of dollars. No exception.

The person who does it is definitely a  
successful business person.

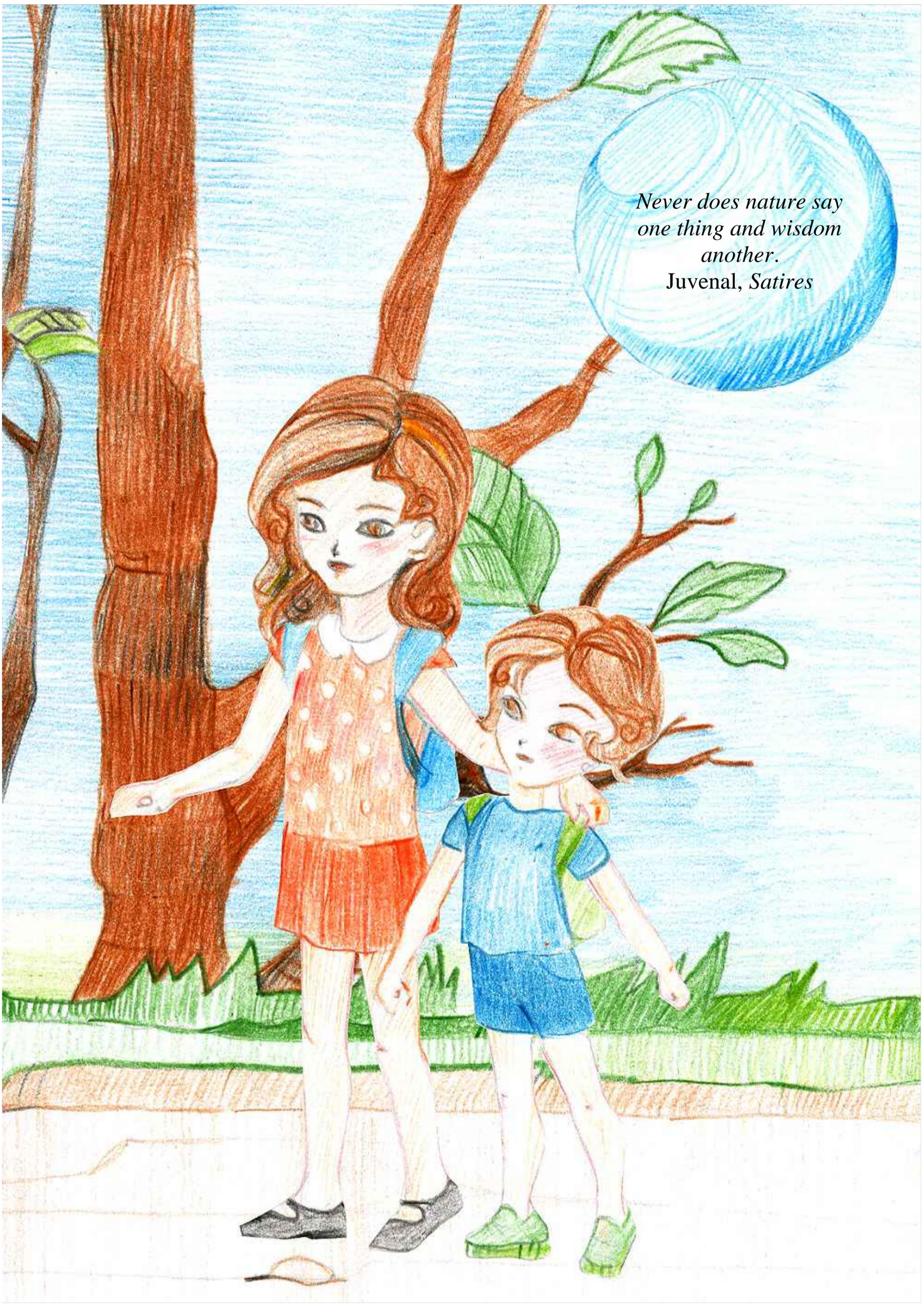
But even more successful is the person  
whose customers are also making millions  
of dollars by purchasing her product.

Renewable energy is one of the easiest  
fields where that can be accomplished.

*One person's trash is  
another person's fortune.*  
Eric Ring

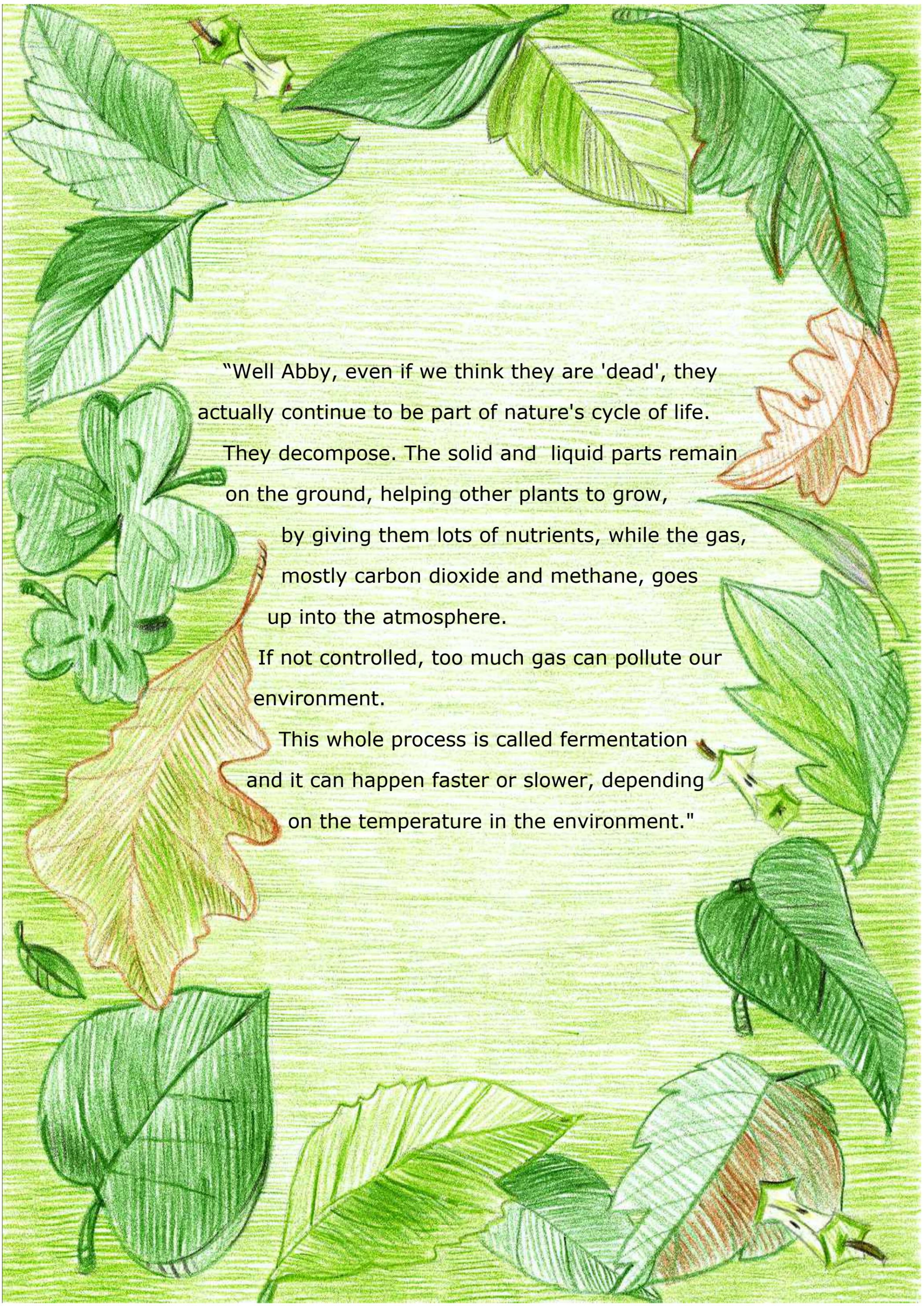


On their way home from school, Alex and Abby are walking through the woods. Looking at all the beauty around them, Abby asks, "Alex, what happens to plants, insects and animals when they die here, in the forest?"



*Never does nature say  
one thing and wisdom  
another.*

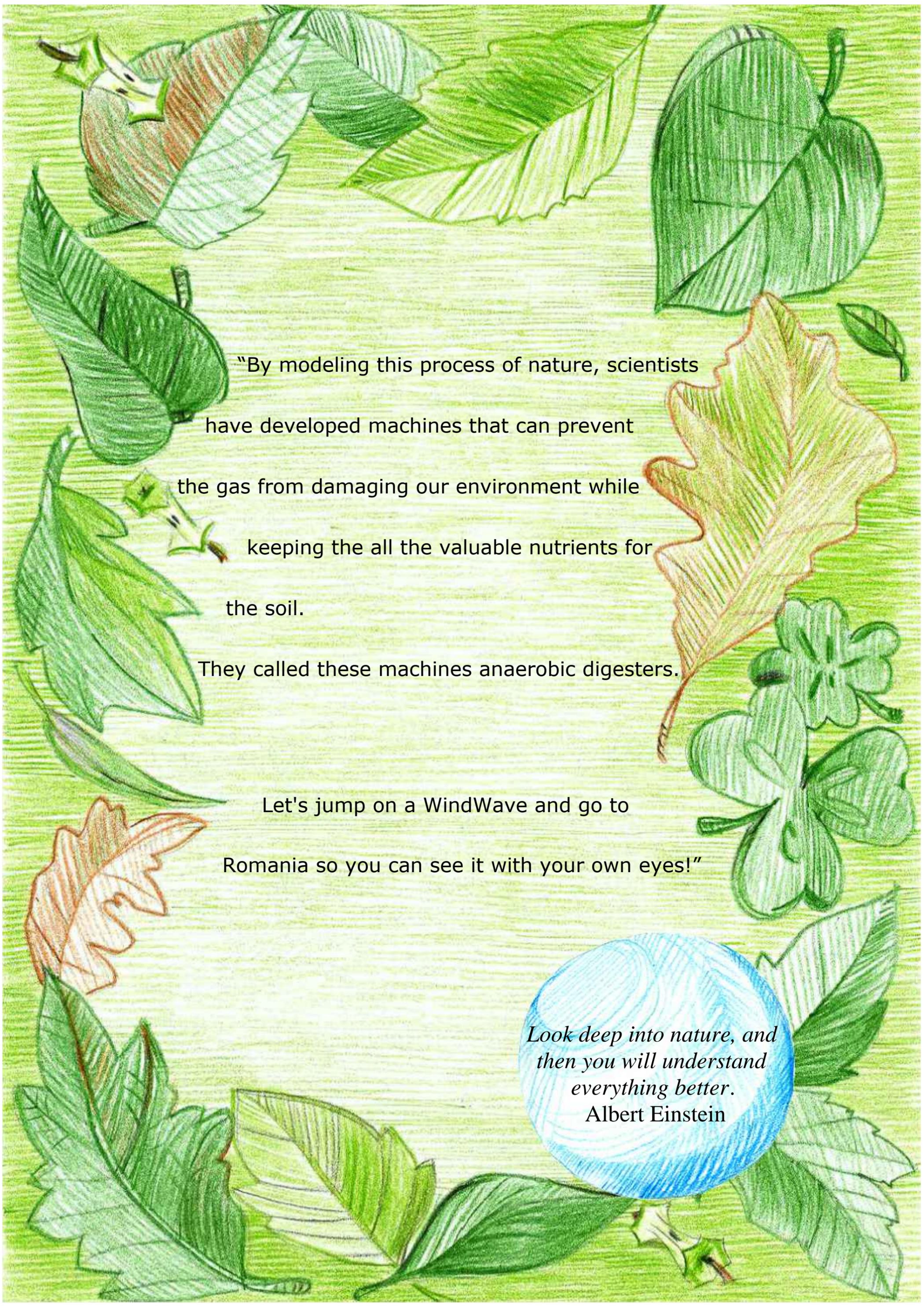
Juvenal, *Satires*



"Well Abby, even if we think they are 'dead', they actually continue to be part of nature's cycle of life. They decompose. The solid and liquid parts remain on the ground, helping other plants to grow, by giving them lots of nutrients, while the gas, mostly carbon dioxide and methane, goes up into the atmosphere.

If not controlled, too much gas can pollute our environment.

This whole process is called fermentation and it can happen faster or slower, depending on the temperature in the environment."



“By modeling this process of nature, scientists have developed machines that can prevent the gas from damaging our environment while keeping the all the valuable nutrients for the soil.

They called these machines anaerobic digesters.

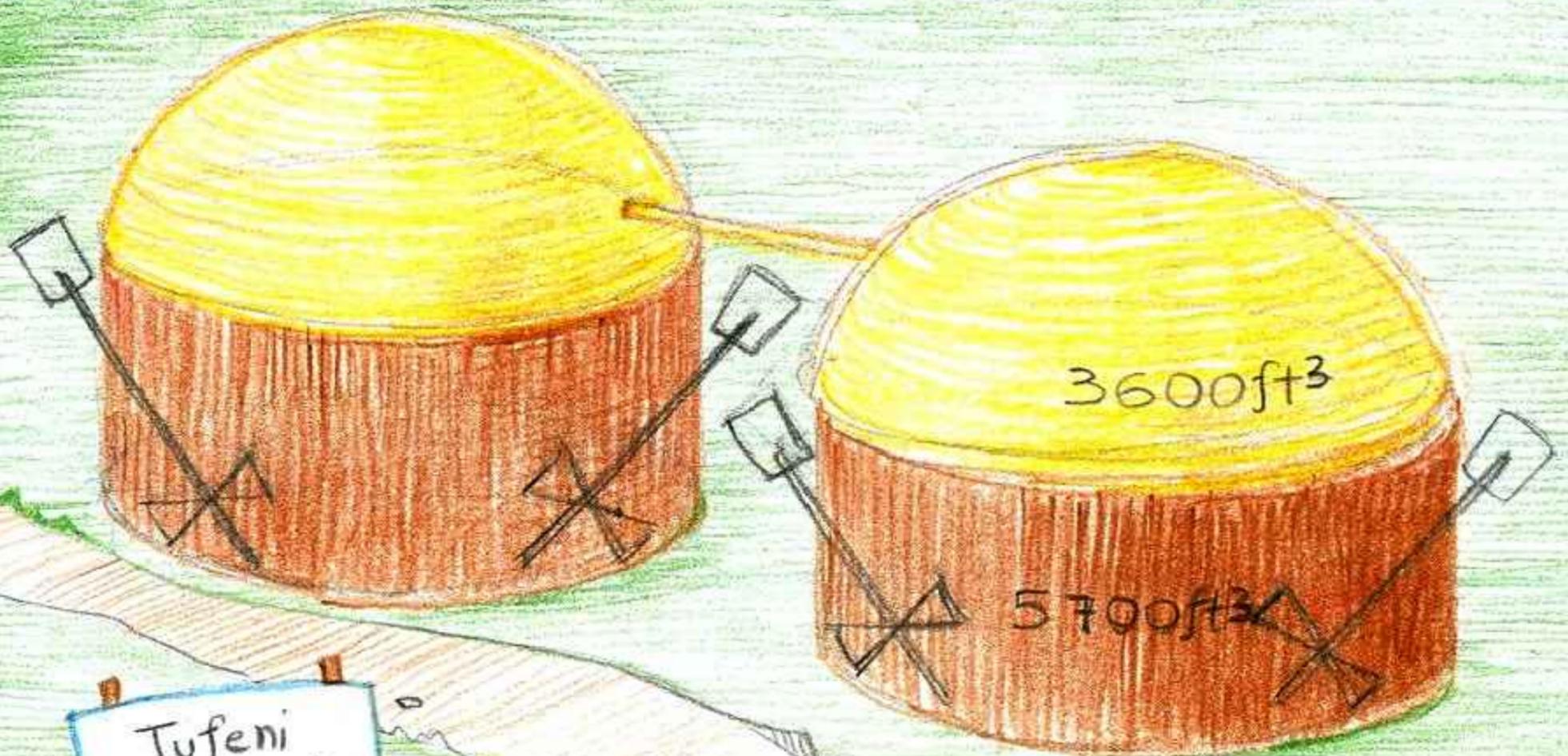
Let's jump on a WindWave and go to Romania so you can see it with your own eyes!”

*Look deep into nature, and then you will understand everything better.*  
Albert Einstein



“These two vertical tanks are called reactors or digesters and they hold liquid waste. In their roofs, they store biogas.

The waste in these containers is mostly manure from 30.000 pigs.



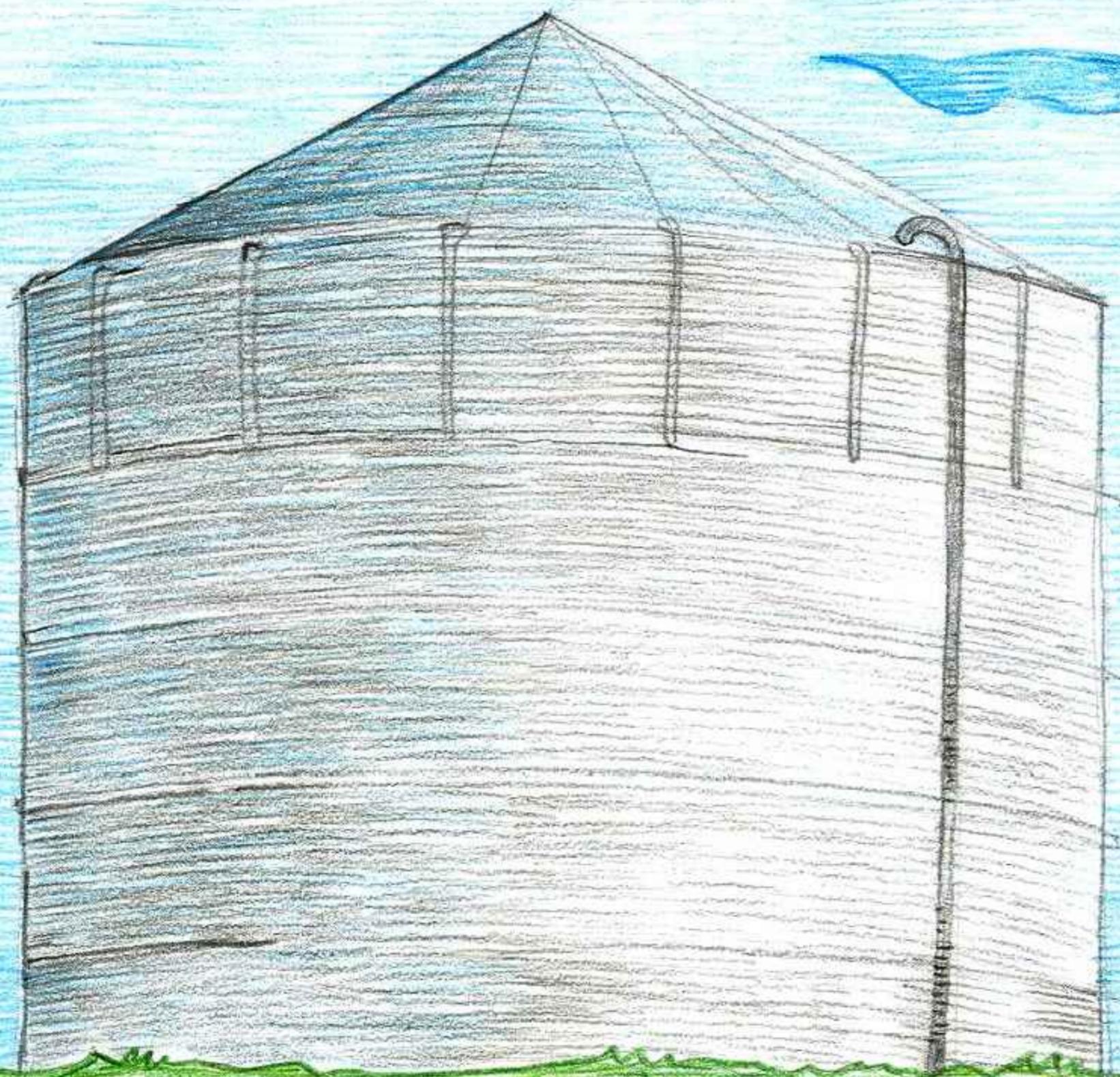
Multiple pipes transport the liquids and solids from the stables to the biogas plant, where they get mixed with some crop residues.

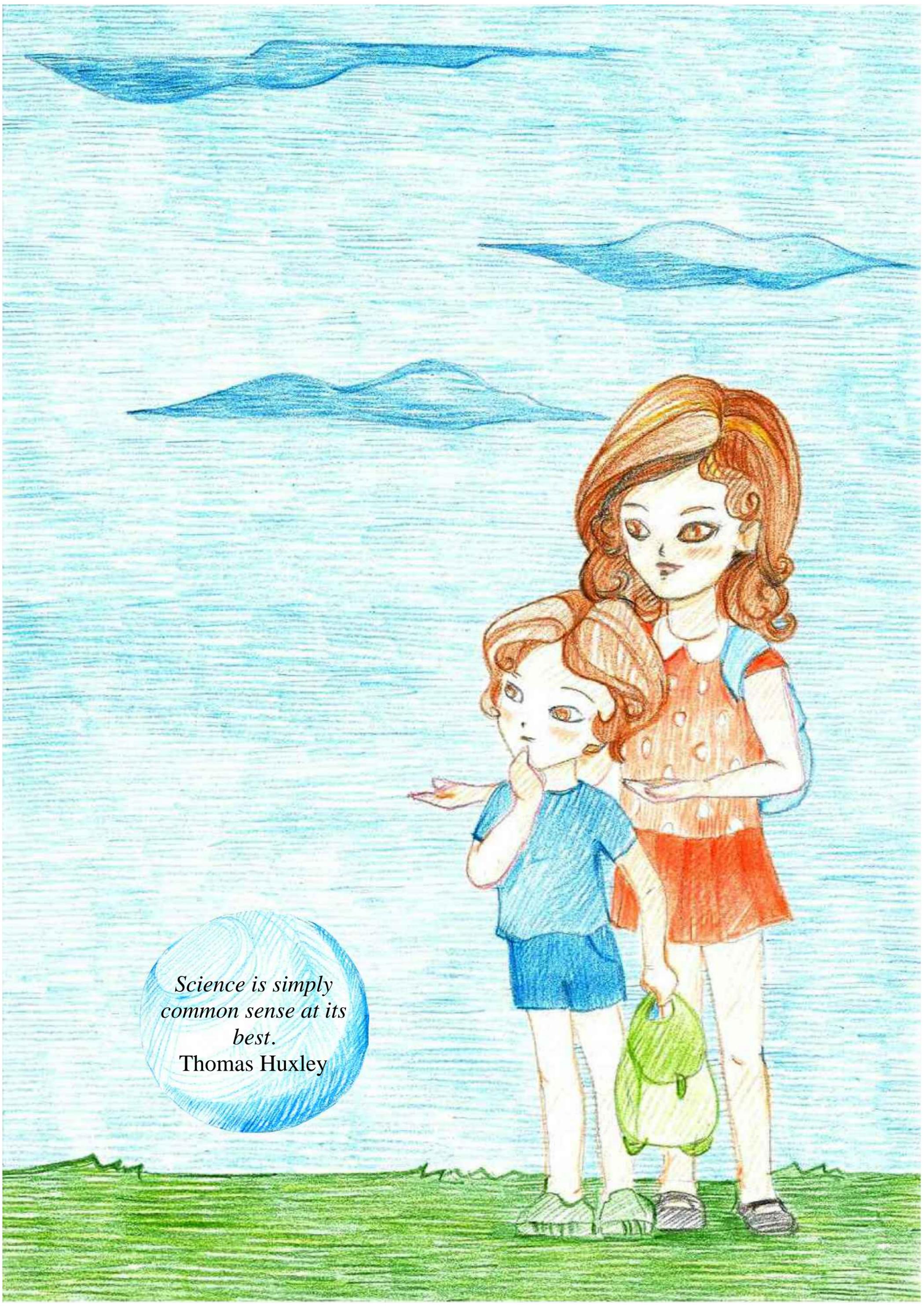
Large quantities of water are added to turn the mixture into a very liquid form. The substrate spends about 21 days here so the biogas can be released.”

“Do the crops, the manure and the water enter the reactor separately? Or are they already mixed together?”

“I'm so glad you asked. Technology in this industry is very advanced. For many years now, scientists building biogas plants use a hydrolysis tank for pre-mixing and preparing the substrate. This is called the hydrolysis phase.

The hydrolysis phase reduces the amount of time needed for digestion: an hour spent in this tank is equivalent to half a day in the digester. Moreover, the quality of the biogas is greatly improved.”

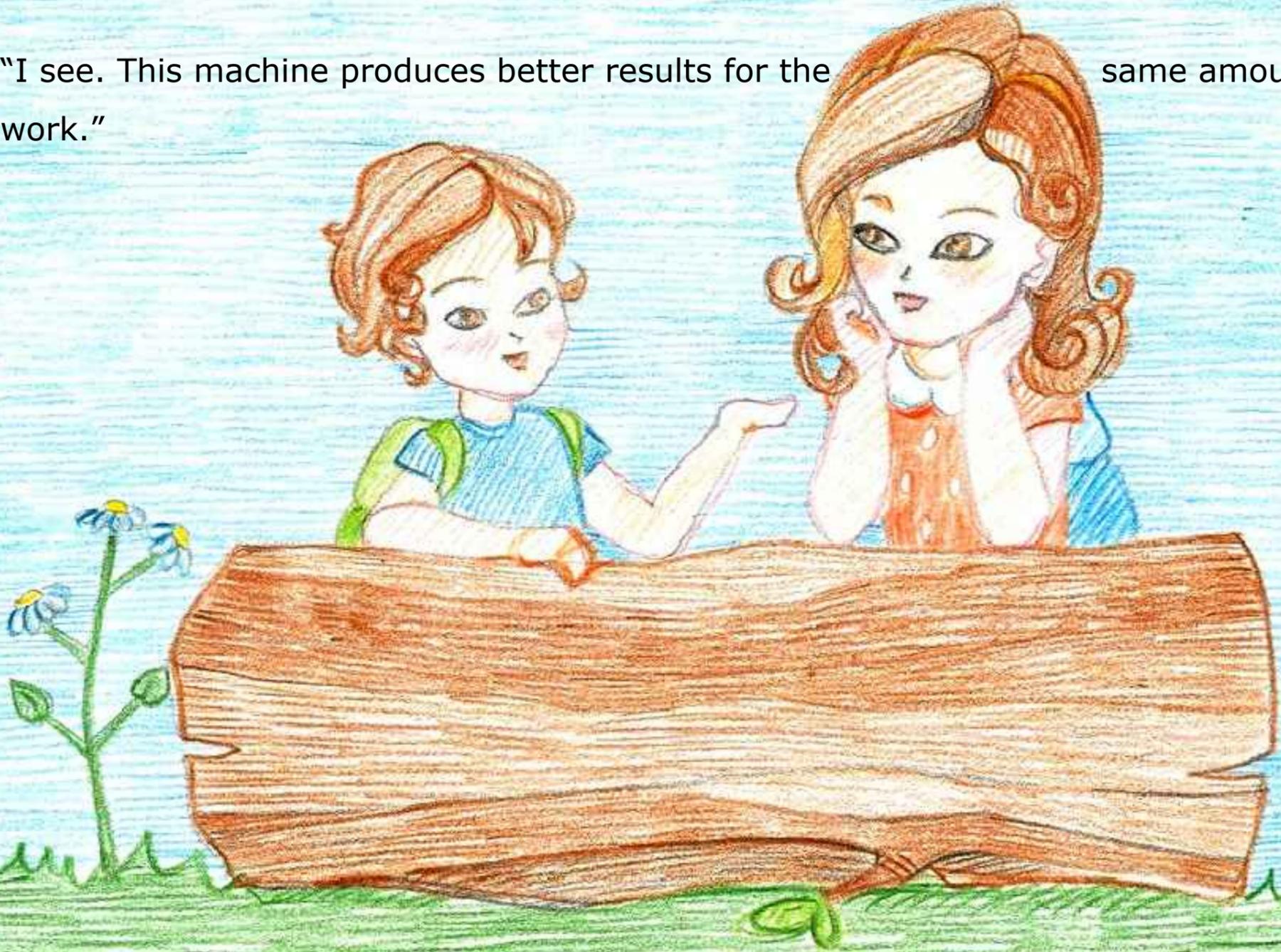




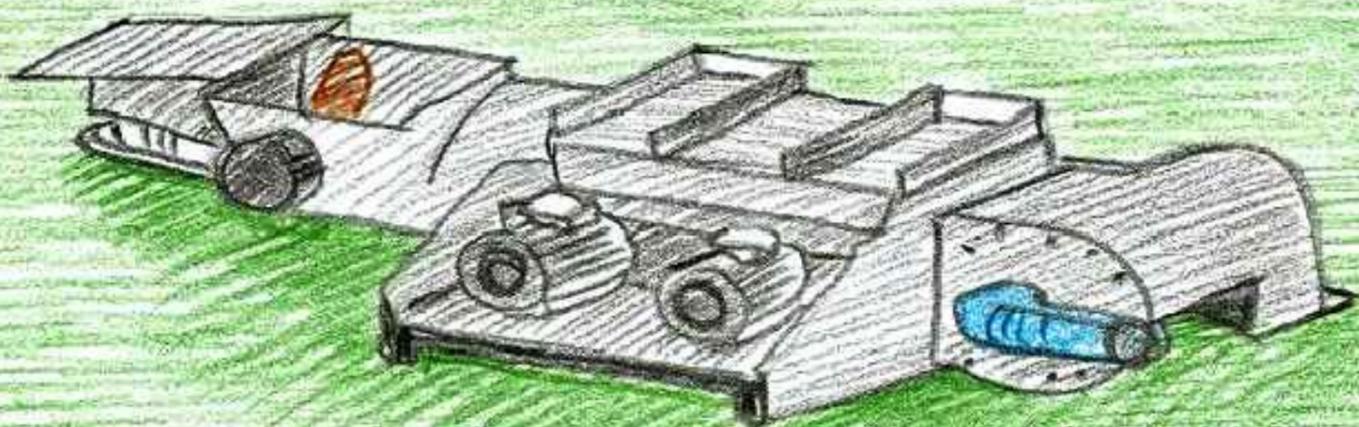
*Science is simply  
common sense at its  
best.*  
Thomas Huxley

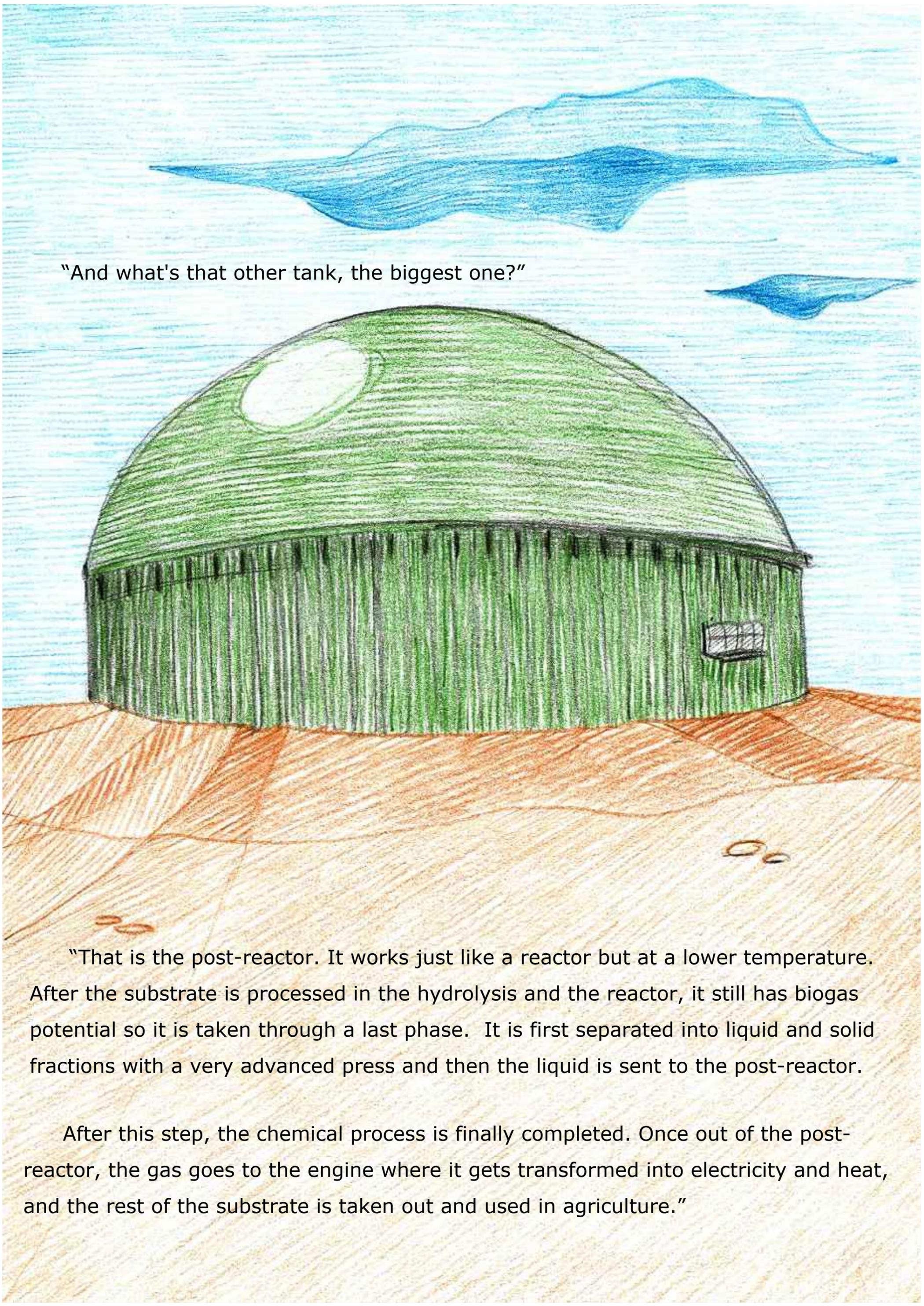
“To make this process even more efficient, a scientist named Jan Driegen created the Molares machine, which shreds solid biomass and opens its cells for a better and faster release of methane. It has been proven that up to 25% more biogas is recovered with the use of the Molares.”

“I see. This machine produces better results for the same amount of work.”



“That's exactly what happens. Increasing productivity and profits of an already very efficient system. This machine is so strong that even if stones or pieces of metal accidentally get inside, it will not break.”

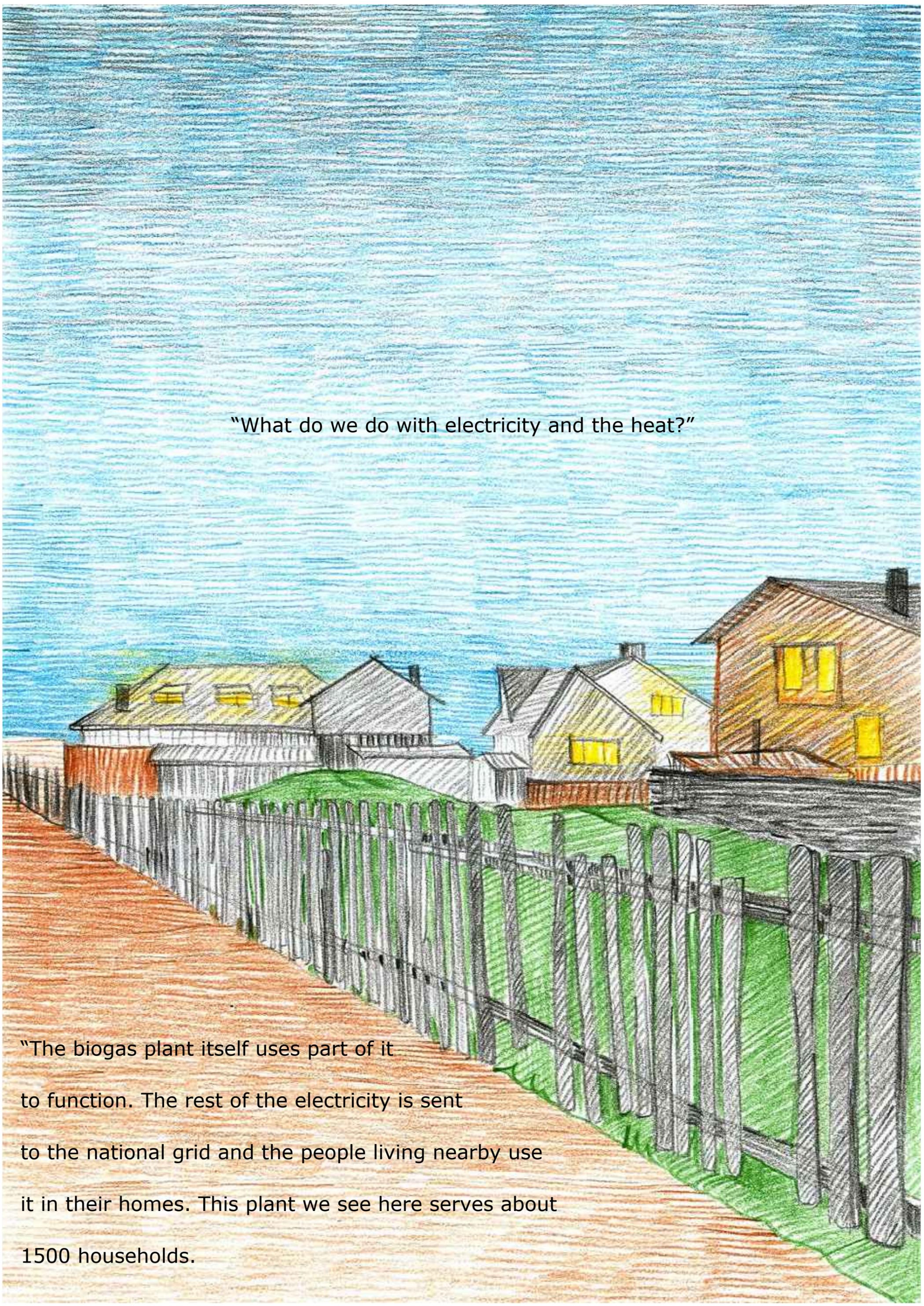




“And what's that other tank, the biggest one?”

“That is the post-reactor. It works just like a reactor but at a lower temperature. After the substrate is processed in the hydrolysis and the reactor, it still has biogas potential so it is taken through a last phase. It is first separated into liquid and solid fractions with a very advanced press and then the liquid is sent to the post-reactor.

After this step, the chemical process is finally completed. Once out of the post-reactor, the gas goes to the engine where it gets transformed into electricity and heat, and the rest of the substrate is taken out and used in agriculture.”

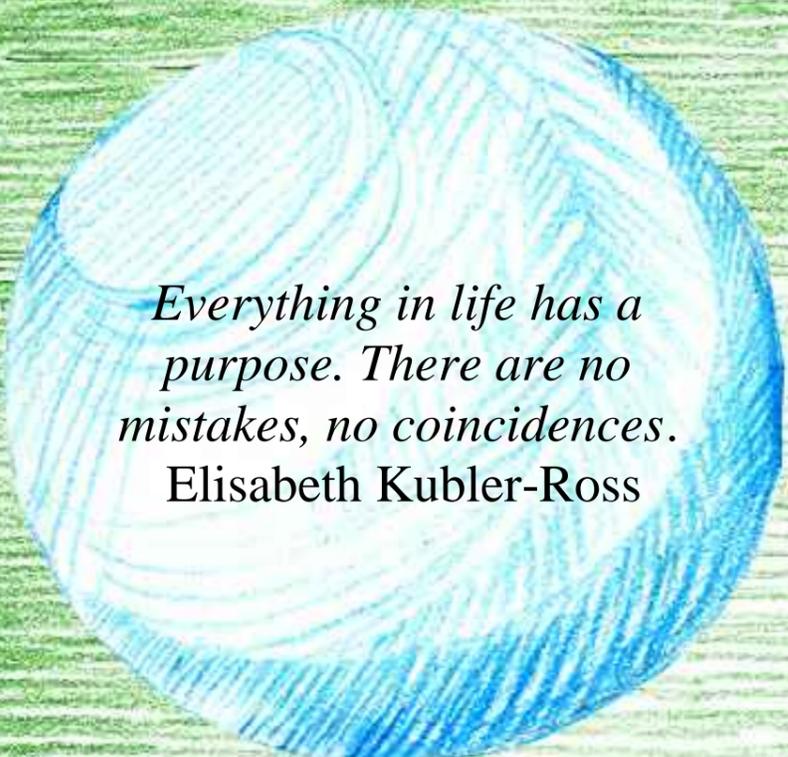


“What do we do with electricity and the heat?”

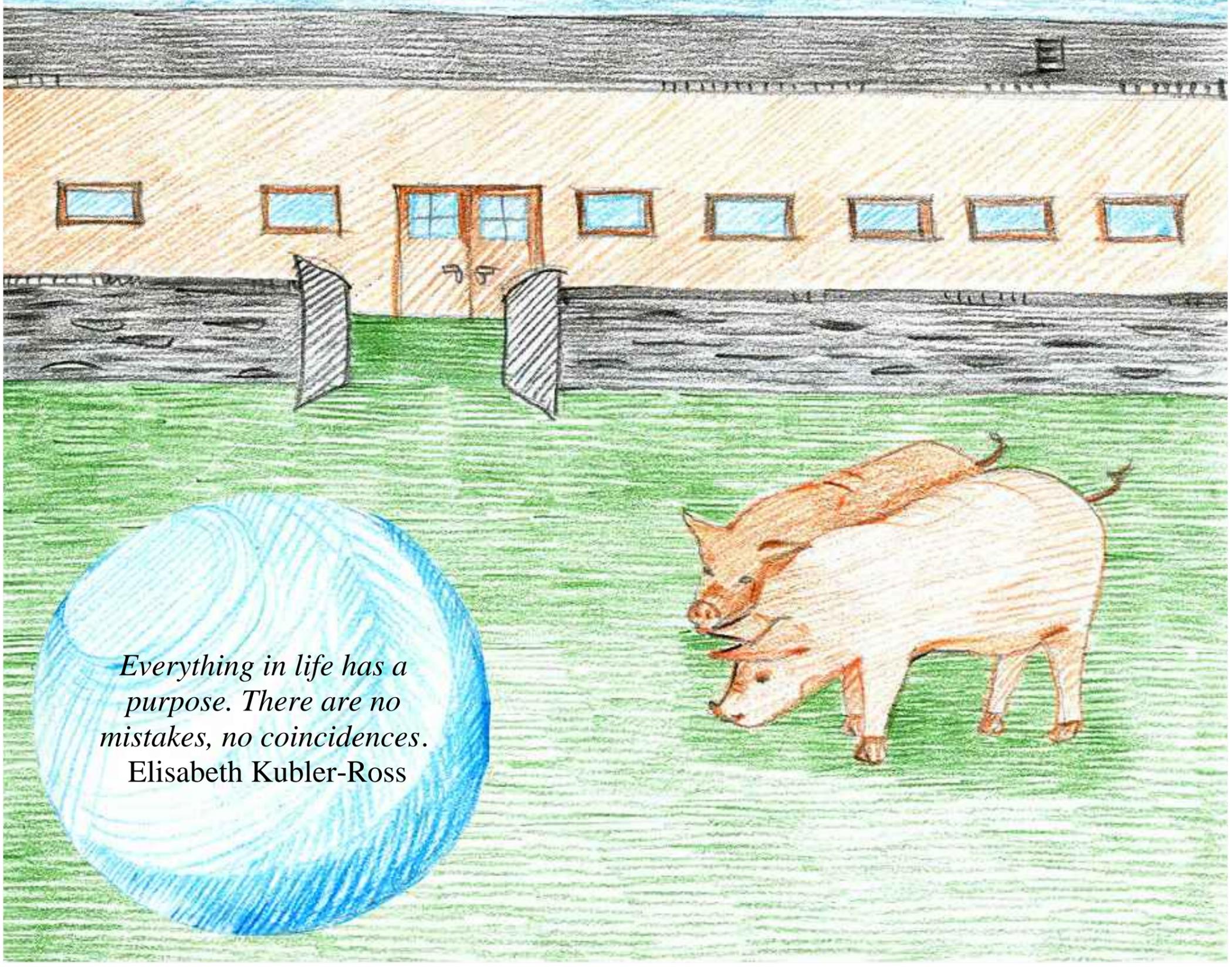
“The biogas plant itself uses part of it to function. The rest of the electricity is sent to the national grid and the people living nearby use it in their homes. This plant we see here serves about 1500 households.

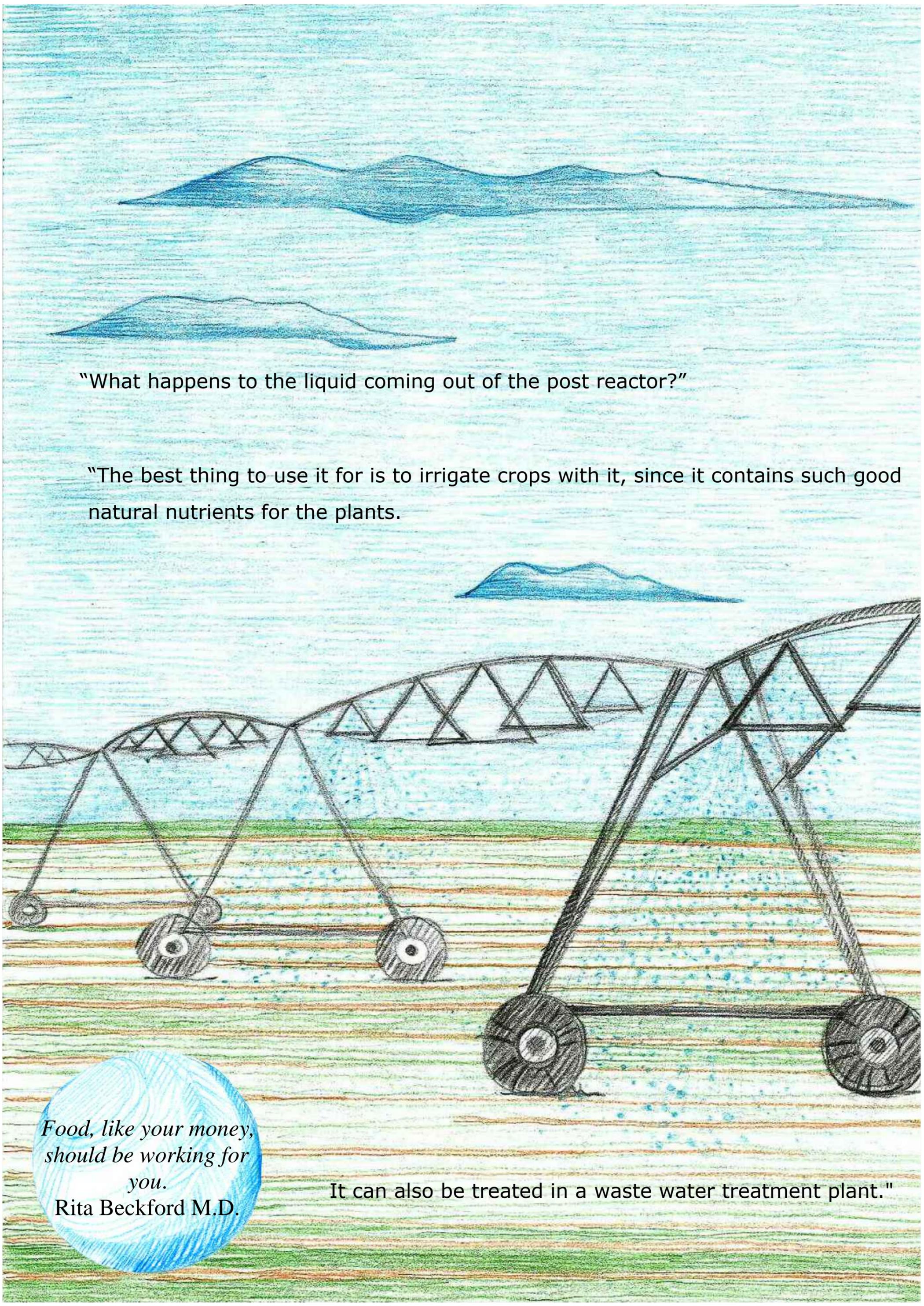
“And the heat is used to dry the solid fraction and control the temperature in the stables where the animals are raised.

Other ways of using the heat would be for swimming pools or green houses.”



*Everything in life has a purpose. There are no mistakes, no coincidences.*  
Elisabeth Kubler-Ross





“What happens to the liquid coming out of the post reactor?”

“The best thing to use it for is to irrigate crops with it, since it contains such good natural nutrients for the plants.

*Food, like your money,  
should be working for  
you.*

Rita Beckford M.D.

It can also be treated in a waste water treatment plant.”

"As far as the solid fraction goes, it can be dried, stored and packed to be sold as fertilizer.

Another option is to spread it on the field."



“Do you now understand the process of anaerobic digestion?”

MASTICATE AND PREDIGESTING

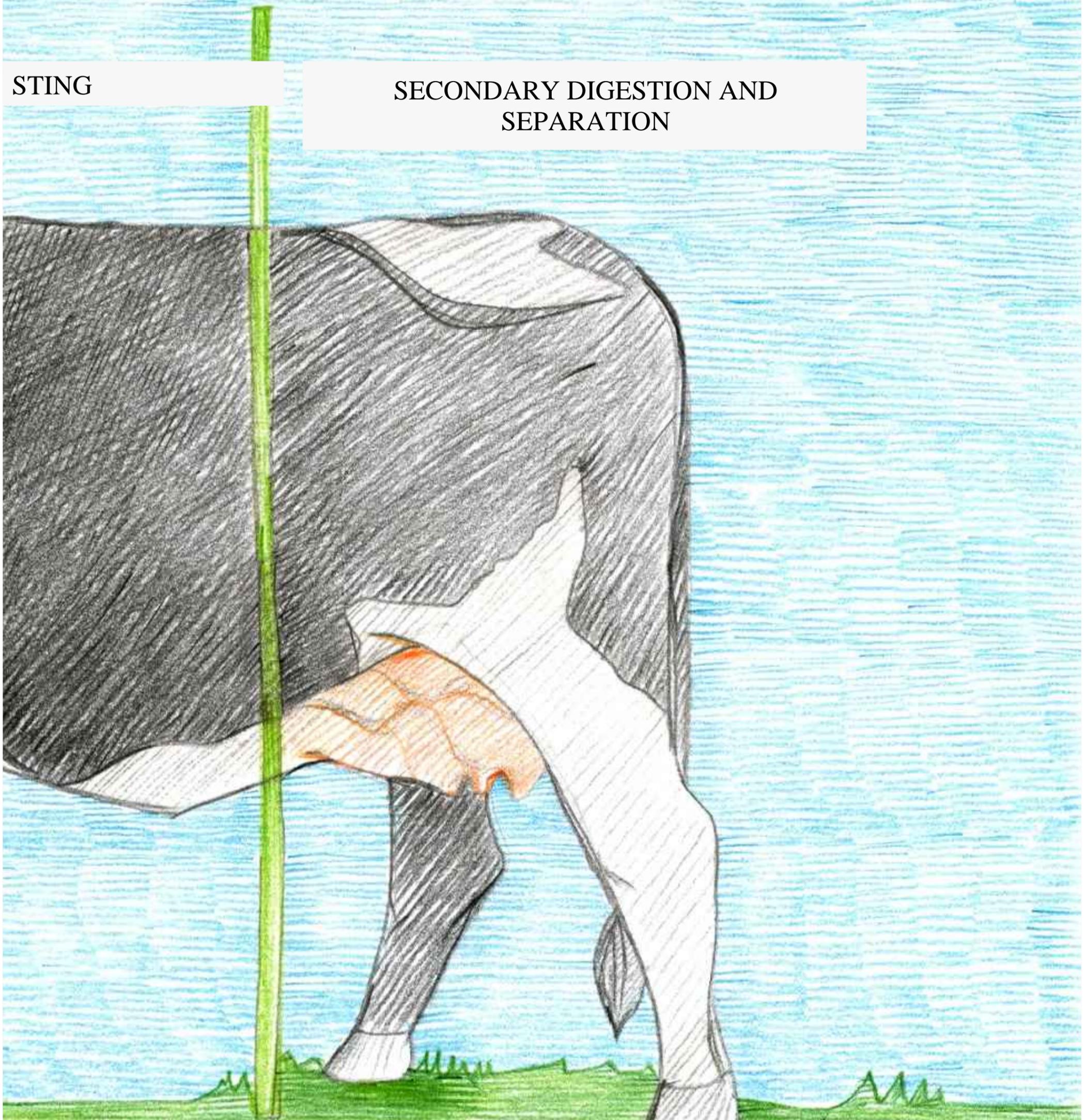
DIGE



HYDROLYSIS & MOLARES

REAC

“Yes. It works just like a ruminant animal. We learned that in school in biology. It's the natural process of digestion.

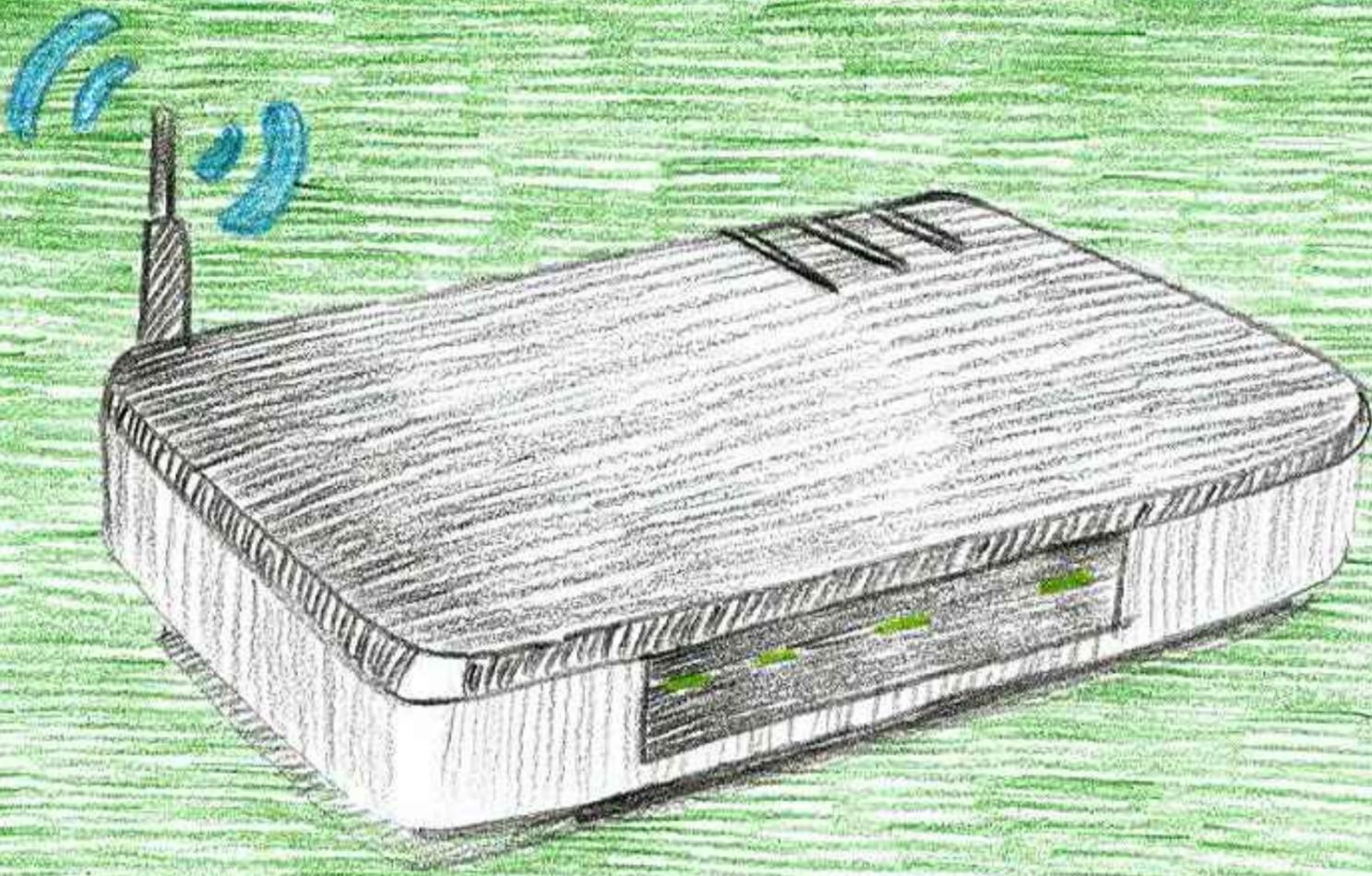


STING

SECONDARY DIGESTION AND SEPARATION

TORS

POST REACTOR & SEPARATION



“Even if it's simple, it's still pretty complex. How can someone keep track of all that's happening here?”

“The whole system can be supervised on a computer. At any moment, the engineers can take control of the installation via Internet to support the operation. If any problem occurs, the program immediately alerts the person responsible for the installation by phone or e-mail.”



*Nanotechnology will let us build computers that are incredibly powerful. We'll have more power in the volume of a sugar cube than exists in the entire world today.*

Ralph Merkle

"Wow! That is really incredible. The only thing I don't really like about this process is that it takes too much water to dilute the substrates, and it takes too long..."

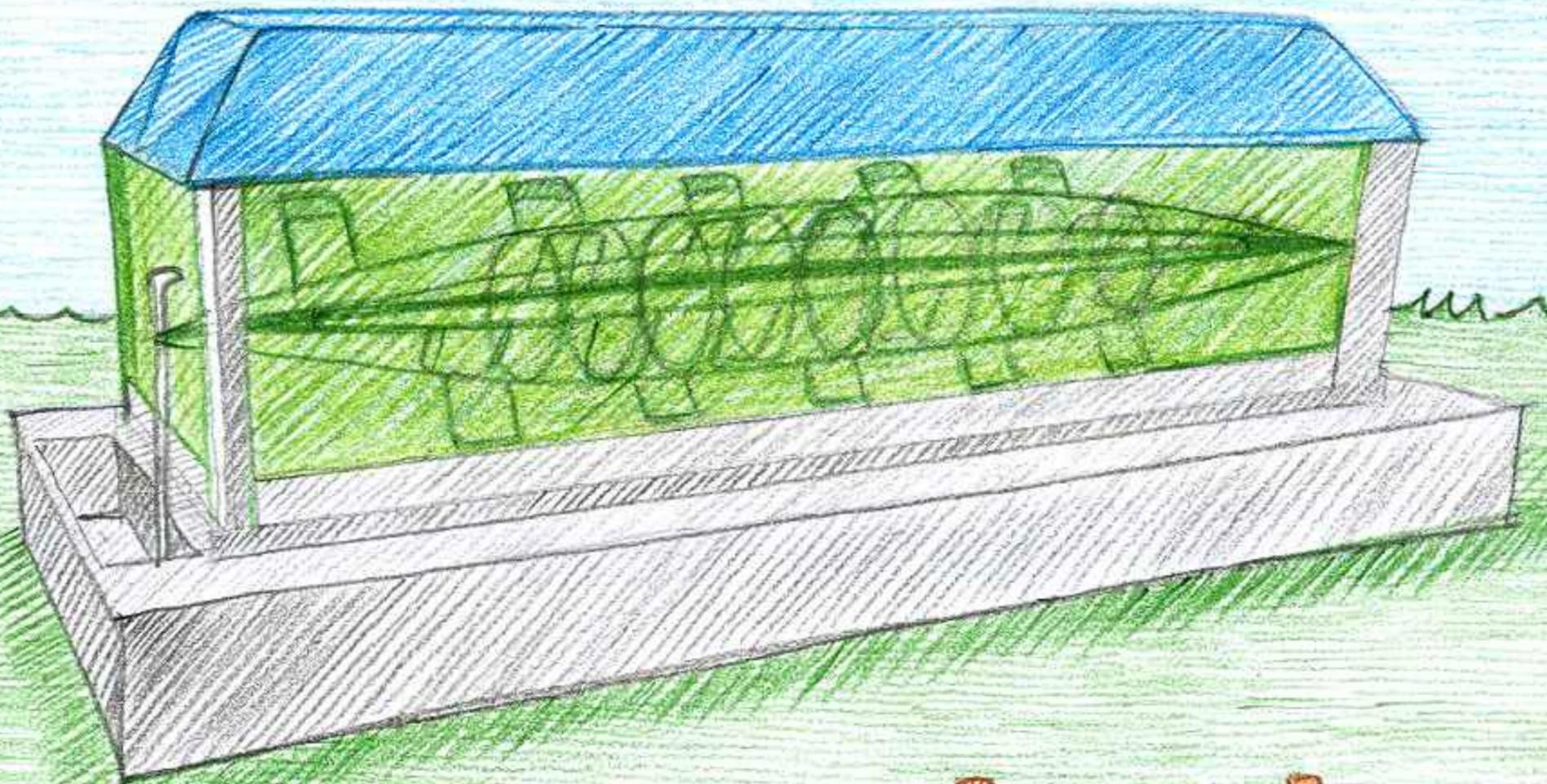
"Well, scientists felt the same way, and they came up with a solution. Let's jump on a WindWave and go to the Netherlands to see what it is!"





"Here we are! In Zeewolde, Netherlands!

This installation uses approximately 35.000 tons of mixed products and provides electricity to about 3000 households. It is using the dry technology of a plug flow reactor. The plug flow reactor requires 3 times less water than the liquid one. It also needs a much shorter time to process the substrate. This installation in Zeewolde has a retention time of only 11 days in the reactor."



"That makes everything easier!

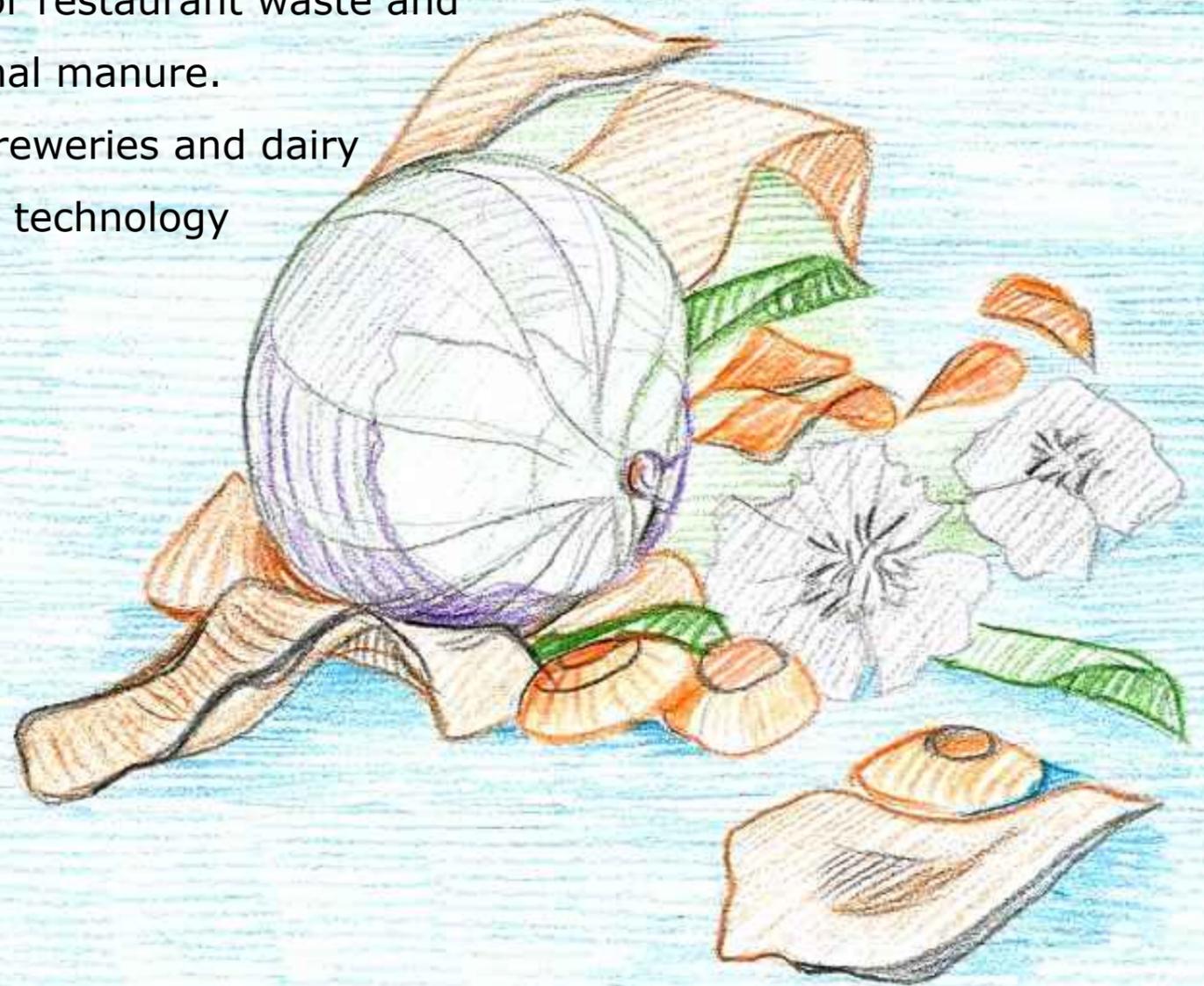
Now I'd like to know more about what exactly can we feed into an anaerobic digestion plant."





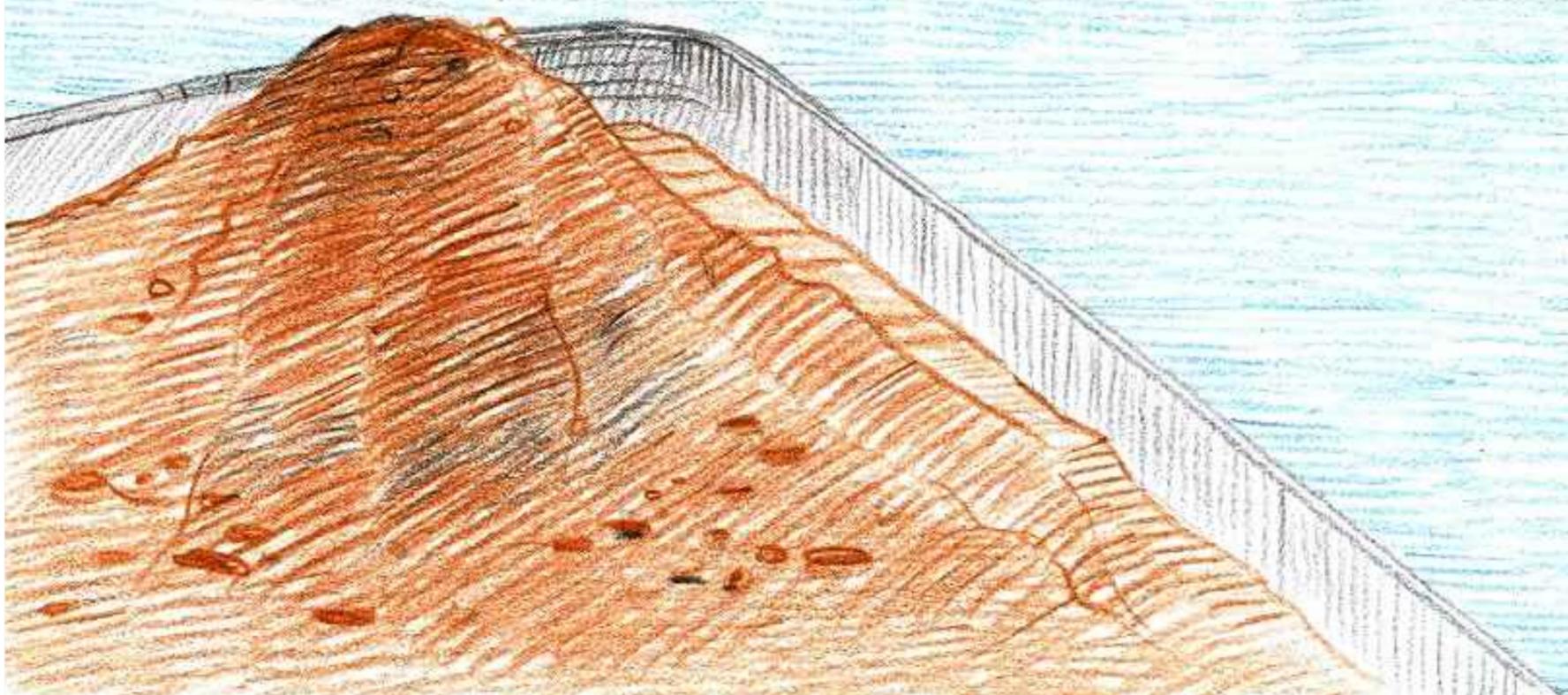
“These biogas plants are designed to process food waste in all its forms: from crop residue to supermarket or restaurant waste and also liquid and solid animal manure.

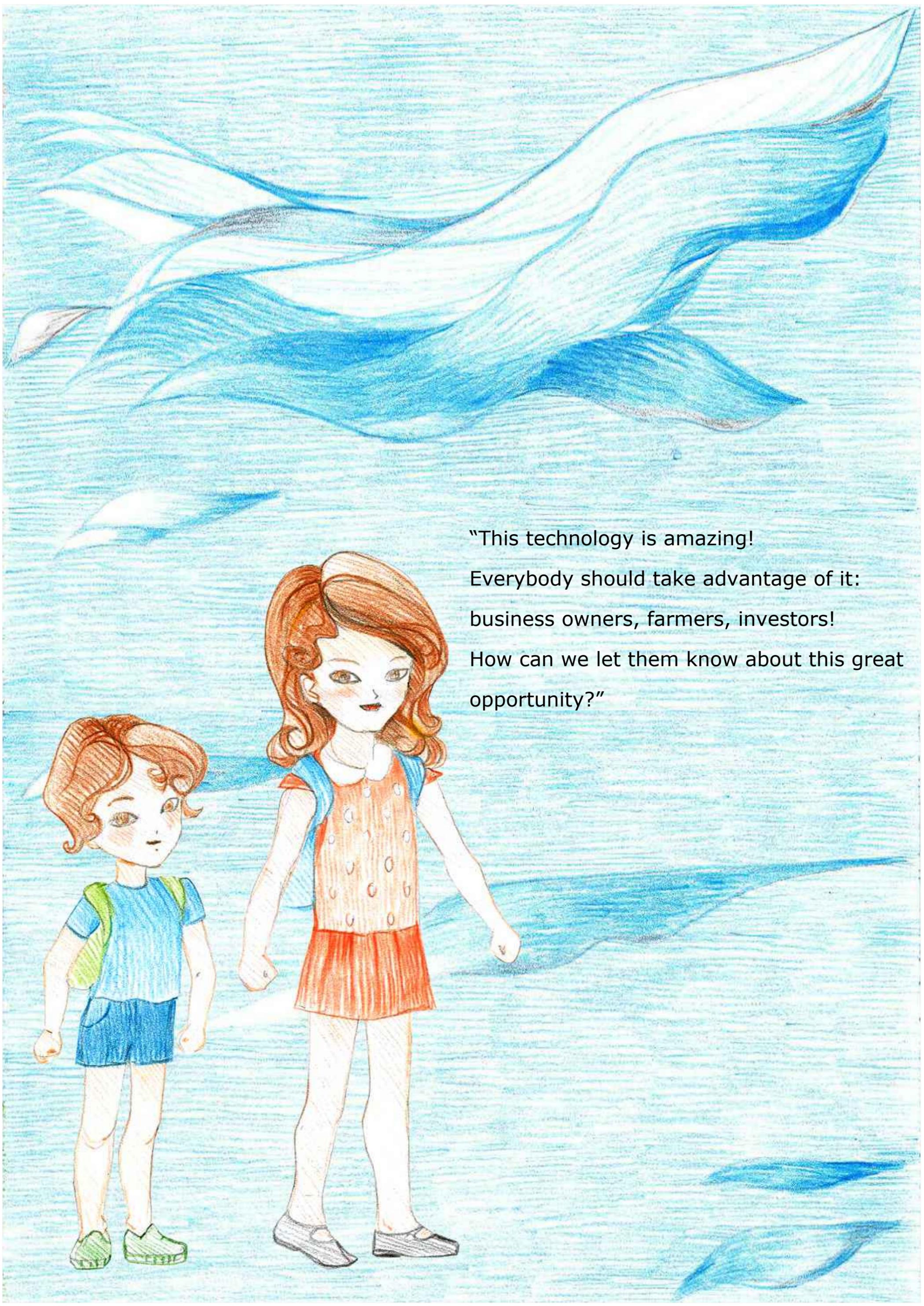
“Big industries like breweries and dairy companies often use this technology to treat the waste.



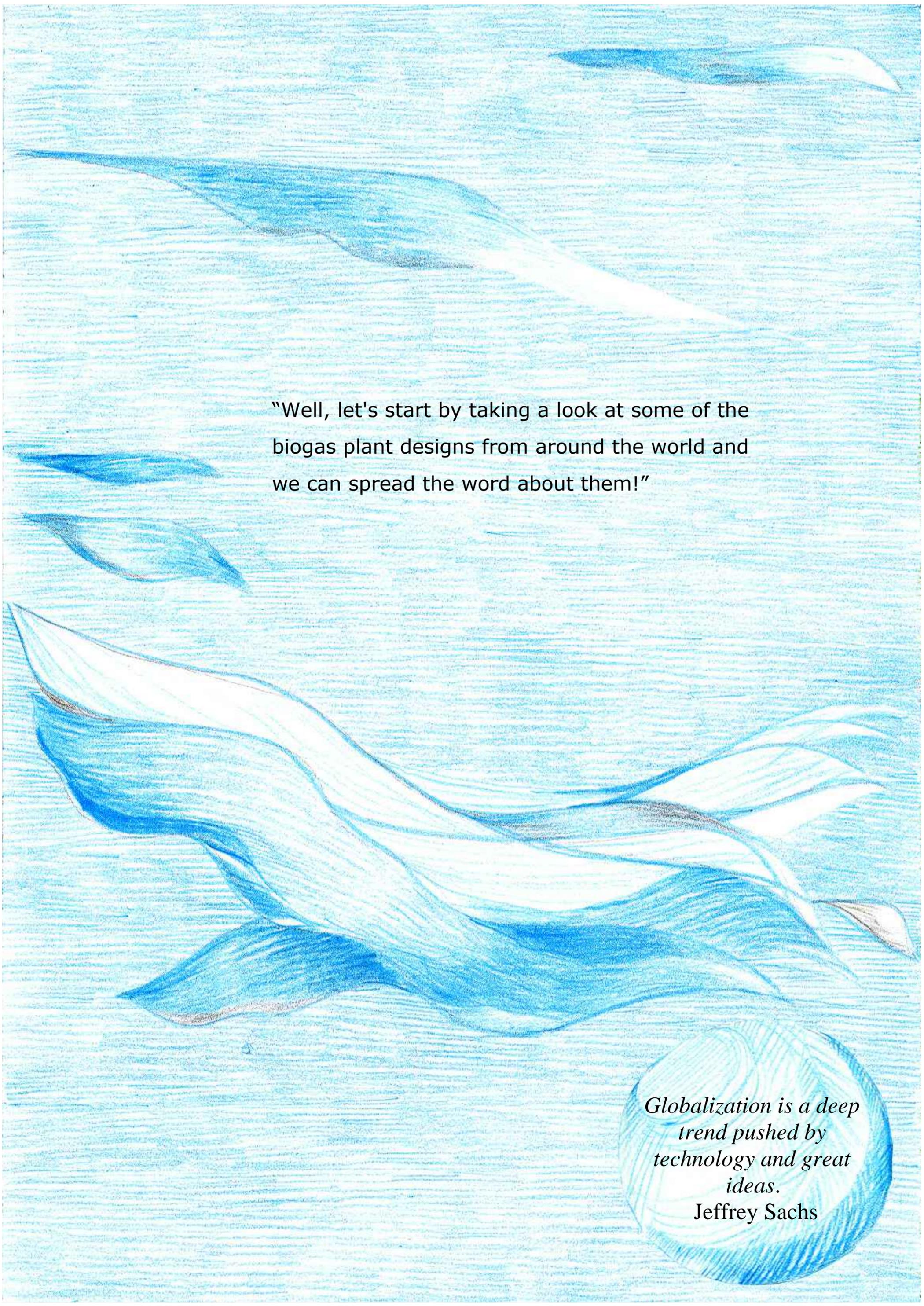
“For example, the production on 1 acre of corn is about 50.000 pounds, which can produce almost 40.000 ft<sup>3</sup> of biogas.

When we refer to animals, from one dairy cow we can obtain approximately 2.000 ft<sup>3</sup> of biogas every year.”





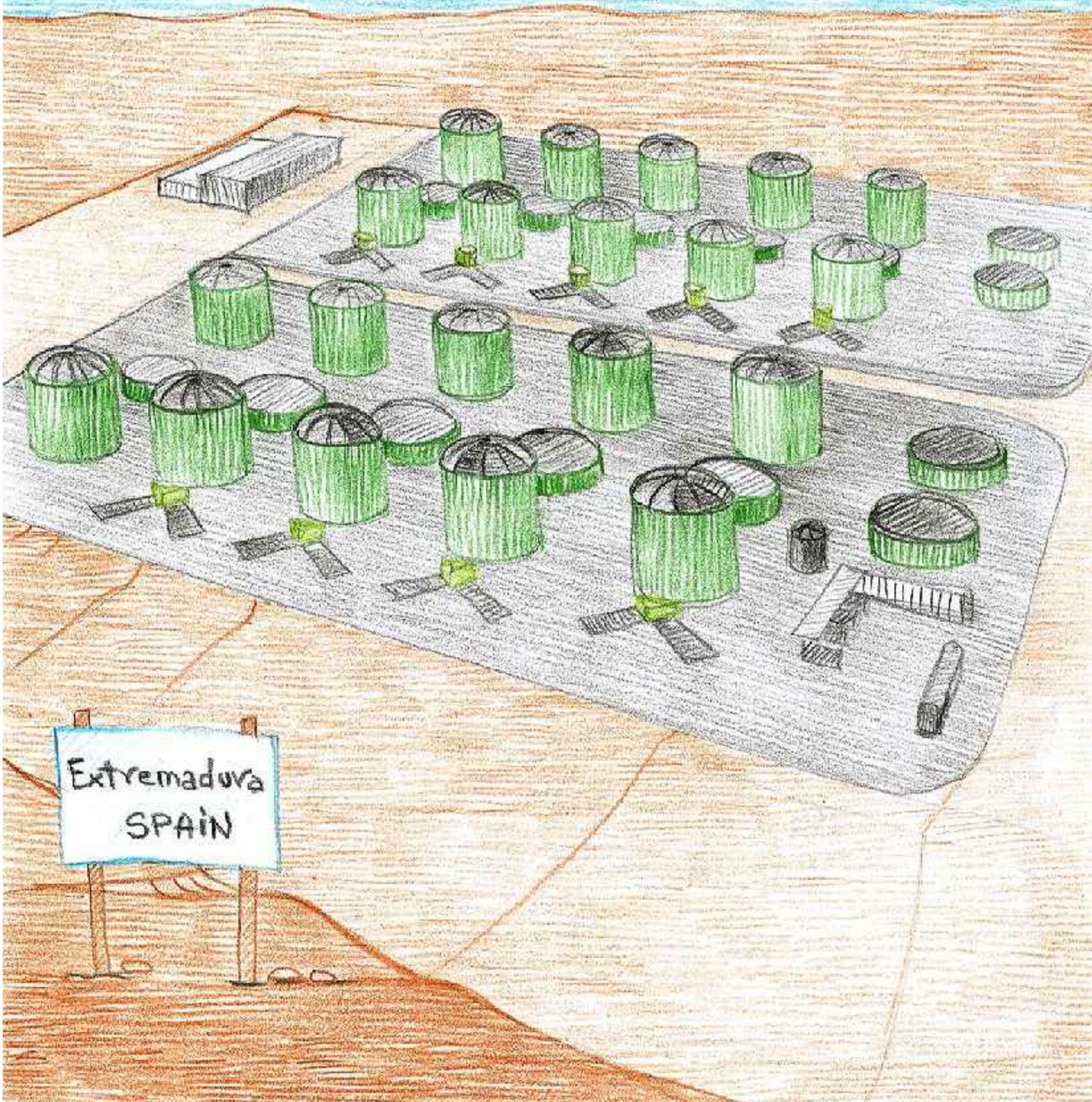
“This technology is amazing!  
Everybody should take advantage of it:  
business owners, farmers, investors!  
How can we let them know about this great  
opportunity?”



“Well, let's start by taking a look at some of the biogas plant designs from around the world and we can spread the word about them!”

*Globalization is a deep trend pushed by technology and great ideas.*  
Jeffrey Sachs

Location	Extremadura, Spain
Process	Liquid digestion - mesophile
Substrate	350.000 tons of corn and tobacco silage per year
Digesters	20 x 176.000 ft <sup>3</sup>
Hydrolysis	-
Secondary digester	10 x 211.000 ft <sup>3</sup>
CHP	50 MWh



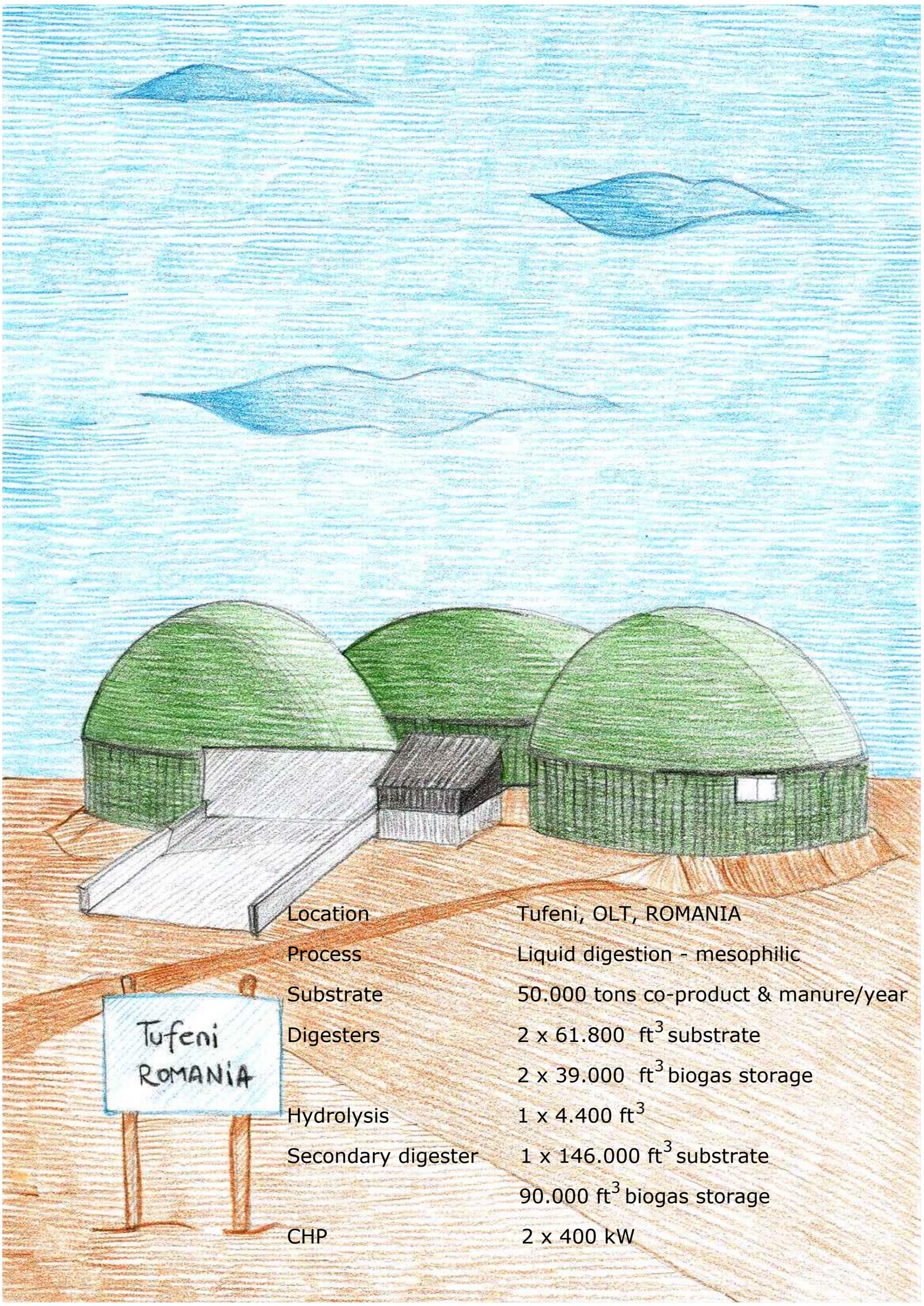


3



Location	Westover, MD, USA
Process	Dry digestion
Substrate	10.500 tons of poultry litter and crop residue per year
Digesters	1 x 41.000 ft <sup>3</sup> substrate + 7000 ft <sup>3</sup> biogas storage
Hydrolysis	1 x 2.500 ft <sup>3</sup>
Secondary digester	Lagoon for liquid storage
CHP	1 MWh





Tufeni  
ROMANIA

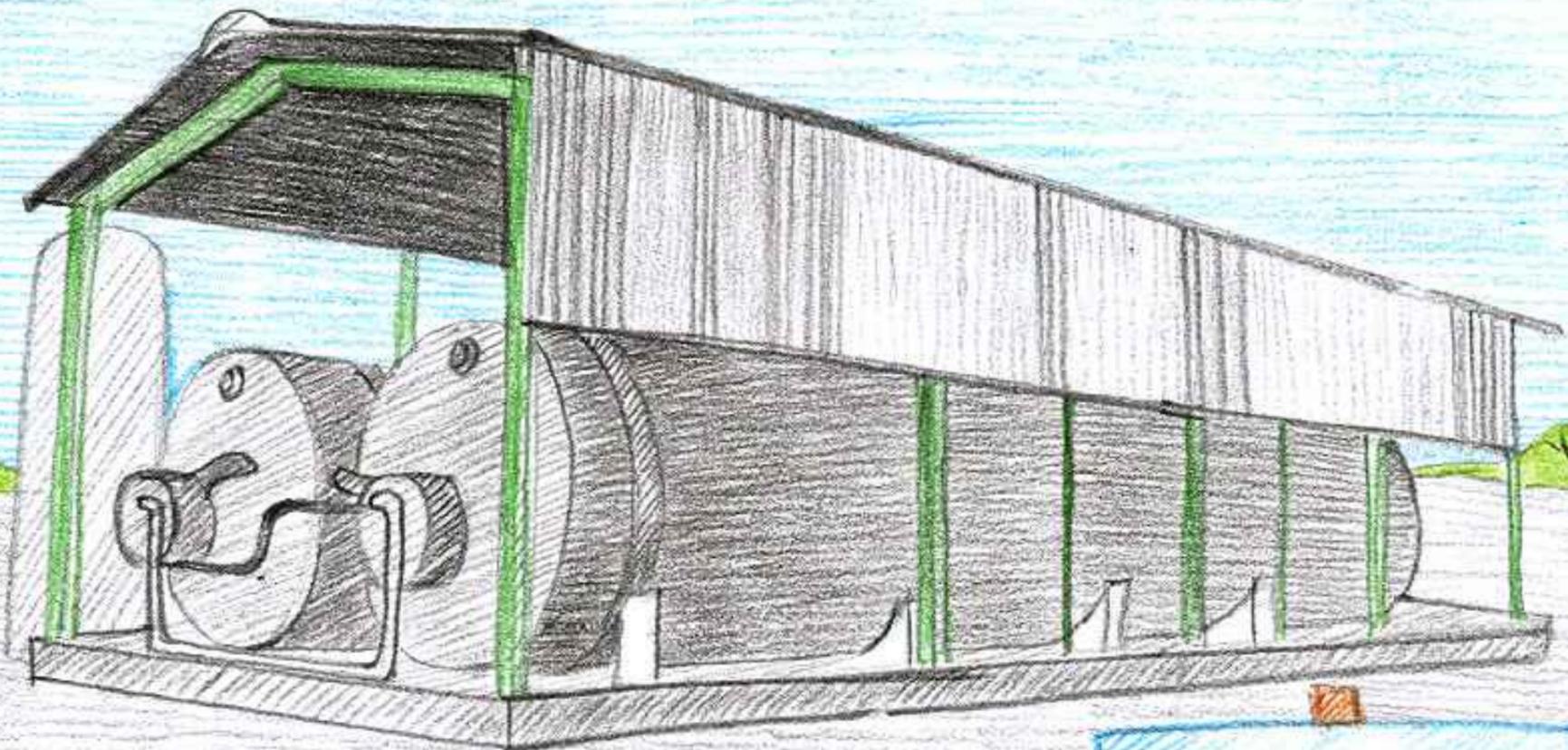
Location	Tufeni, OLT, ROMANIA
Process	Liquid digestion - mesophilic
Substrate	50.000 tons co-product & manure/year
Digesters	2 x 61.800 ft <sup>3</sup> substrate 2 x 39.000 ft <sup>3</sup> biogas storage
Hydrolysis	1 x 4.400 ft <sup>3</sup>
Secondary digester	1 x 146.000 ft <sup>3</sup> substrate 90.000 ft <sup>3</sup> biogas storage
CHP	2 x 400 kW

Location	Zeewolde / Flevoland / Netherlands
Process	Dry digestion
Substrate	35.000 tons of co-product and manure per year
Digesters	Plug flow 2 x 27.000 ft <sup>3</sup>
Hydrolysis	1 x 13.500 ft <sup>3</sup>
Secondary digester	1 x 70.600 ft <sup>3</sup> substrate + 85.000 ft <sup>3</sup> biogas storage
CHP	2 x 713 kW

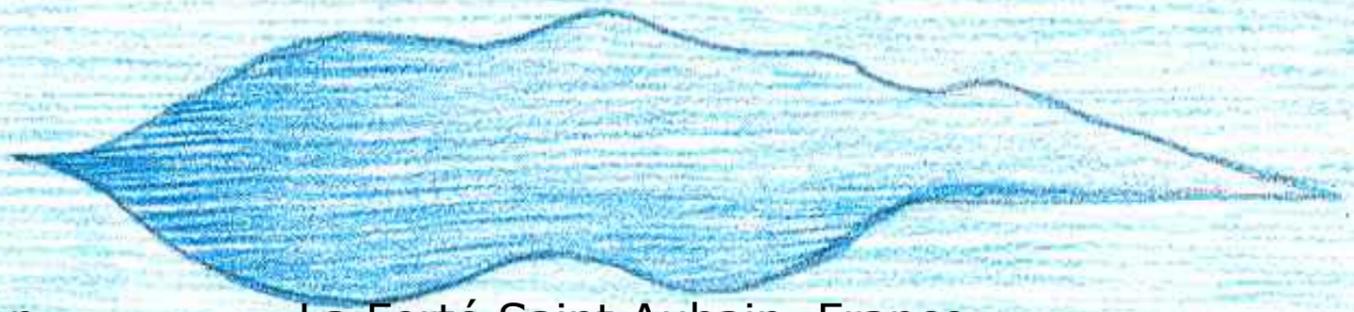


Location Poitou-Charentes, France  
Process Dry digestion  
Substrate 11.000 tons of co-product and manure per year  
Digesters Plug flow 2 x 11.800 ft<sup>3</sup>

Hydrolysis 1 x 2.800 ft<sup>3</sup>  
Secondary digester 124.000 ft<sup>3</sup> liquid storage lagoon  
CHP 400KWh



Bintu - Charentes  
FRANCE



Location La Ferté Saint Aubain, France

Process Dry digestion

Substrate 30.000 tons of co-product and manure per year



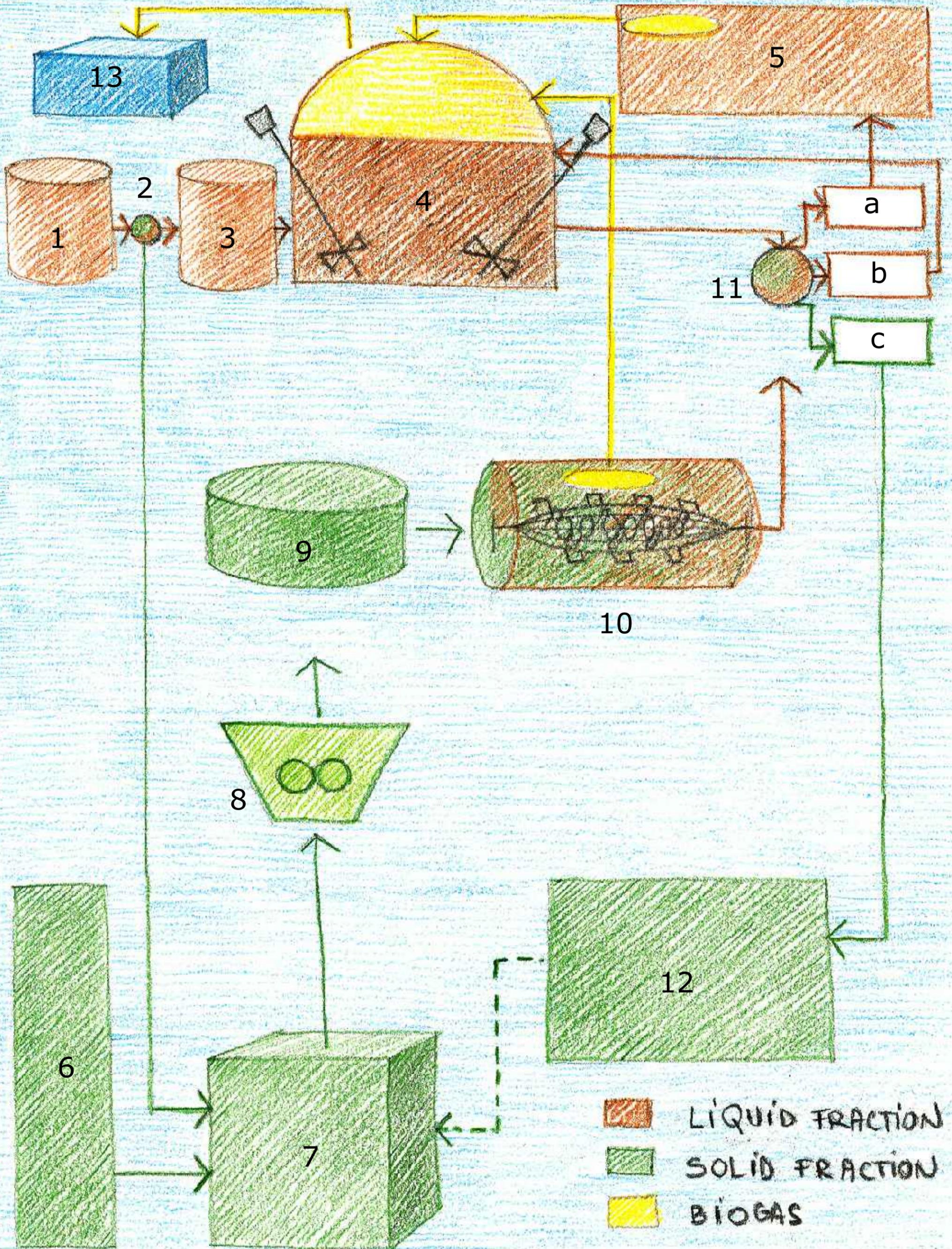
Digesters Plug flow 44.000 ft<sup>3</sup>

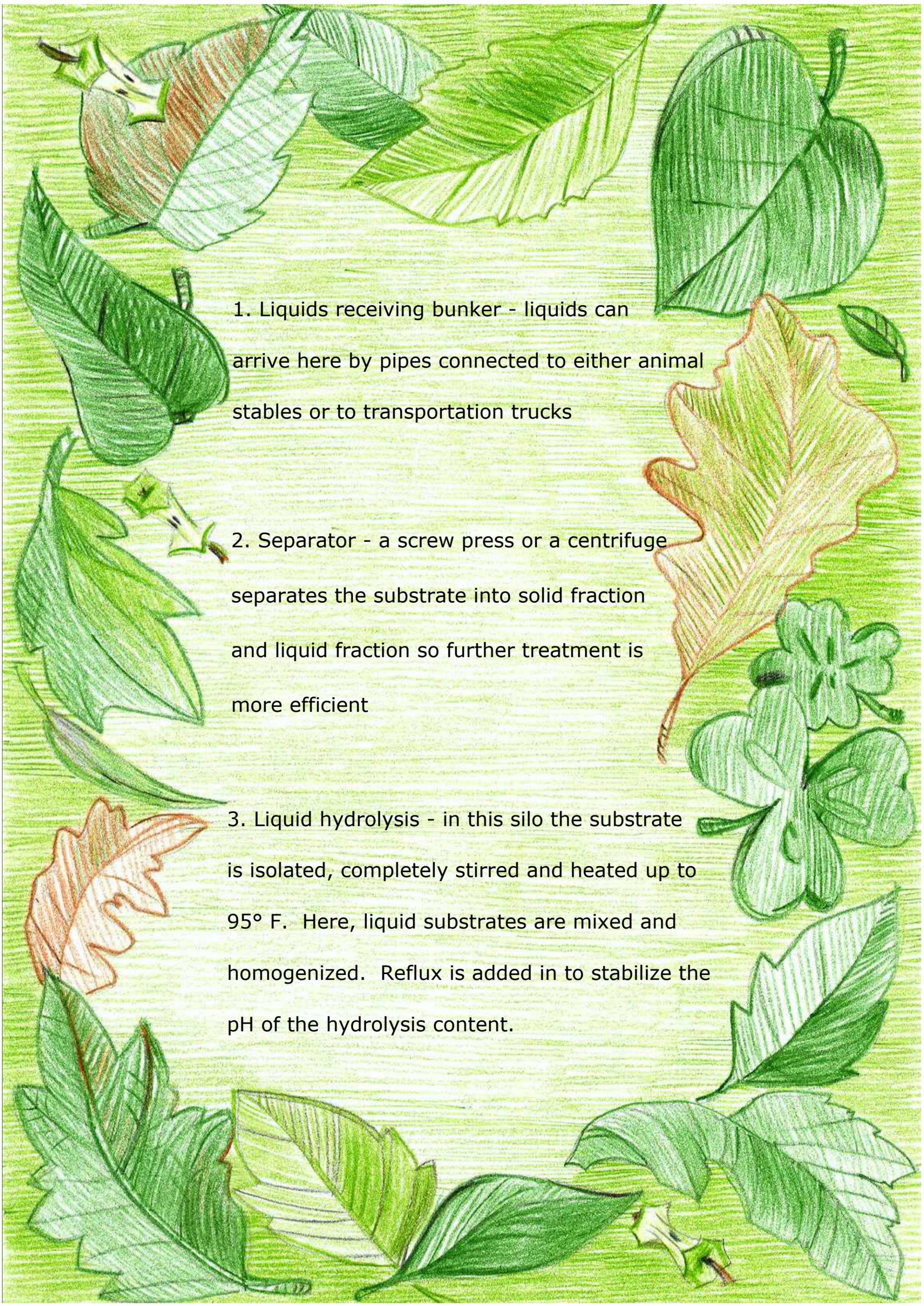
Hydrolysis 1 x 1.800 ft<sup>3</sup>

Secondary digester -

CHP 800 KWh

# Hybrid Biogas System

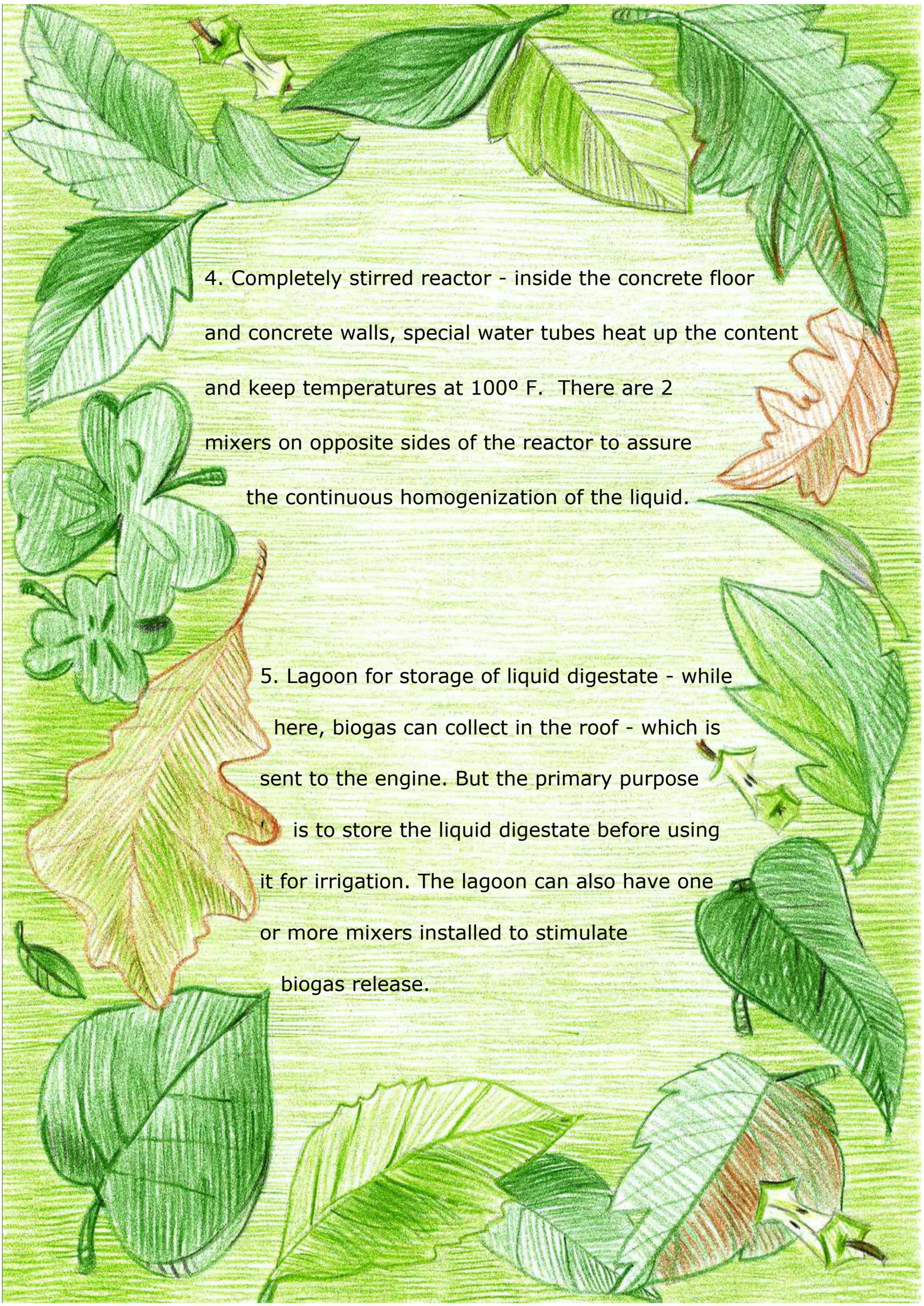




1. Liquids receiving bunker - liquids can arrive here by pipes connected to either animal stables or to transportation trucks

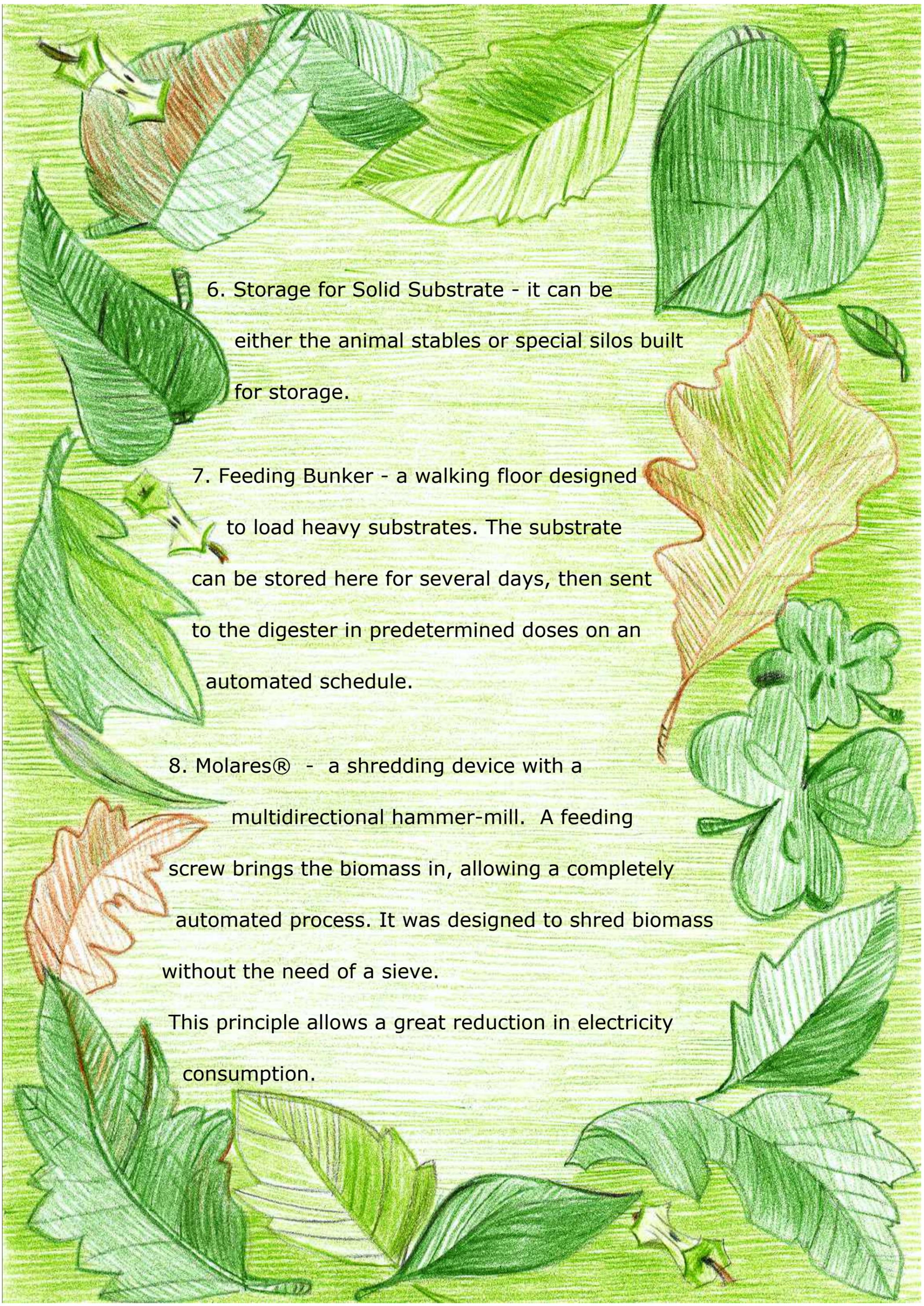
2. Separator - a screw press or a centrifuge separates the substrate into solid fraction and liquid fraction so further treatment is more efficient

3. Liquid hydrolysis - in this silo the substrate is isolated, completely stirred and heated up to 95° F. Here, liquid substrates are mixed and homogenized. Reflux is added in to stabilize the pH of the hydrolysis content.



4. Completely stirred reactor - inside the concrete floor and concrete walls, special water tubes heat up the content and keep temperatures at 100° F. There are 2 mixers on opposite sides of the reactor to assure the continuous homogenization of the liquid.

5. Lagoon for storage of liquid digestate - while here, biogas can collect in the roof - which is sent to the engine. But the primary purpose is to store the liquid digestate before using it for irrigation. The lagoon can also have one or more mixers installed to stimulate biogas release.

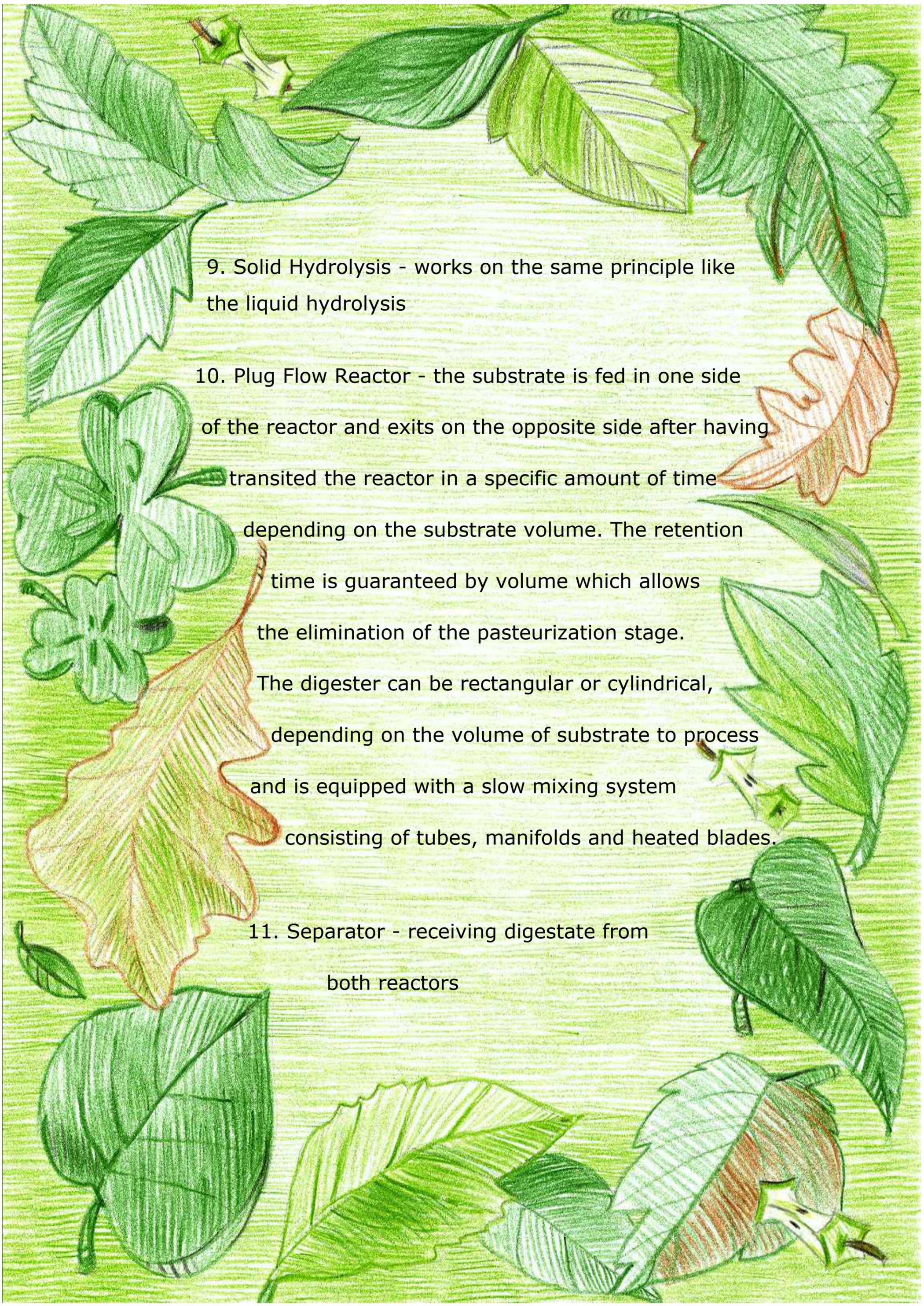


6. Storage for Solid Substrate - it can be either the animal stables or special silos built for storage.

7. Feeding Bunker - a walking floor designed to load heavy substrates. The substrate can be stored here for several days, then sent to the digester in predetermined doses on an automated schedule.

8. Molaes® - a shredding device with a multidirectional hammer-mill. A feeding screw brings the biomass in, allowing a completely automated process. It was designed to shred biomass without the need of a sieve.

This principle allows a great reduction in electricity consumption.



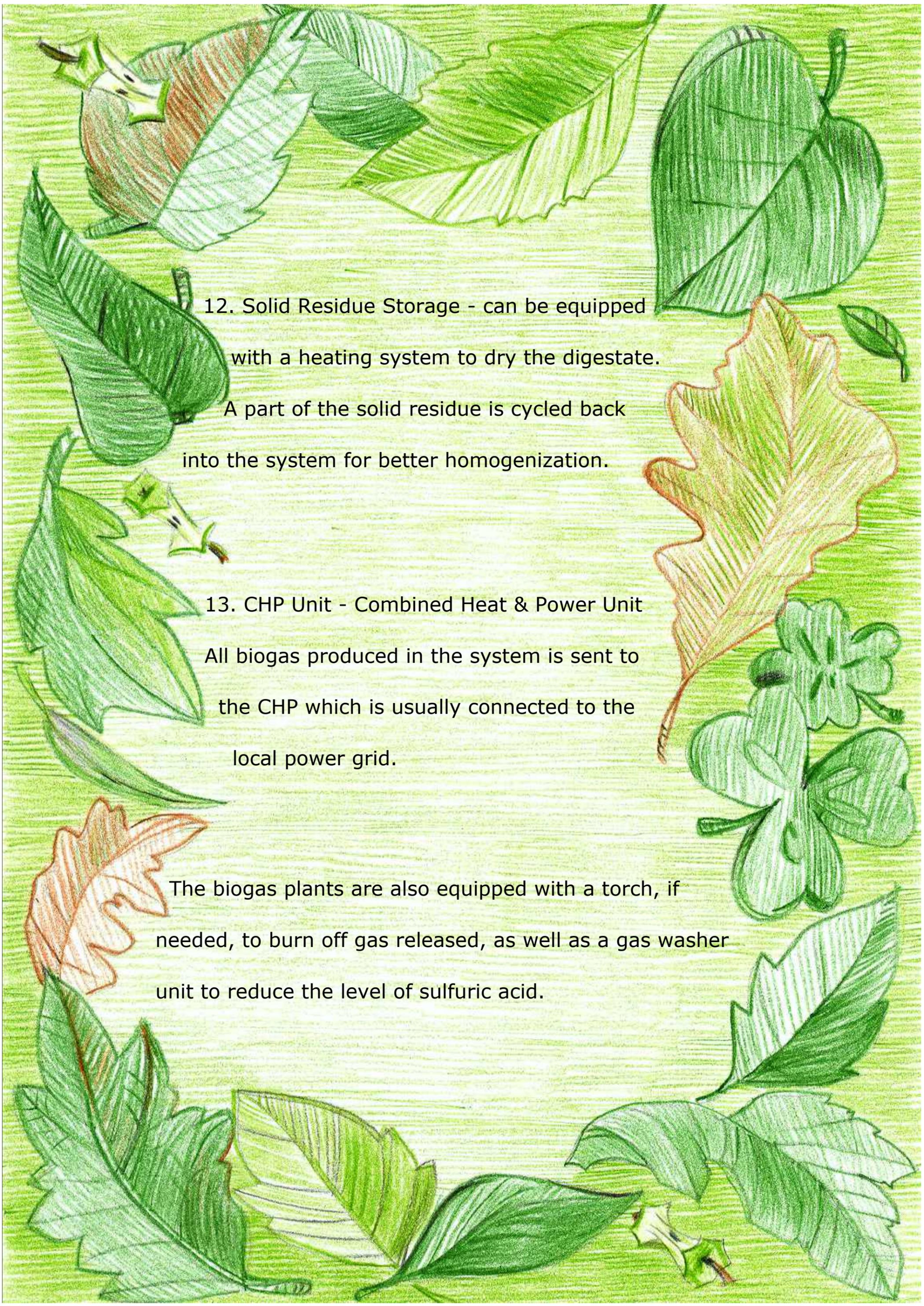
9. Solid Hydrolysis - works on the same principle like the liquid hydrolysis

10. Plug Flow Reactor - the substrate is fed in one side of the reactor and exits on the opposite side after having transited the reactor in a specific amount of time

depending on the substrate volume. The retention time is guaranteed by volume which allows the elimination of the pasteurization stage.

The digester can be rectangular or cylindrical, depending on the volume of substrate to process and is equipped with a slow mixing system consisting of tubes, manifolds and heated blades.

11. Separator - receiving digestate from both reactors



12. Solid Residue Storage - can be equipped with a heating system to dry the digestate.

A part of the solid residue is cycled back into the system for better homogenization.

13. CHP Unit - Combined Heat & Power Unit

All biogas produced in the system is sent to the CHP which is usually connected to the local power grid.

The biogas plants are also equipped with a torch, if needed, to burn off gas released, as well as a gas washer unit to reduce the level of sulfuric acid.



This was our quick journey through the anaerobic digestion industry.

I hope you enjoyed it and you will use this knowledge and awareness to create benefits and profits for you, your employees and your customers.

Do not hesitate to contact me at [Carmen@ThePowerOfBiomass.com](mailto:Carmen@ThePowerOfBiomass.com) for any inquiry about anaerobic digestion systems and projects.

Carmen

Trandafirescu



An illustration of a woman with red hair, wearing a blue top and a red skirt, standing next to a smaller child with red hair, wearing a blue shirt and blue shorts. They are standing on a path made of large green leaves.



## About the Author

Carmen Trandafirescu has been working in the biogas industry for over 10 years, consulting customers on the best technology option for their projects, promoting and selling anaerobic digestion systems in Europe, North America and Asia.

