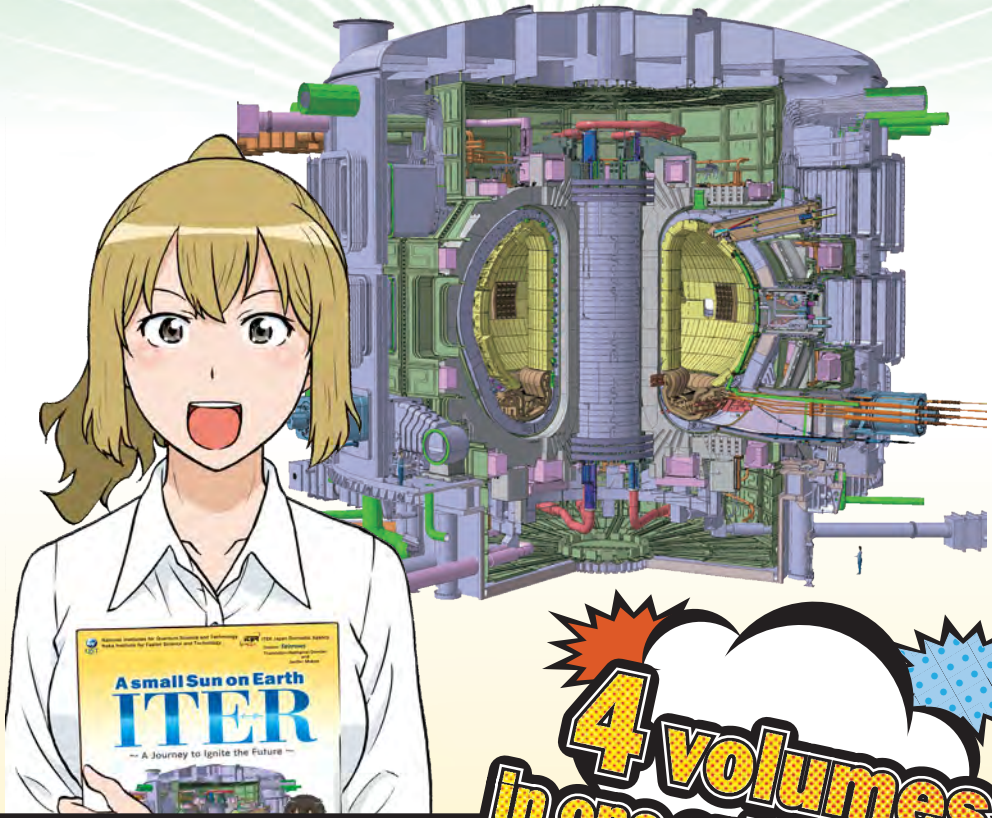
National Institutes for
Quantum Science and Technology
Naka Institute for Fusion Science and Technology

ITER Japan Domestic Agency

A small Sun on Earth

ITER

イーター



4 volumes in one epic omnibus!

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Quantum Science and Technology
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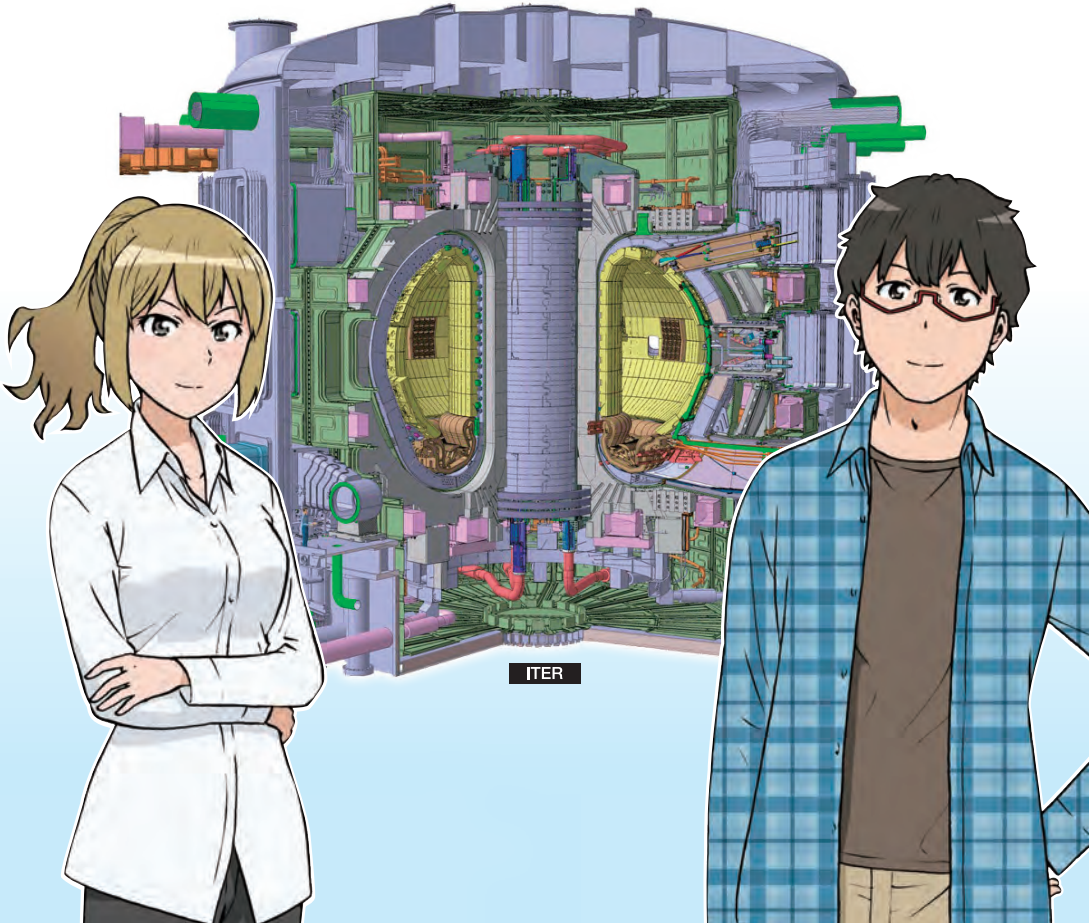
Dessin: Ta'rrows
Translation:Nathaniel Duncan
and
Jenifer Mukae

A small Sun on Earth

ITER (イーター)

～ A Journey to Ignite the Future ～



CHARACTERS

SOLÉANE

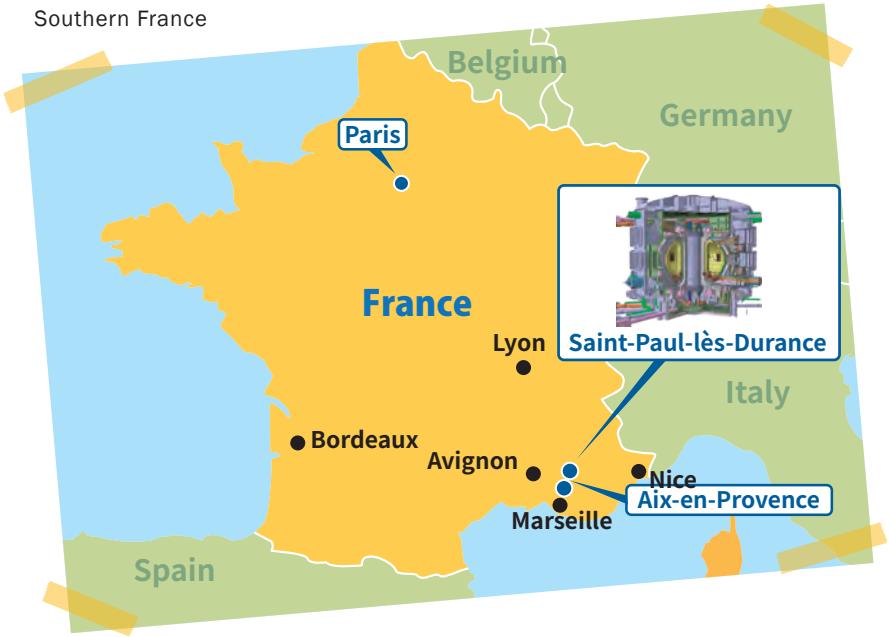
A female researcher studying fusion energy at the ITER Organization in Saint-Paul-lès-Durance, France.

TAIYO TENNO

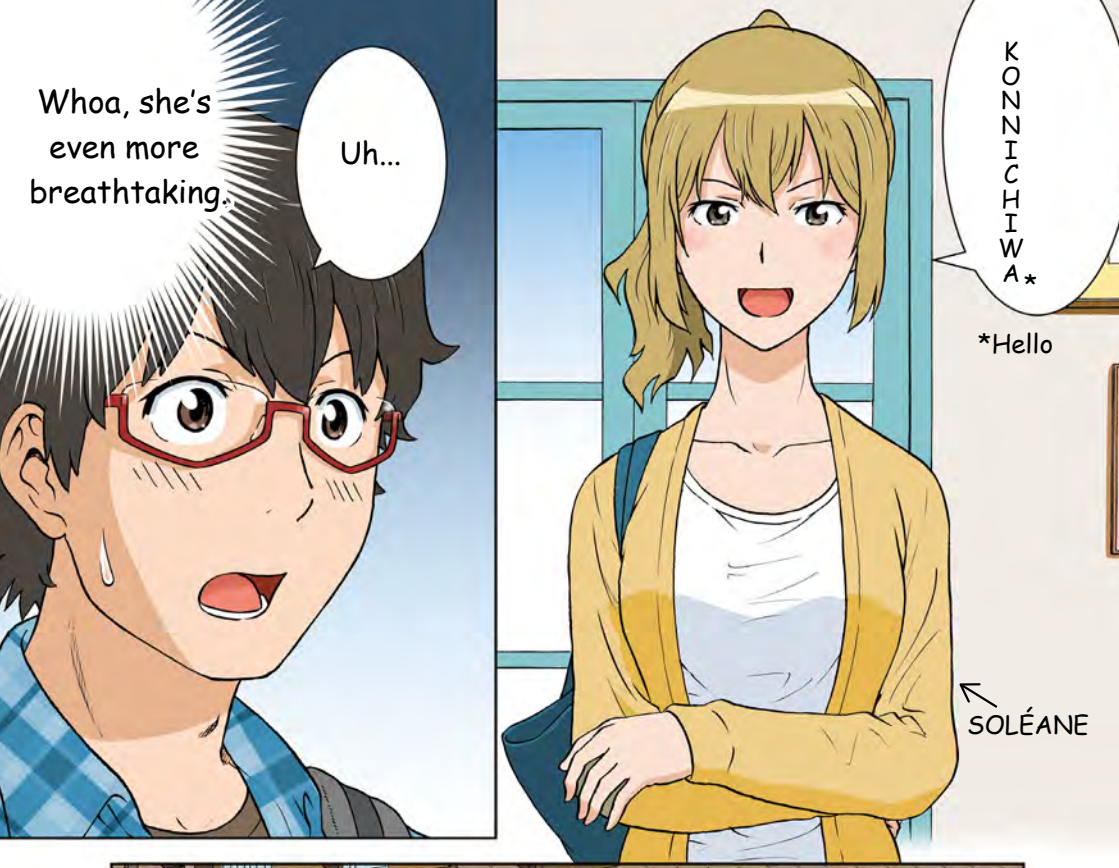
A Japanese art university student who meets SOLÉANE during a trip to France and becomes interested in fusion energy.

Setting of the Story

Saint-Paul-lès-Durance and Aix-en-Provence, Southern France

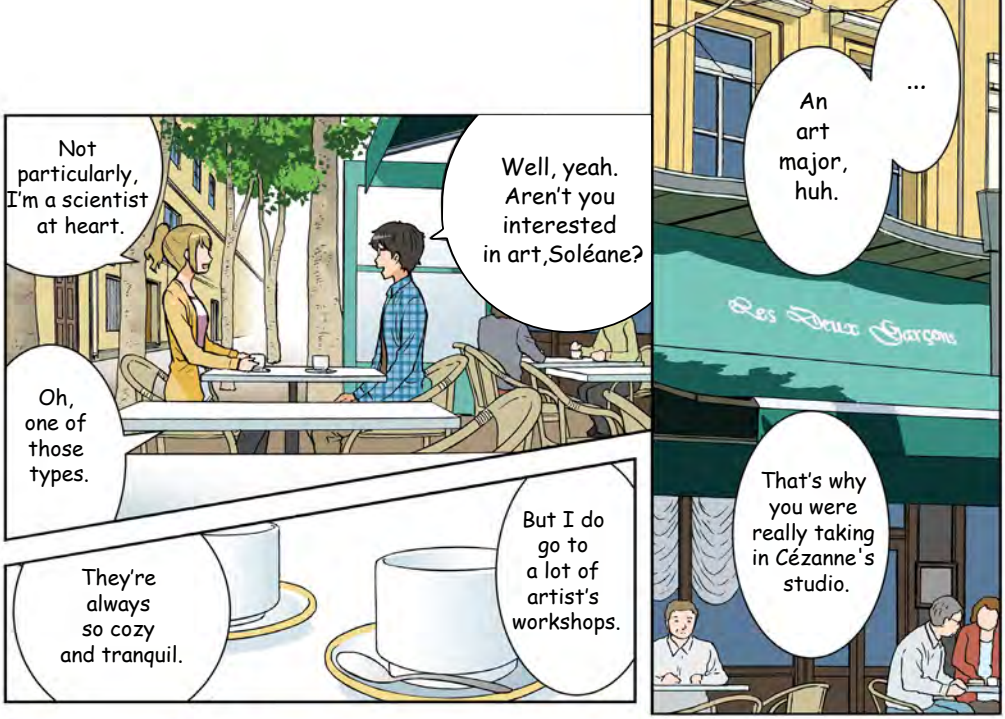



At Paul Cézanne's studio in Aix-en-Provence in the southeast of France…
Truly breathtaking…
Hey,are you from Japan?
You a fan of Cézanne?

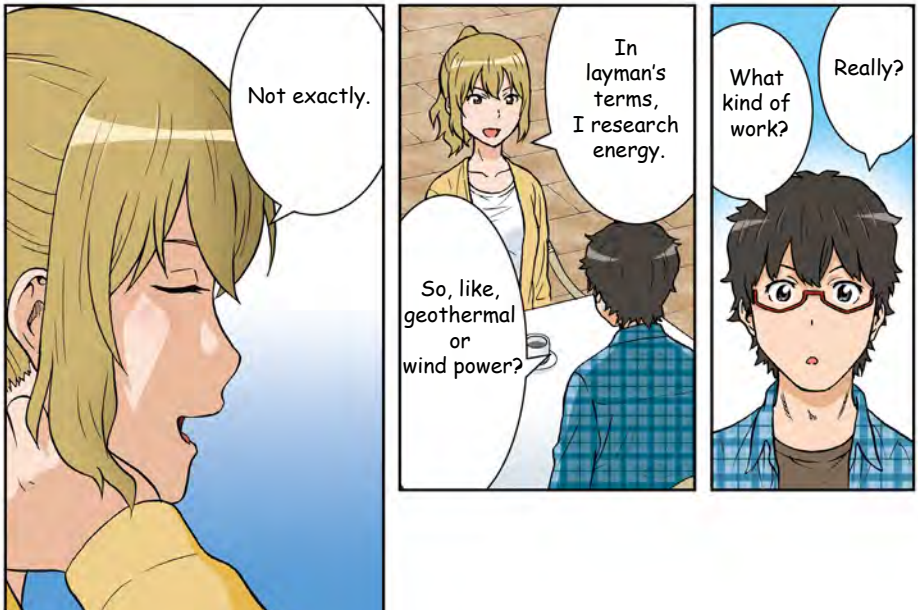

Whoa, she's even more breathtaking.
Uh...
KONNICHIWA*
*Hello
SOLÉANE


I'm an art major on my summer vacation taking a world tour of famous sites.
My name's TAIYO.


Aix-en-Provence was my next stop to see where the father of Post-Impressionism worked.
TEEHEE
ニコッ


...
An art major, huh.
Les Deux Garçons
That's why you were really taking in Cézanne's studio.
Well, yeah. Aren't you interested in art,Soléane?
Not particularly, I'm a scientist at heart.
Oh, one of those types.
But I do go to a lot of artist's workshops.
They're always so cozy and tranquil.


Where did you learn to speak Japanese?
Well,
My work has some deep connections with Japan.


Not exactly.
In layman's terms, I research energy.
So, like, geothermal or wind power?
Really?
What kind of work?

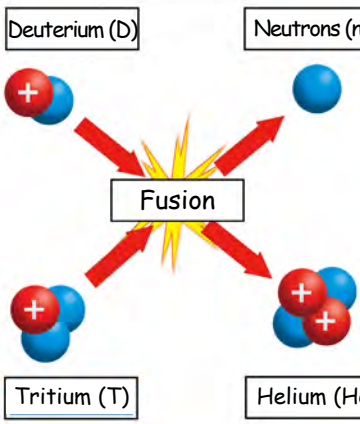

I research something more… futuristic.
?
That sun in the sky …
Essentially, we're trying to build it here on Earth.
The sun… on Earth!?
Yep! Well,
we're trying to recreate the "mechanism" the sun uses to produce energy.
Most people think that the sun is hot and bright because it's burning…
But it's not actually on fire.

Nuclear… fusion?

NUCLEAR FUSION!

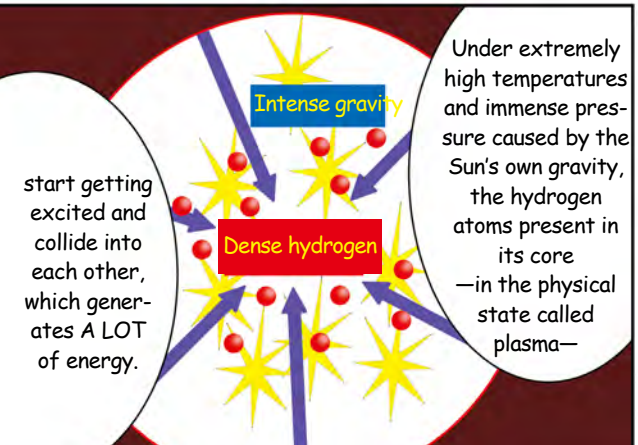
So, if it's not on fire, how does the sun keep on shining?

The sun gets its energy by smashing small light elements together to make heavier elements in a process called nuclear fusion.



Put simply,

*The figure above depicts the reaction that would occur on Earth. In the Sun, a proton-proton chain reaction occurs.



start getting excited and collide into each other, which generates A LOT of energy.

Under extremely high temperatures and immense pressure caused by the Sun's own gravity, the hydrogen atoms present in its core —in the physical state called plasma—

The loss of a small amount of mass when forming these heavier elements produces a tremendous amount of energy.

Energy generated

Speed of light

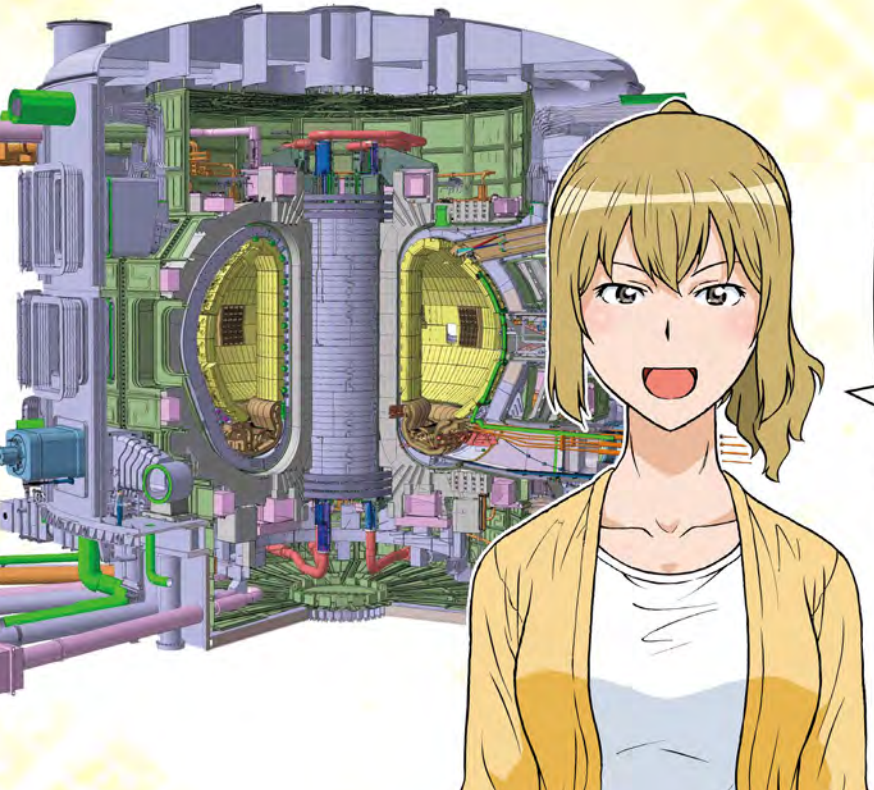
$E=mc^2$

Mass lost

That's why the sun has continued to shine for as long as it has.

That is what I and people from all over the world are working on for the global energy research project called…

To replicate the same principle that powers fusion in the Sun, except in a more controlled way on Earth.

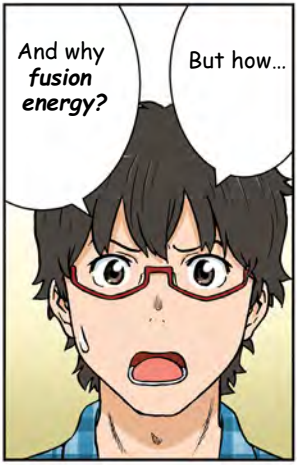


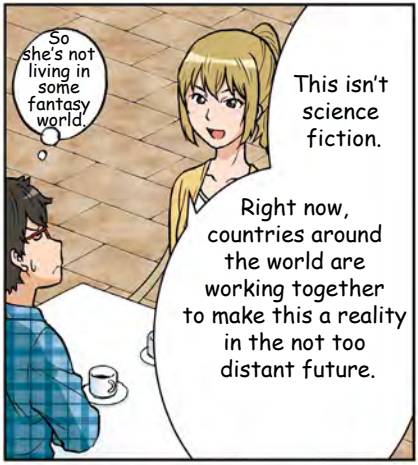
ITER

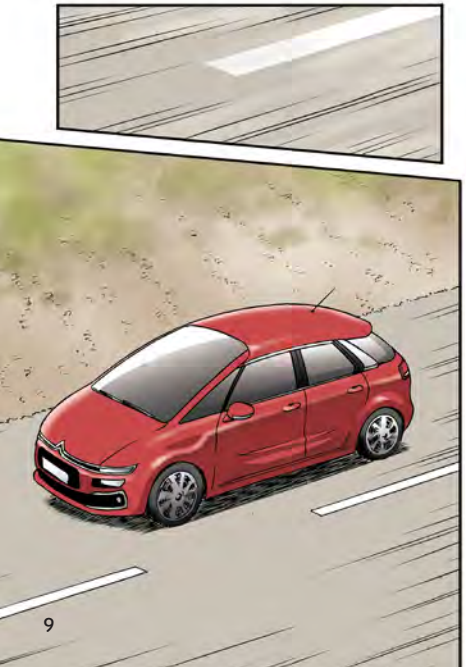
-An international project for the realization of Fusion Energy.


A sun on earth? What is she on about? Like that could actually happen.
Is she an alchemist?
The ITER... project?


Piqued your interest, have I?


And why ***fusion energy?***
But how...

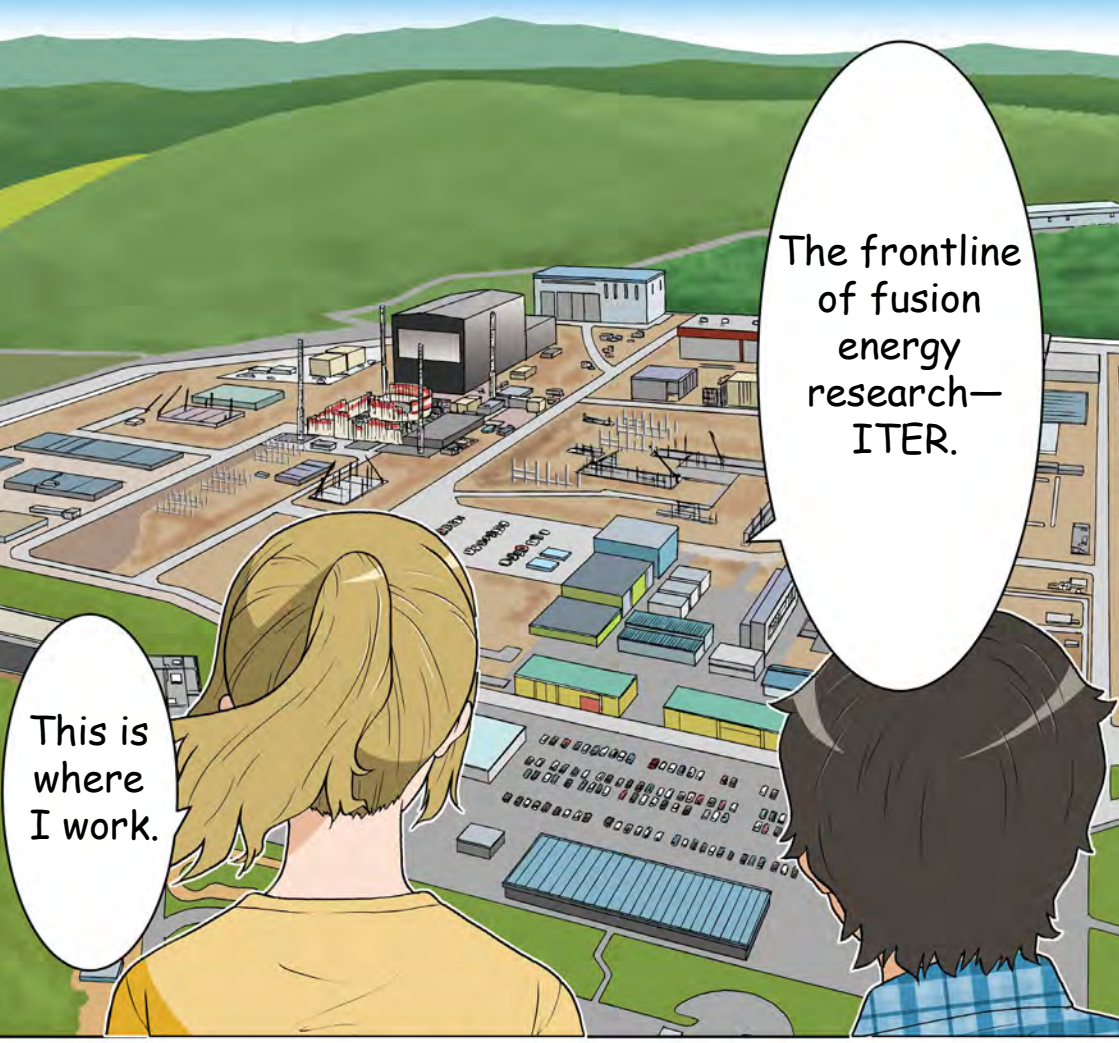

So she's not living in some fantasy world.
This isn't science fiction.
Right now, countries around the world are working together to make this a reality in the not too distant future.



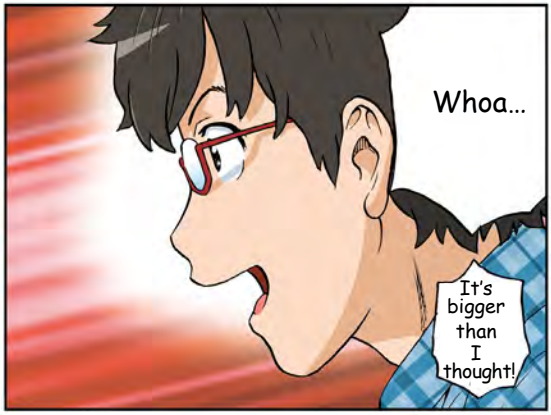

You bet!

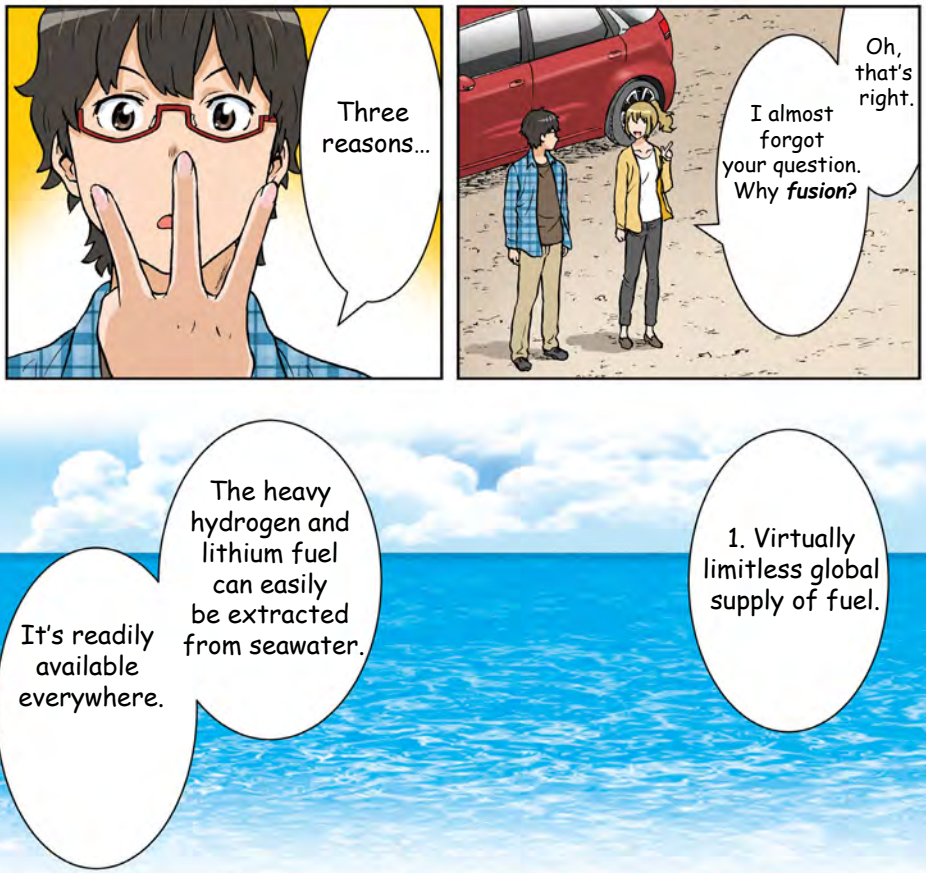

If you're free, wanna come check out the ITER site?
It's only about an hour's drive.
Uh...

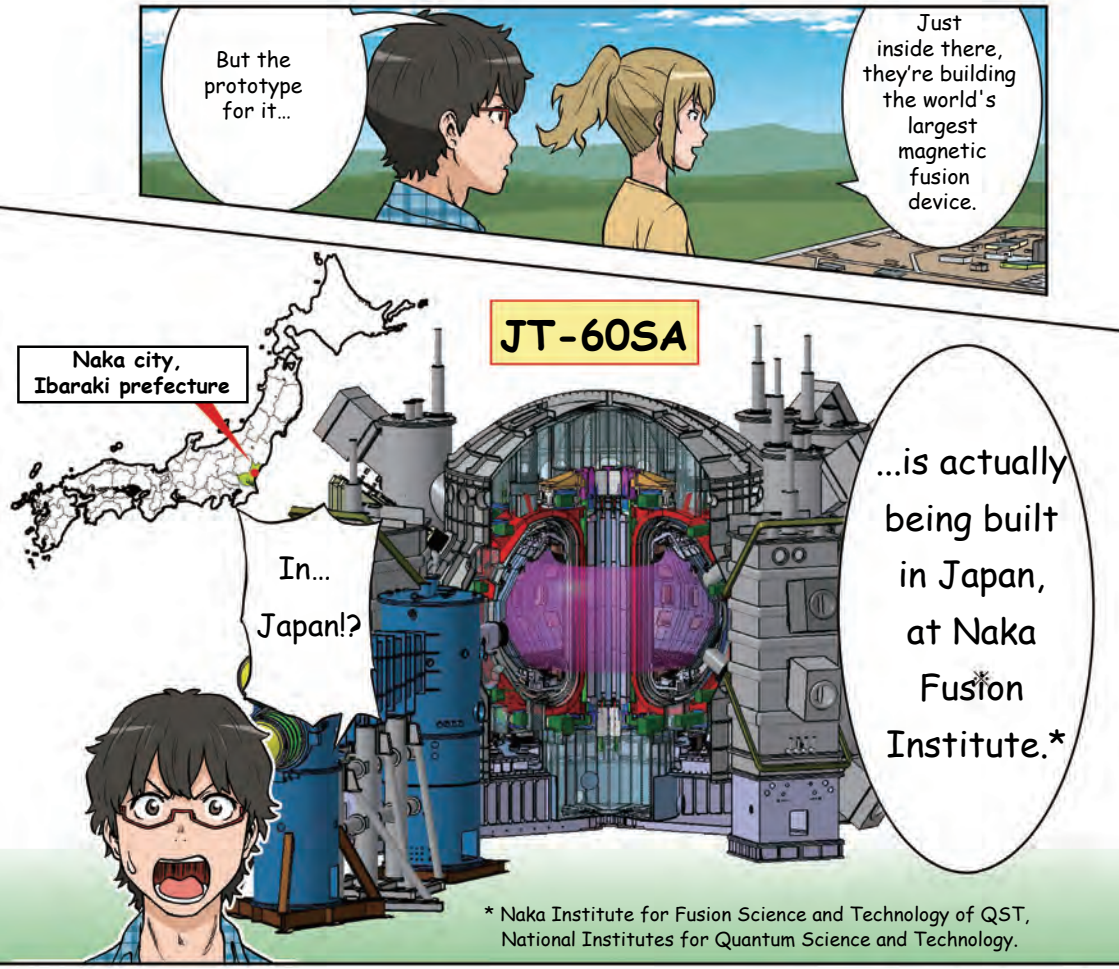

Humans have always used and revered the sun.
But it wasn't until the early 20th century that we found out why it glows.
And to think that now a renewable source of energy
is within our grasp by creating a sun on earth.
screech
Oil, coal, and uranium are all limited resources.
Something is going to have to take their place eventually, and fusion is a viable alternative.
The future aspirations of humanity lie here,
where the feasibility of fusion energy will come to fruition.
Wha...!?

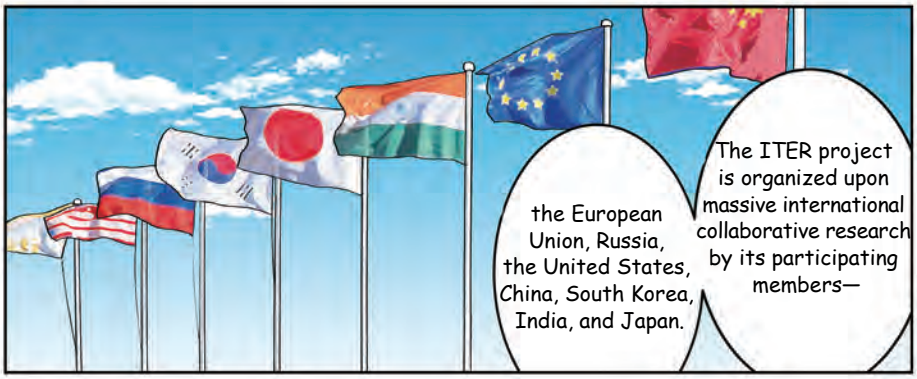

The frontline of fusion energy research—ITER.
This is where I work.

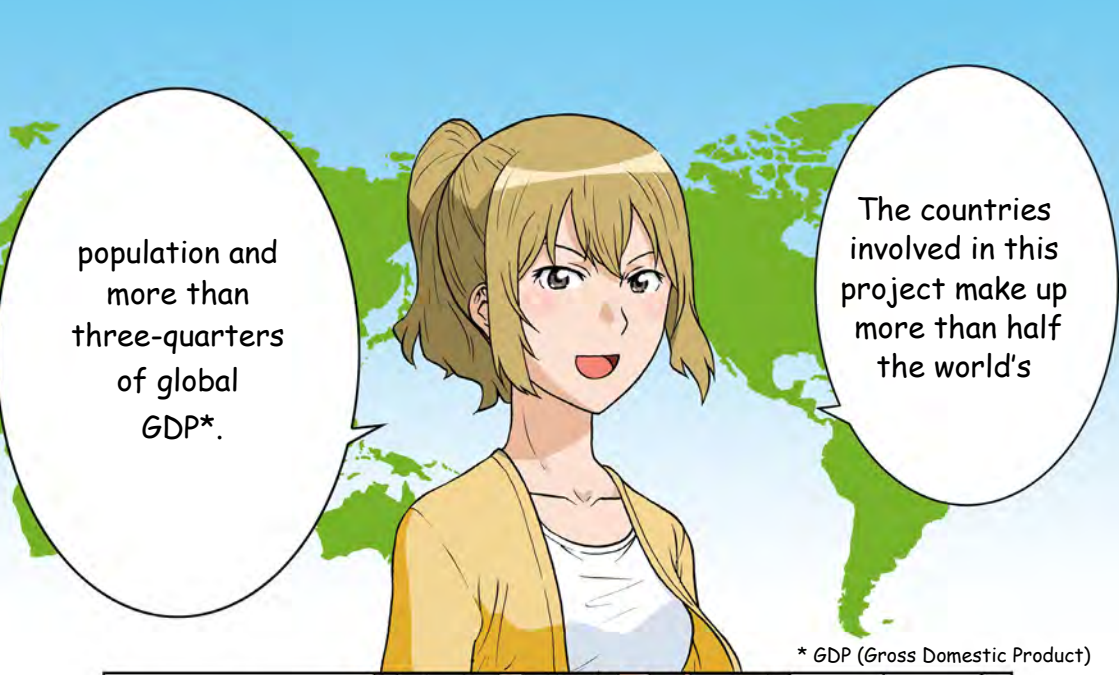

A lot of Japanese researchers work here, too.


Whoa...
It's bigger than I thought!

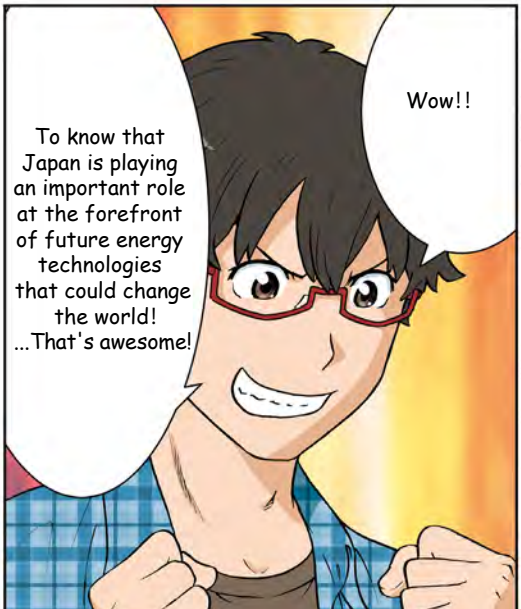

Three reasons...
Oh, that's right.
I almost forgot your question. Why *fusion*?
1. Virtually limitless global supply of fuel.
The heavy hydrogen and lithium fuel can easily be extracted from seawater.
It's readily available everywhere.
A safe and stable energy source that's good for the environment...
2. Only a small amount of fuel is required to produce an enormous amount of energy.
3. It's a guaranteed safe source of energy and environmentally friendly.

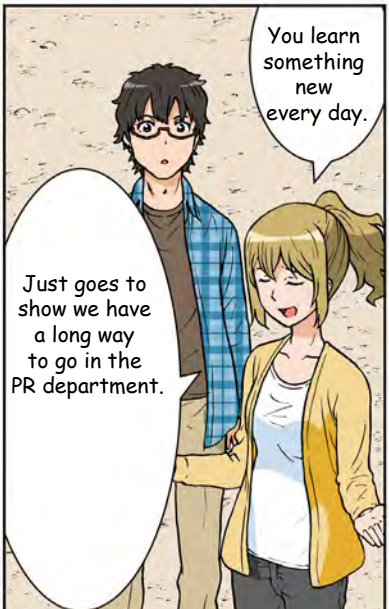

But the prototype for it…
Just inside there, they're building the world's largest magnetic fusion device.
Naka city, Ibaraki prefecture
JT-60SA
In… Japan!?
…is actually being built in Japan, at Naka Fusion Institute.*
* Naka Institute for Fusion Science and Technology of QST, National Institutes for Quantum Science and Technology.

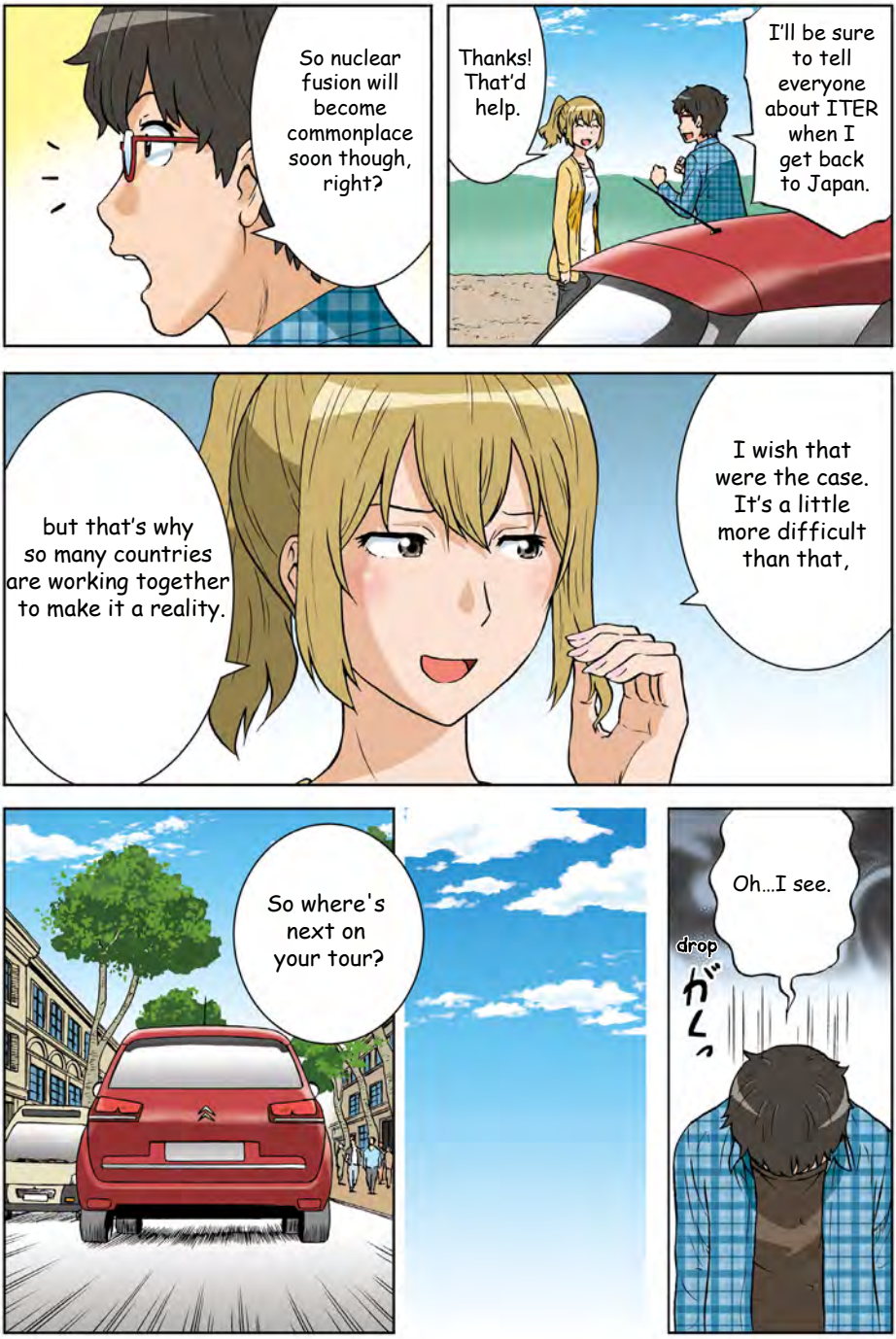

the European Union, Russia, the United States, China, South Korea, India, and Japan.
The ITER project is organized upon massive international collaborative research by its participating members—

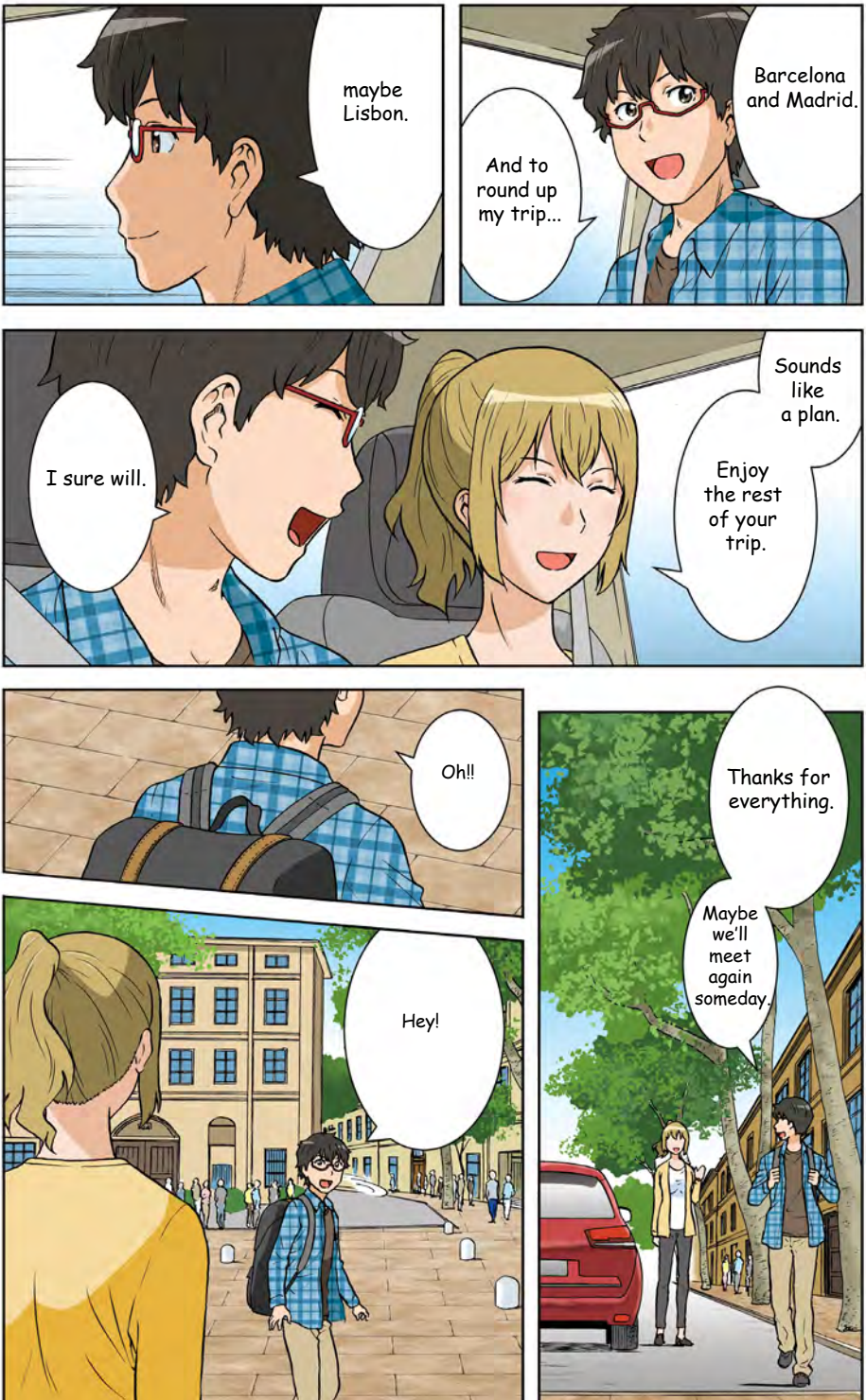


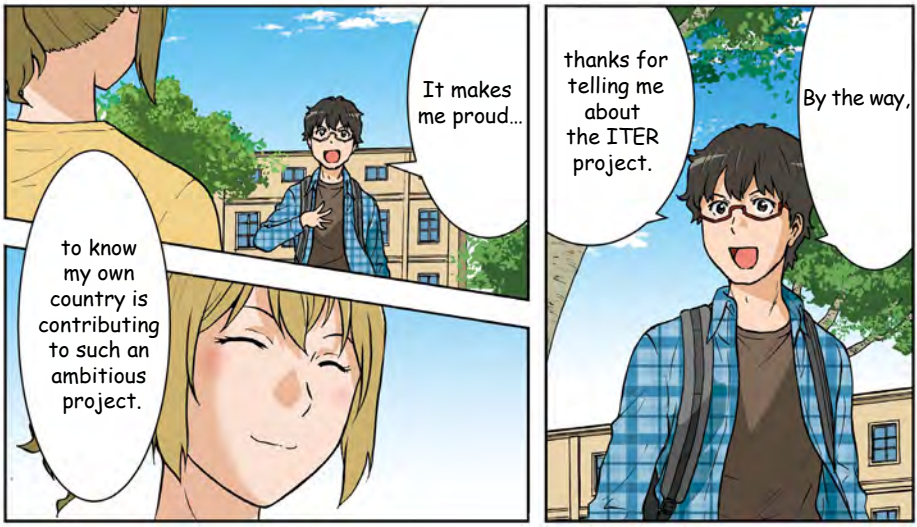
* GDP (Gross Domestic Product)

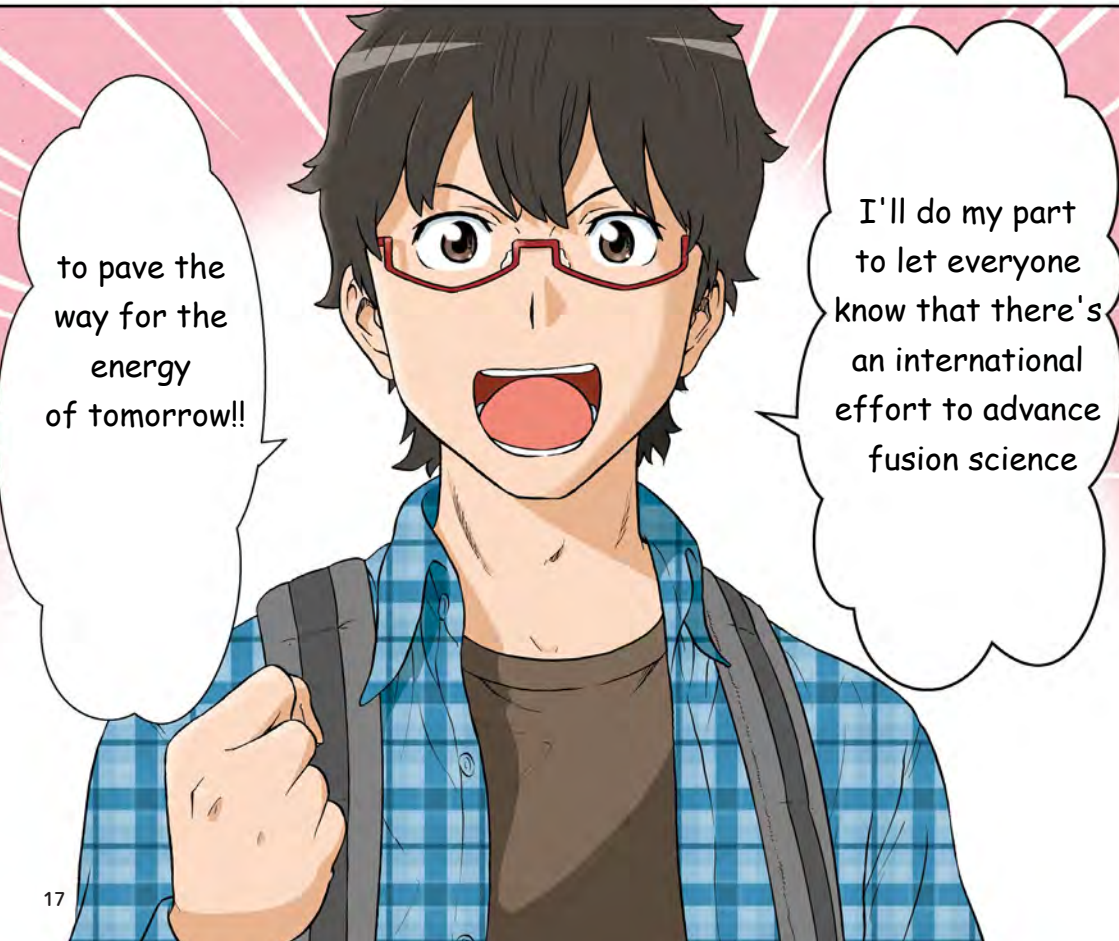





So nuclear fusion will become commonplace soon though, right?
Thanks! That'd help.
I'll be sure to tell everyone about ITER when I get back to Japan.
but that's why so many countries are working together to make it a reality.
I wish that were the case. It's a little more difficult than that,
So where's next on your tour?
Oh…I see.
drop
ガくっ


maybe Lisbon.
Barcelona and Madrid.
And to round up my trip...
Sounds like a plan.
I sure will.
Enjoy the rest of your trip.
Oh!!
Thanks for everything.
Maybe we'll meet again someday.
Hey!


It makes me proud...
to know my own country is contributing to such an ambitious project.
By the way,
thanks for telling me about the ITER project.


I'll do my part to let everyone know that there's an international effort to advance fusion science
to pave the way for the energy of tomorrow!!

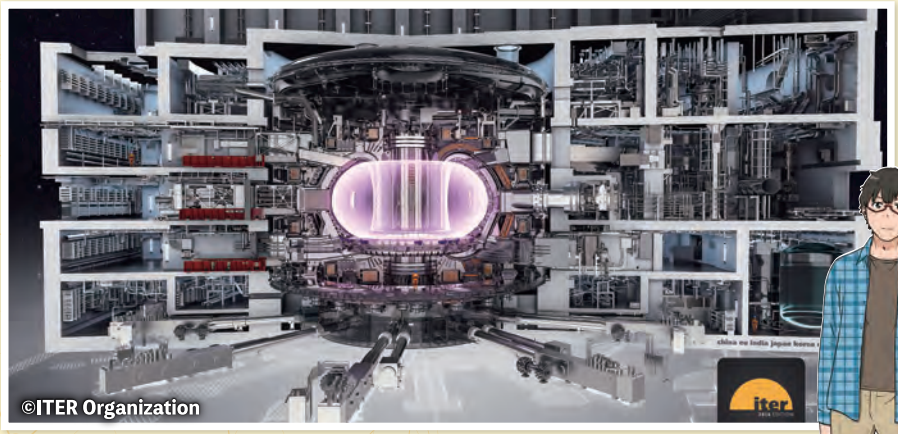
ITER Site in Southern France

Saint-Paul-lès-Durance

ITER Organization Website

The ITER Organization (International Thermonuclear Experimental Reactor Organization) is an international body established in 2007 to carry out the ITER Project—an initiative aimed at realizing fusion energy. It is a collaborative effort among the seven ITER members: Japan, the European Union, the United States, Russia, China, South Korea, and India.

The ITER Project involves the construction of the ITER fusion experimental reactor in Saint-Paul-lès-Durance, southern France. This facility will be used to conduct scientific and technological research to demonstrate the feasibility of fusion energy as a sustainable energy source.



The Three Main Objectives of ITER

1. To achieve a fusion reaction, specifically a burning plasma, which yields a ten-fold return on energy (Q=10) for approximately 400 seconds.
2. To test and validate the technologies and engineering solutions necessary for a future fusion power plant.
3. To test extracting heat from fusion-generated energy and conduct experiments on tritium breeding for fuel self-sufficiency.

National Institutes for
Quantum and Radiological Science and Technology
Naka Fusion Institute

ITER Japan Domestic Agency

A small Sun on Earth

ITER (イーター)

～ The Spirit of Monozukuri and the Way to ITER～

CHARACTERS

TAIYO TENNO

An art major in the thick of job hunting. He became drawn to ITER after his chance encounter with Soléane in France. He previously completed an internship at ITER in Volume 2.

SOLÉANE

A French researcher working at ITER in Saint-Paul-les-Durance. Currently lives in Aix-en-Provence.
She was the one who initially got Taiyo interested in ITER.

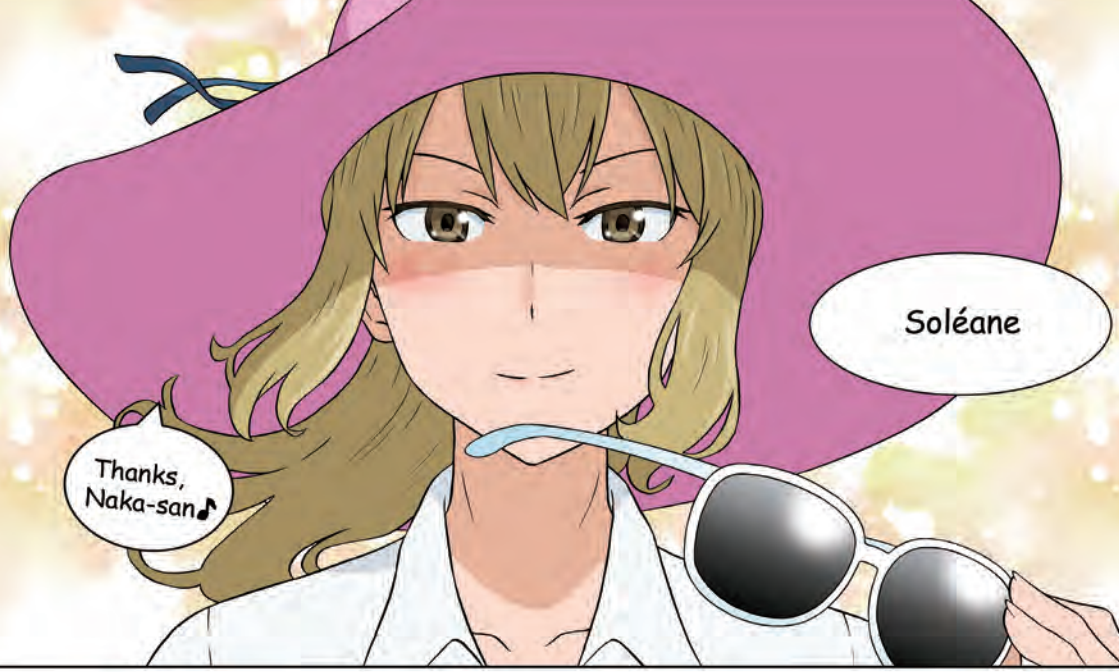
HAYATO NAKA

Employee of the Japanese domestic agency for the ITER Project, QST (National Institutes for Quantum and Radiological Science and Technology).

KOSEI HIGASHIDE

The head engineer for the toroidal field (TF) coils, which generate the magnetic field required to confine plasma in order to produce nuclear fusion. He takes great pride in his work.


roll
roll
whoooooosh
Phew, this heat is on a whole other level than the Mediterranean.
Hop in!
Welcome to Japan!

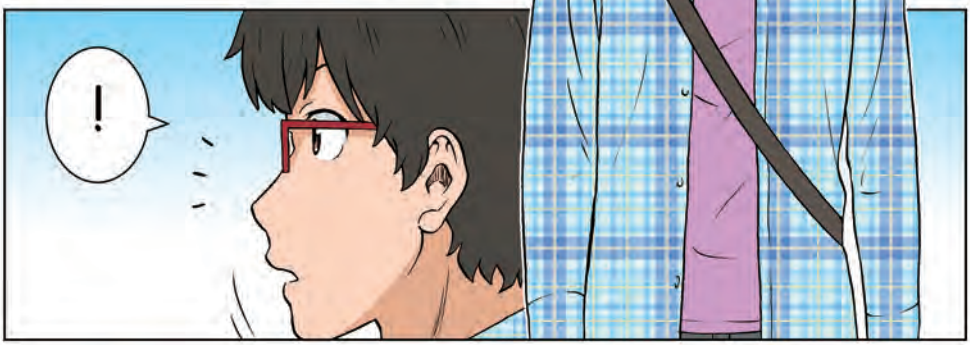

Soléane
Thanks, Naka-san♪

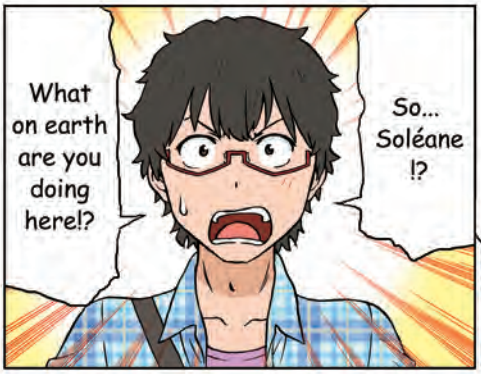

vroom
Mind if we take a little detour first?

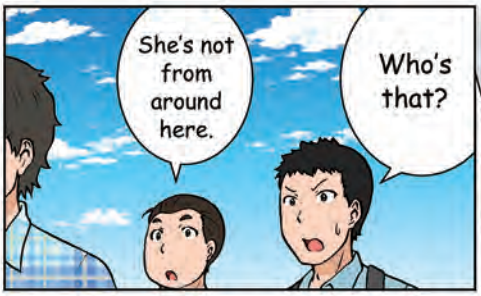

You're the best.

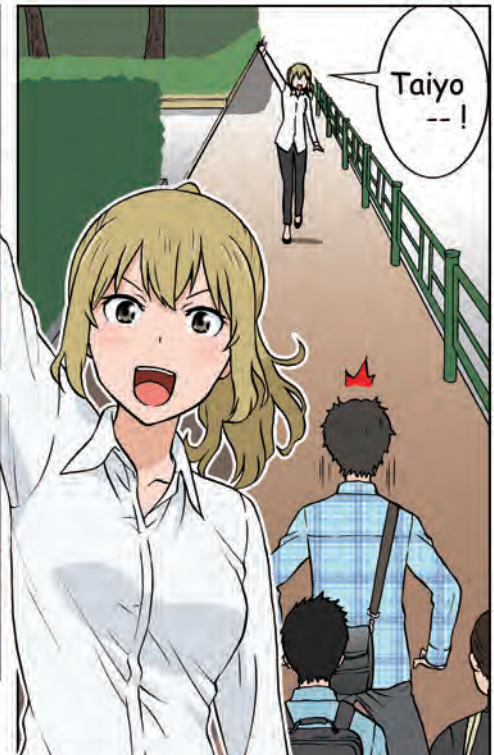

Gotta go see about that guy, huh?
For you, sure thing.
QST employee (National Institutes for Quantum and Radiological Science and Technology)

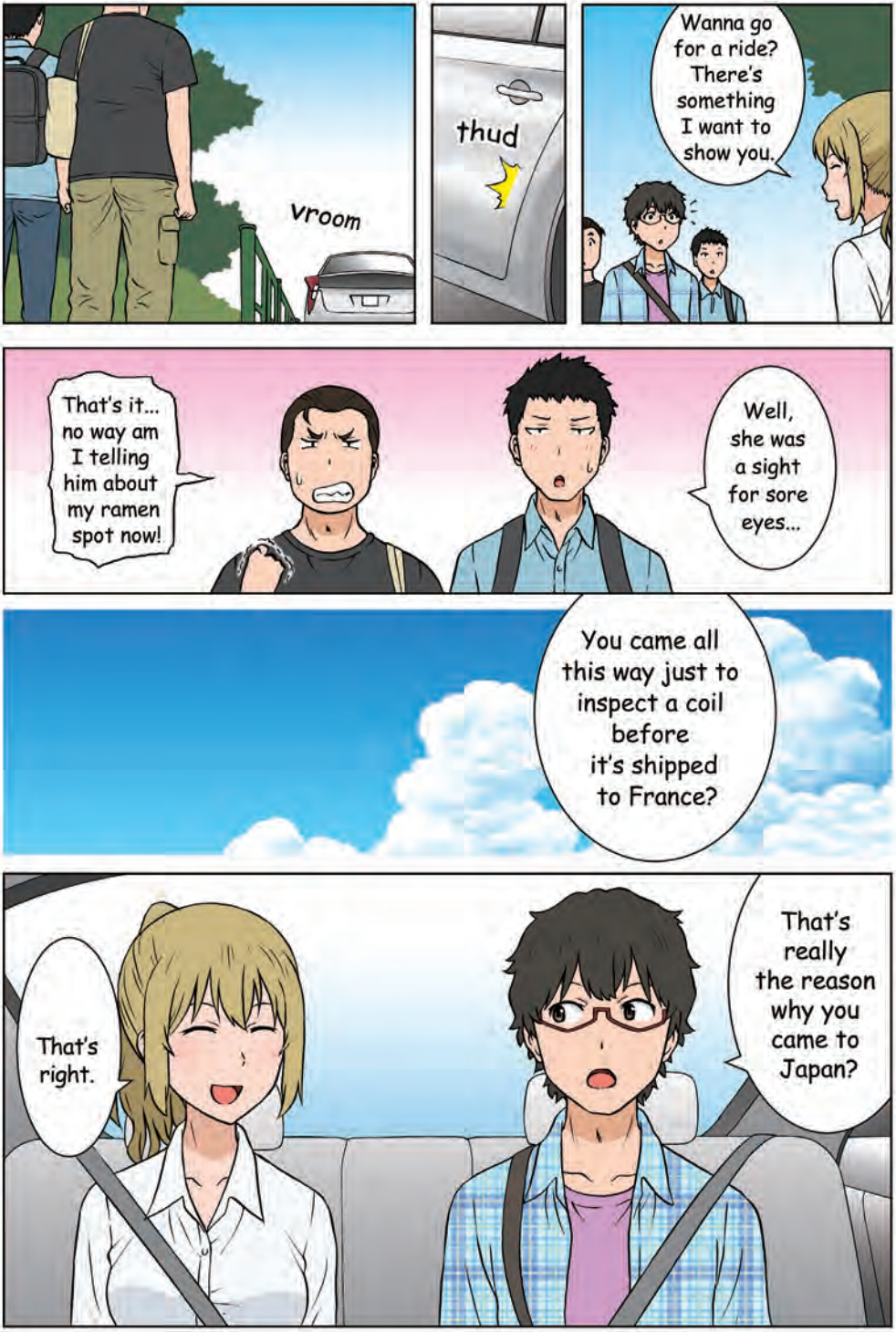

I found this awesome ramen joint!
Hey, Taiyo! Wanna go grab a bite?
Man is it hot ...
Ramen!? In this heat?

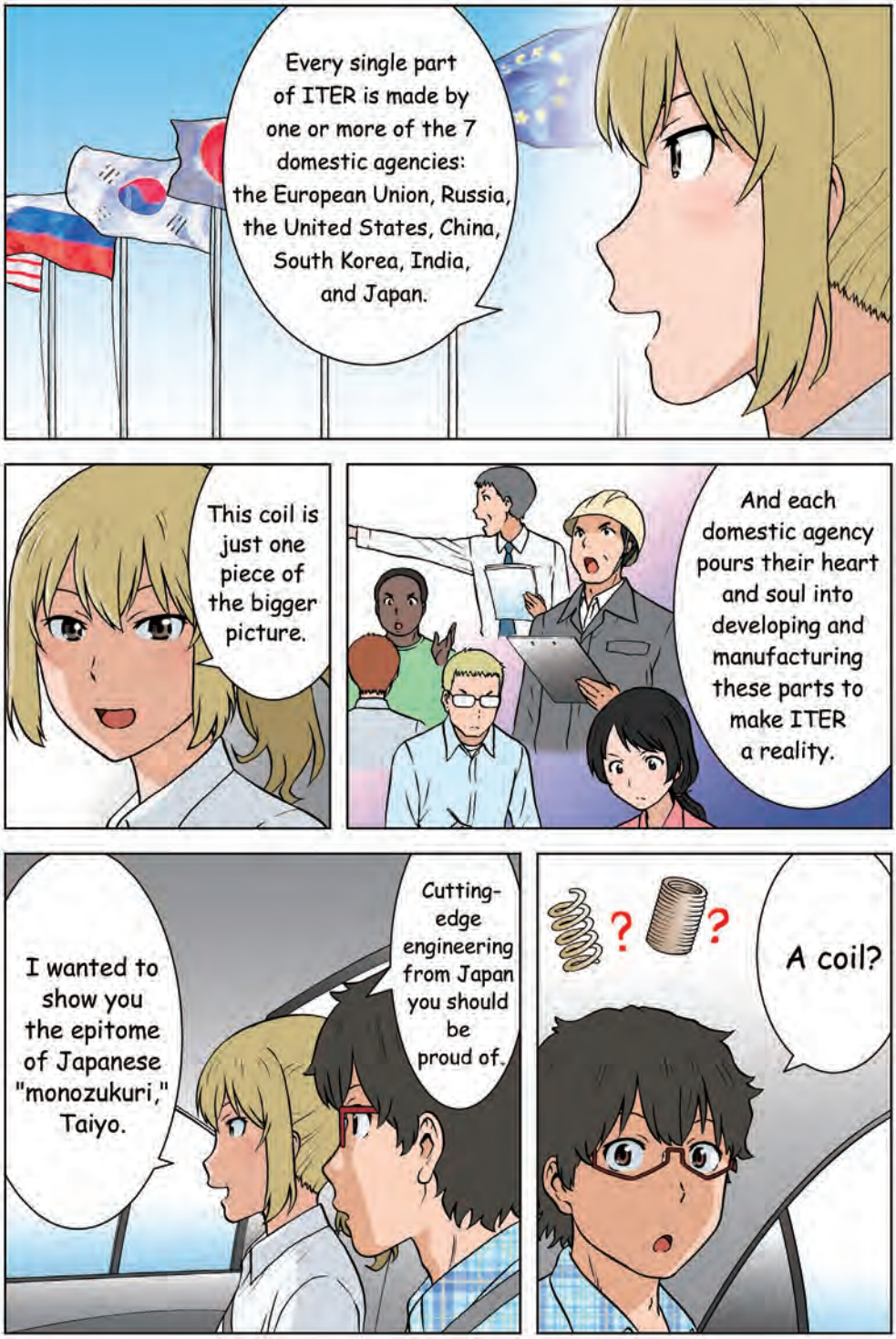

!


What on earth are you doing here!?
So... Soléane !?

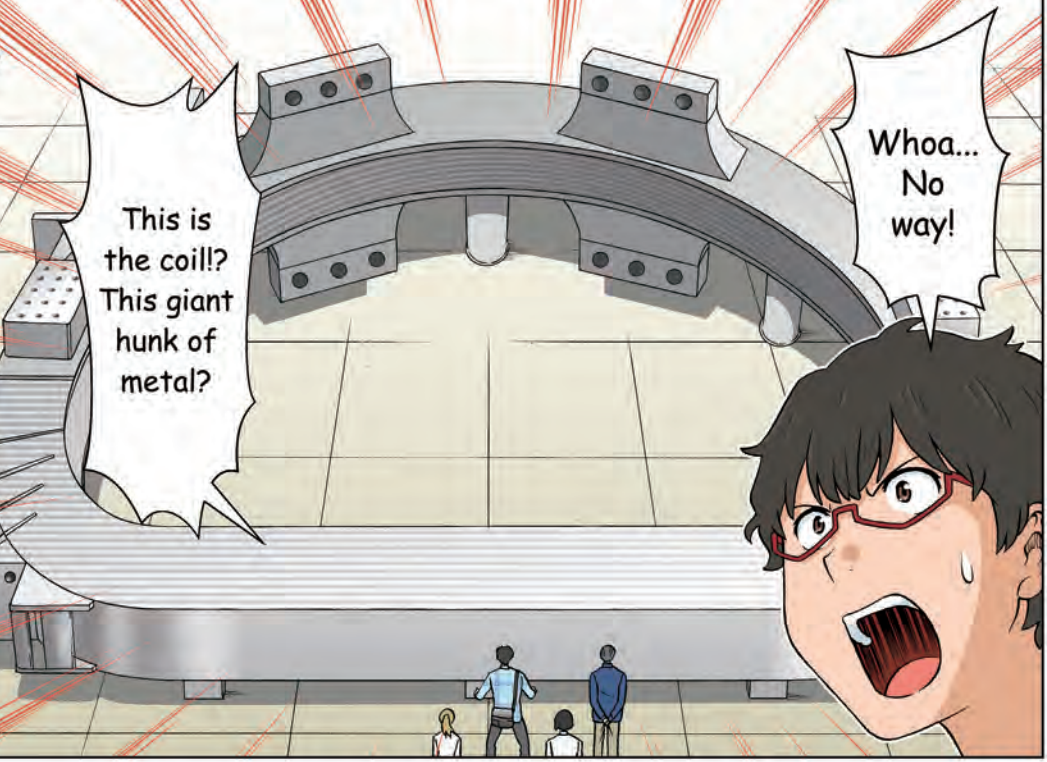

She's not from around here.
Who's that?

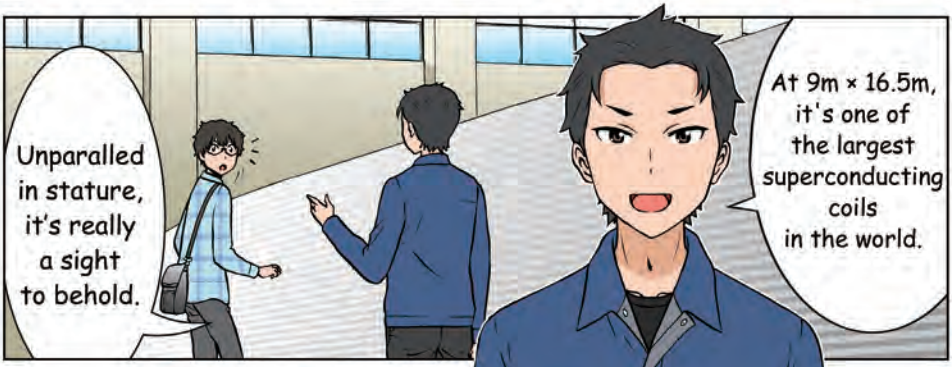

Taiyo -- !

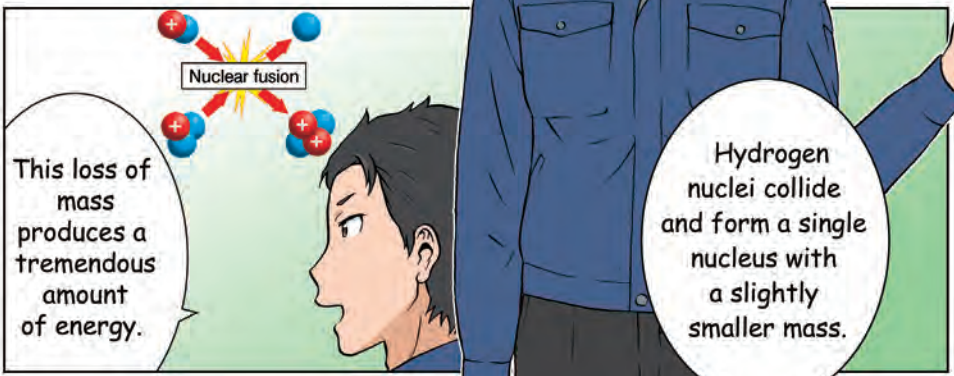

vroom
thud
Wanna go for a ride? There's something I want to show you.
That's it... no way am I telling him about my ramen spot now!
Well, she was a sight for sore eyes...
You came all this way just to inspect a coil before it's shipped to France?
That's right.
That's really the reason why you came to Japan?

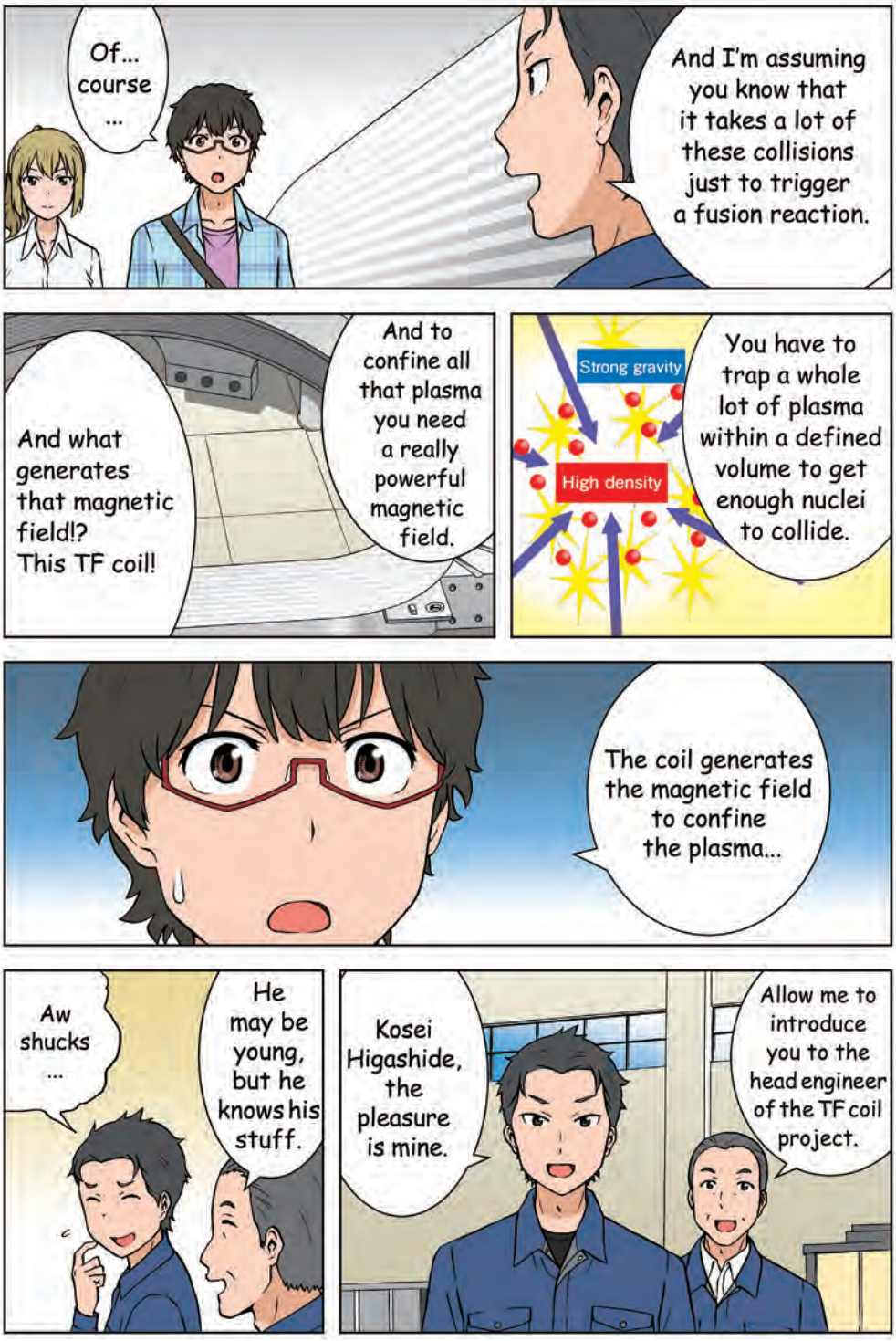

Every single part of ITER is made by one or more of the 7 domestic agencies: the European Union, Russia, the United States, China, South Korea, India, and Japan.
This coil is just one piece of the bigger picture.
And each domestic agency pours their heart and soul into developing and manufacturing these parts to make ITER a reality.
I wanted to show you the epitome of Japanese "monozukuri," Taiyo.
Cutting-edge engineering from Japan you should be proud of.
? ?
A coil?

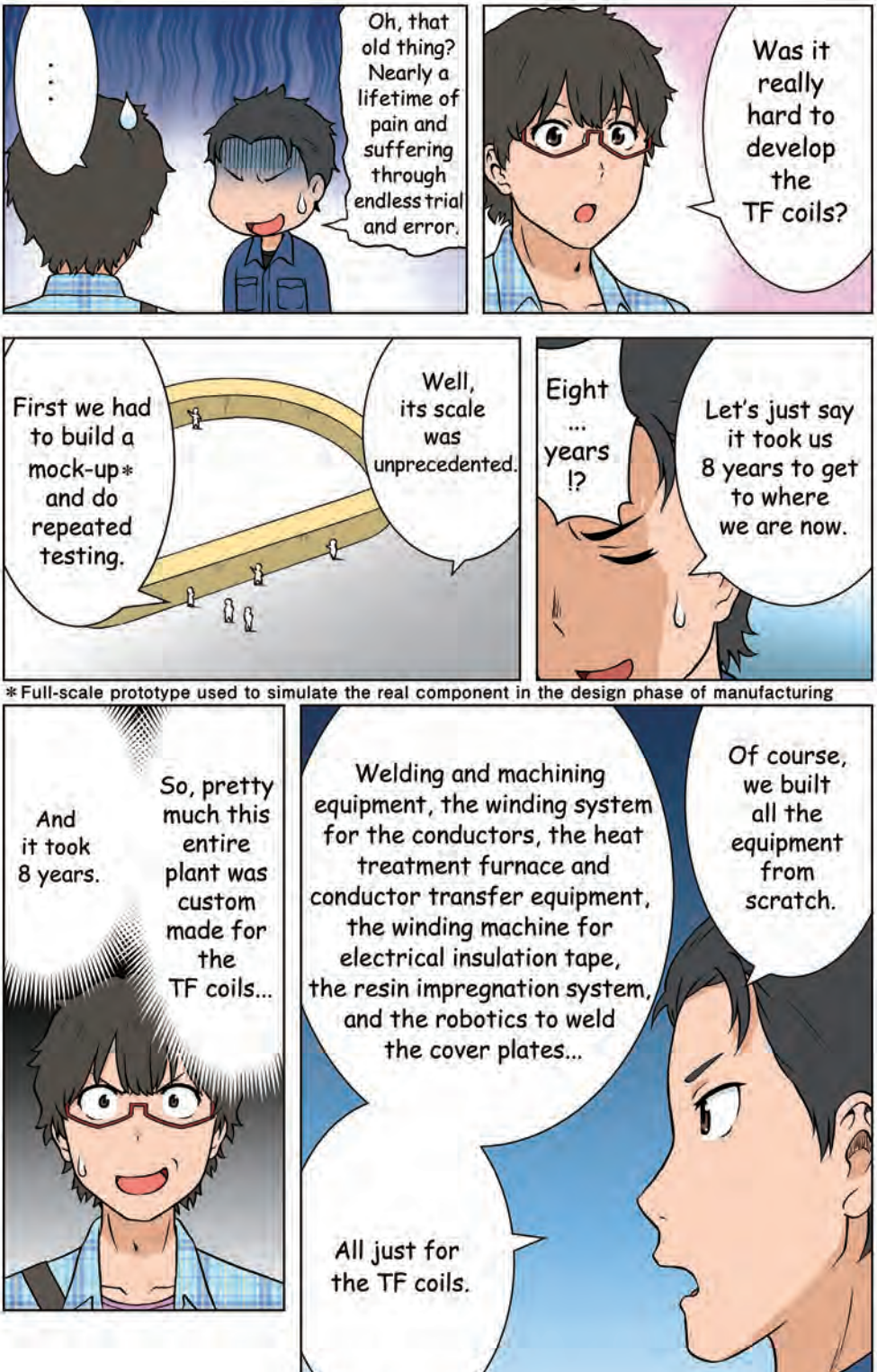

of monozukuri ...
screech
The epitome...
And Taiyo, was it?
Soléane -san, Naka -san
Welcome to the toroidal field (TF) coil manufacturing plant.
!
Come on in.

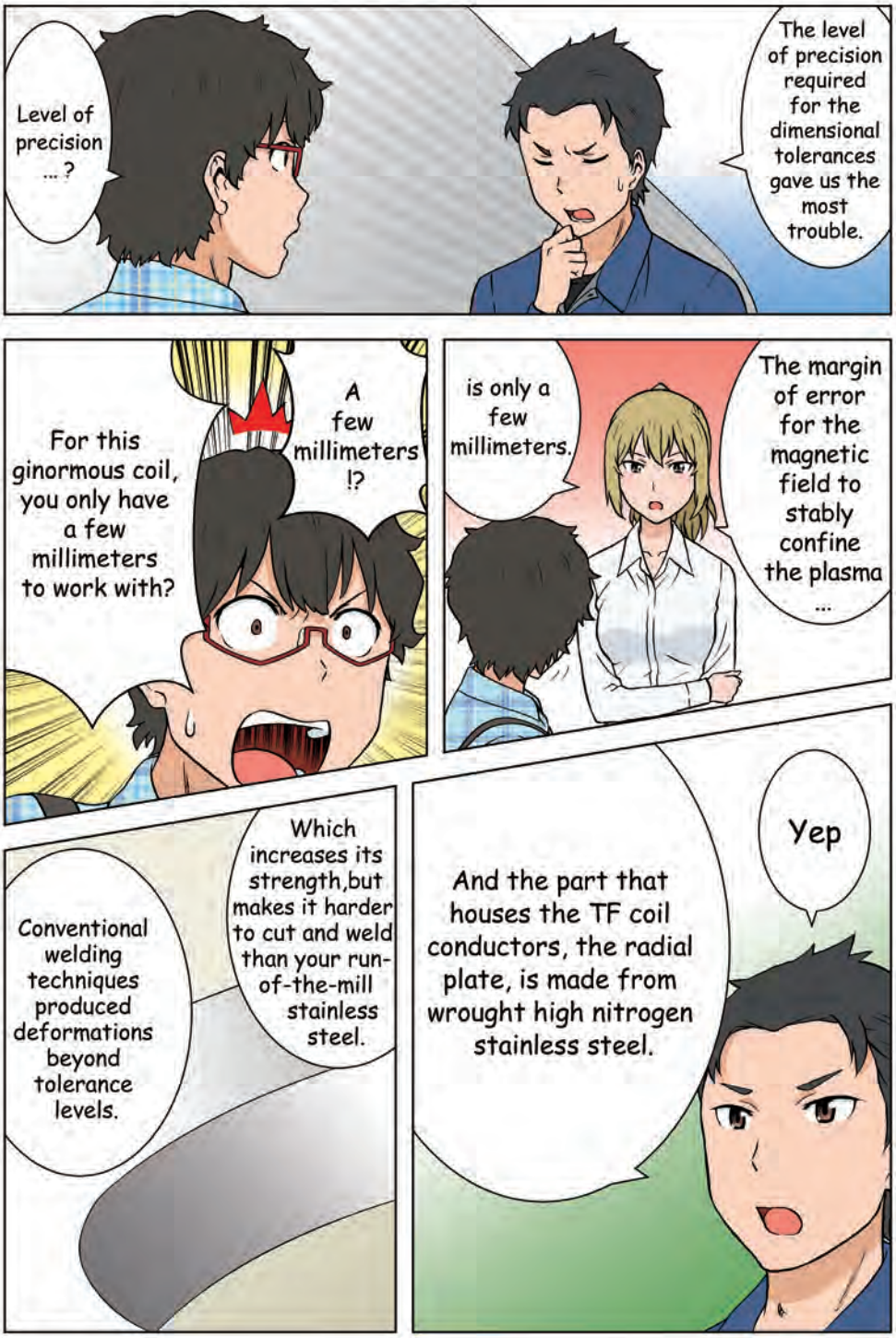

This is the coil!? This giant hunk of metal?
Whoa... No way!

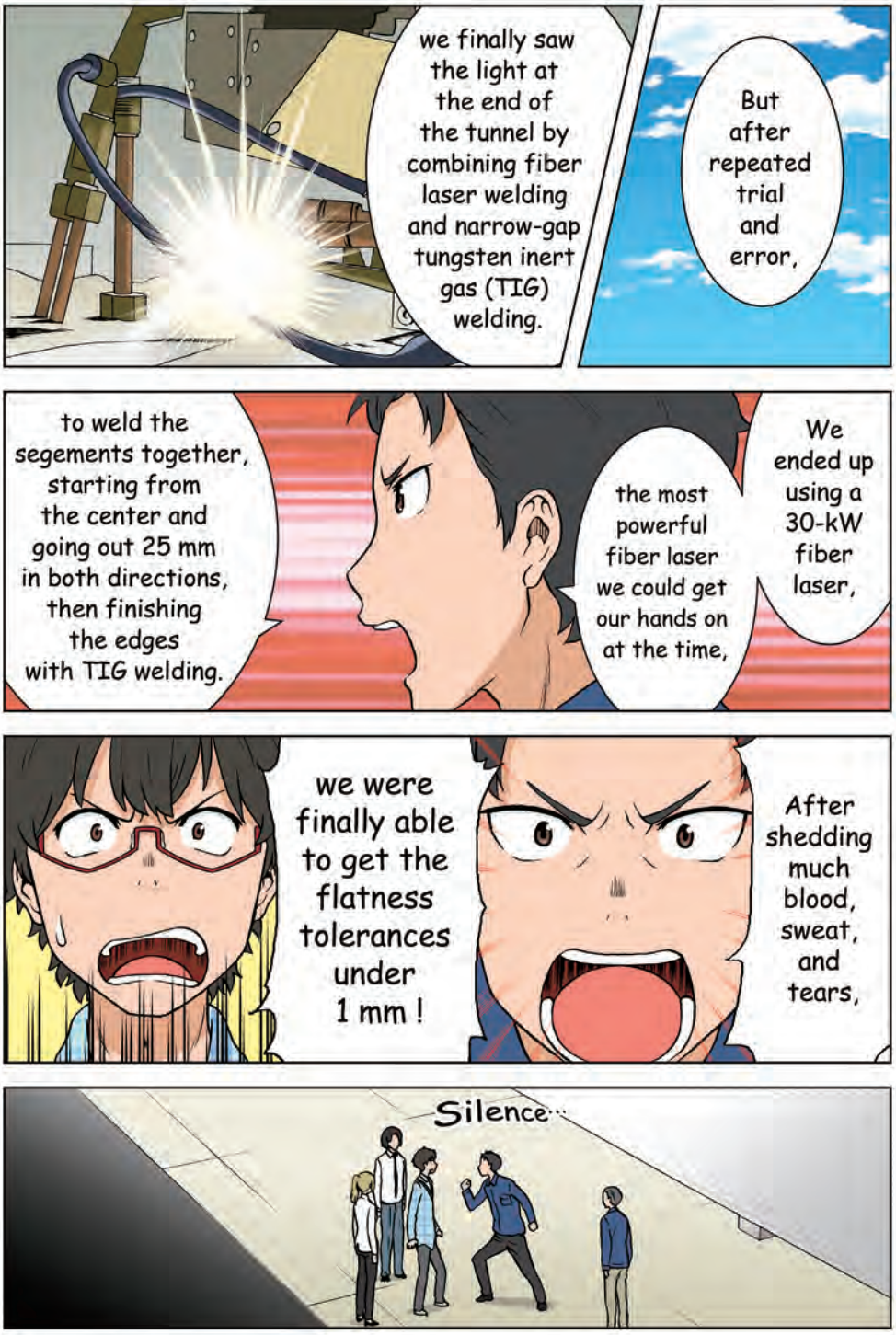

Unparalled in stature, it's really a sight to behold.
At 9m × 16.5m, it's one of the largest superconducting coils in the world.

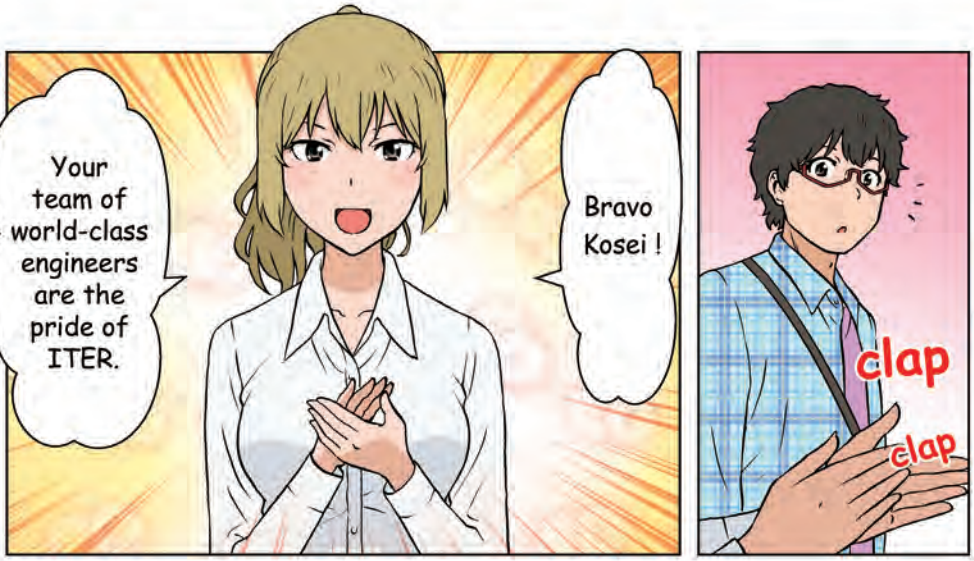

Nuclear fusion
This loss of mass produces a tremendous amount of energy.
Hydrogen nuclei collide and form a single nucleus with a slightly smaller mass.


Of... course ...
And I'm assuming you know that it takes a lot of these collisions just to trigger a fusion reaction.
And what generates that magnetic field!? This TF coil!
And to confine all that plasma you need a really powerful magnetic field.
Strong gravity
High density
You have to trap a whole lot of plasma within a defined volume to get enough nuclei to collide.
The coil generates the magnetic field to confine the plasma...
Aw shucks ...
He may be young, but he knows his stuff.
Kosei Higashide, the pleasure is mine.
Allow me to introduce you to the head engineer of the TF coil project.


. . . .
Oh, that old thing? Nearly a lifetime of pain and suffering through endless trial and error.
Was it really hard to develop the TF coils?
First we had to build a mock-up* and do repeated testing.
Well, its scale was unprecedented.
Eight ... years !?
Let's just say it took us 8 years to get to where we are now.
*Full-scale prototype used to simulate the real component in the design phase of manufacturing
And it took 8 years.
So, pretty much this entire plant was custom made for the TF coils...
Welding and machining equipment, the winding system for the conductors, the heat treatment furnace and conductor transfer equipment, the winding machine for electrical insulation tape, the resin impregnation system, and the robotics to weld the cover plates...
Of course, we built all the equipment from scratch.
All just for the TF coils.


Level of precision ...?
The level of precision required for the dimensional tolerances gave us the most trouble.
For this ginormous coil, you only have a few millimeters to work with?
A few millimeters !?
is only a few millimeters.
The margin of error for the magnetic field to stably confine the plasma ...
Yep
And the part that houses the TF coil conductors, the radial plate, is made from wrought high nitrogen stainless steel.
Which increases its strength,but makes it harder to cut and weld than your run-of-the-mill stainless steel.
Conventional welding techniques produced deformations beyond tolerance levels.

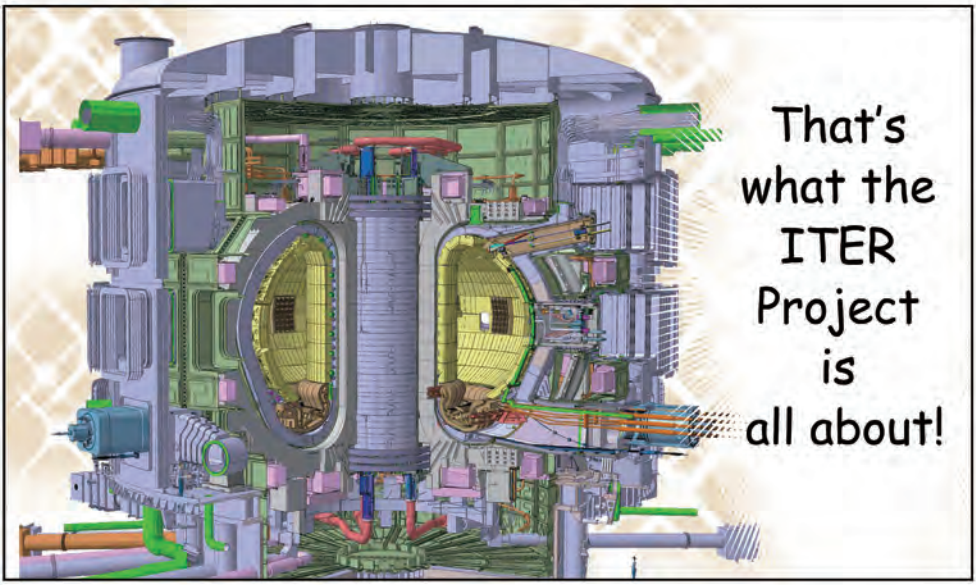

we finally saw the light at the end of the tunnel by combining fiber laser welding and narrow-gap tungsten inert gas (TIG) welding.
But after repeated trial and error,
to weld the segements together, starting from the center and going out 25 mm in both directions, then finishing the edges with TIG welding.
the most powerful fiber laser we could get our hands on at the time,
We ended up using a 30-kW fiber laser,
we were finally able to get the flatness tolerances under 1 mm !
After shedding much blood, sweat, and tears,
Silence…

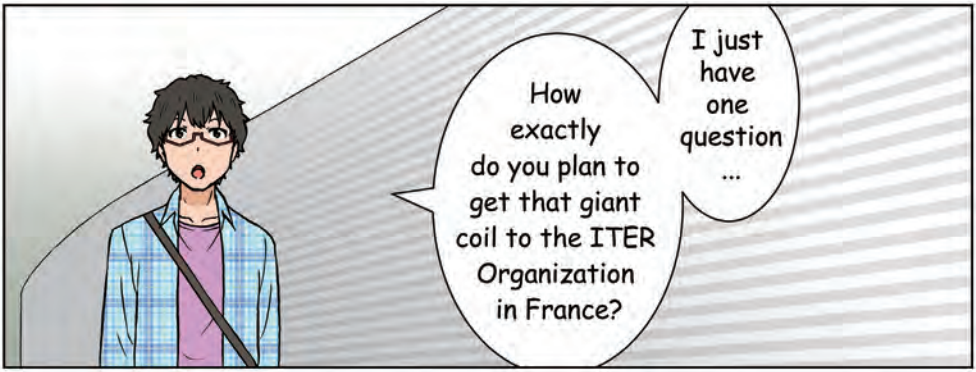

Your team of world-class engineers are the pride of ITER.
Bravo Kosei !
clap
clap

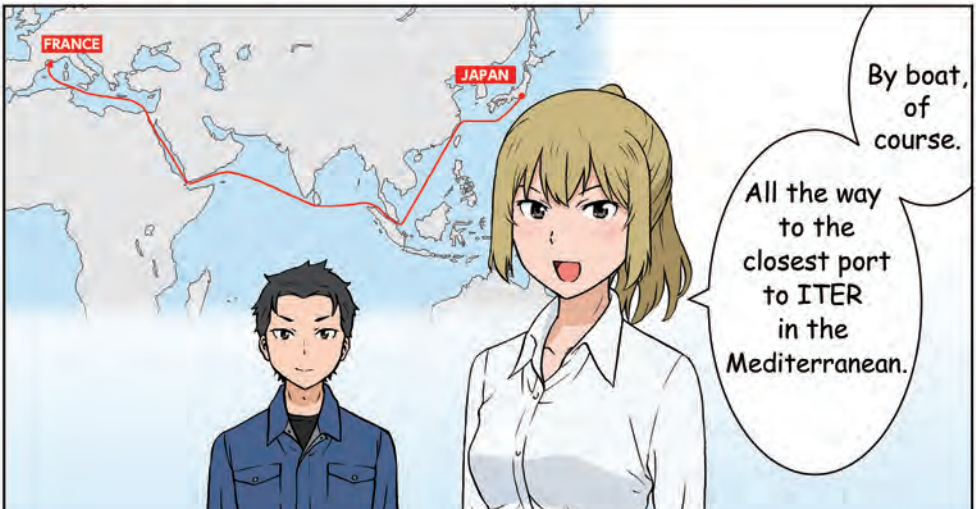

...
We couldn't have done it without the help of our suppliers.
Sorry, guess I got a bit carried away.
Well, we didn't go it alone.


And to think, people from all over the world share in this passion...

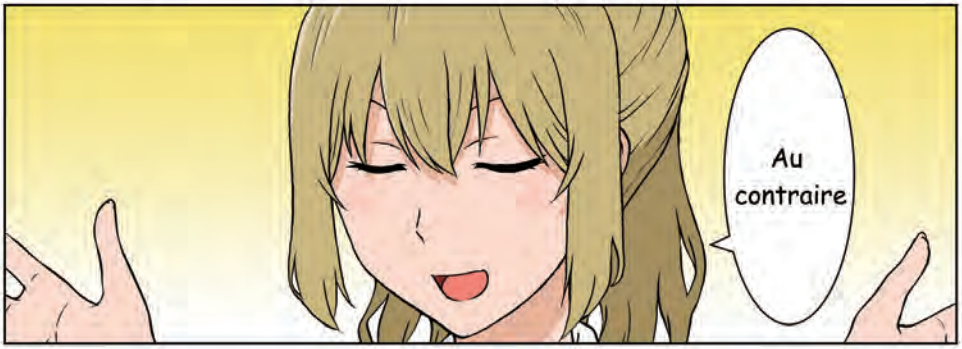

The passion you all have for ITER is really something else !
Wow !

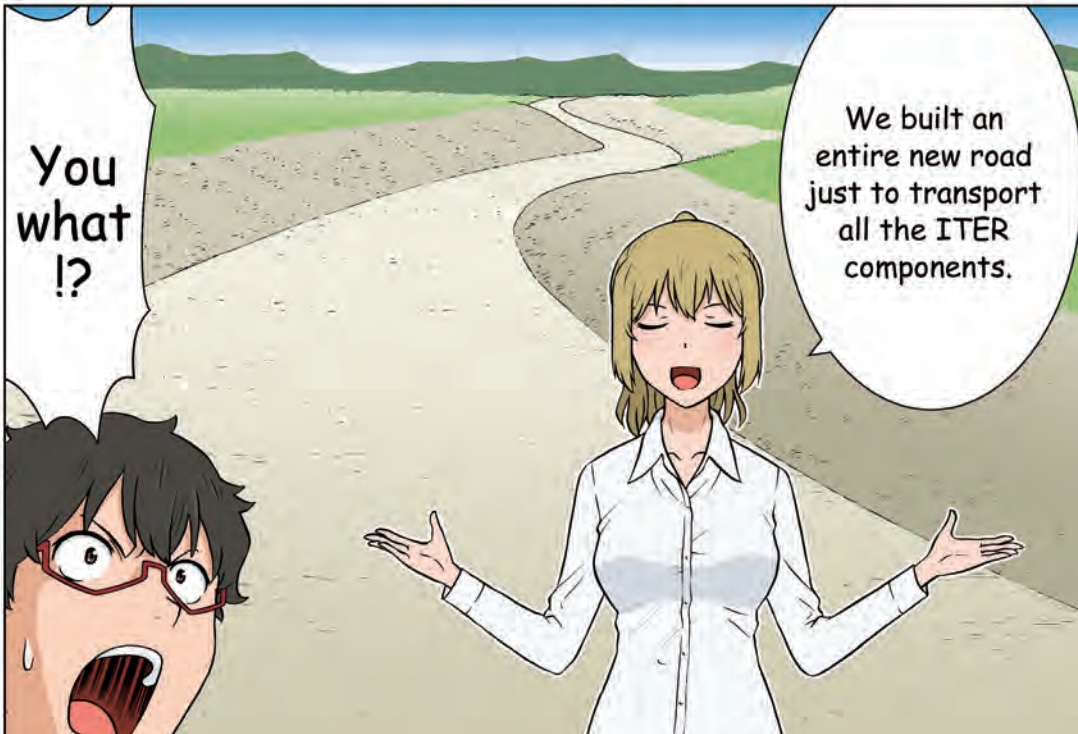

That's what the ITER Project is all about!

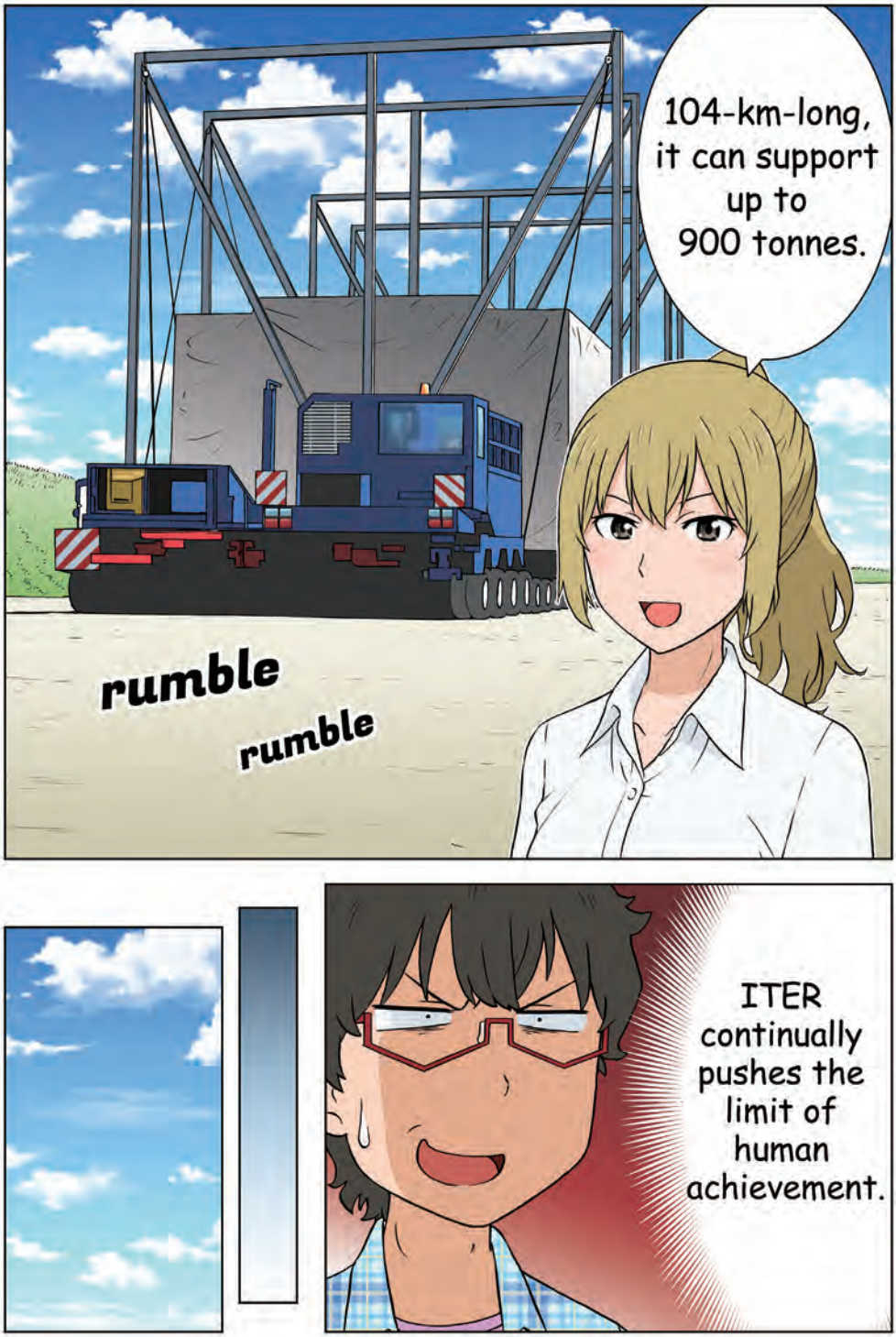

I just have one question ...
How exactly do you plan to get that giant coil to the ITER Organization in France?

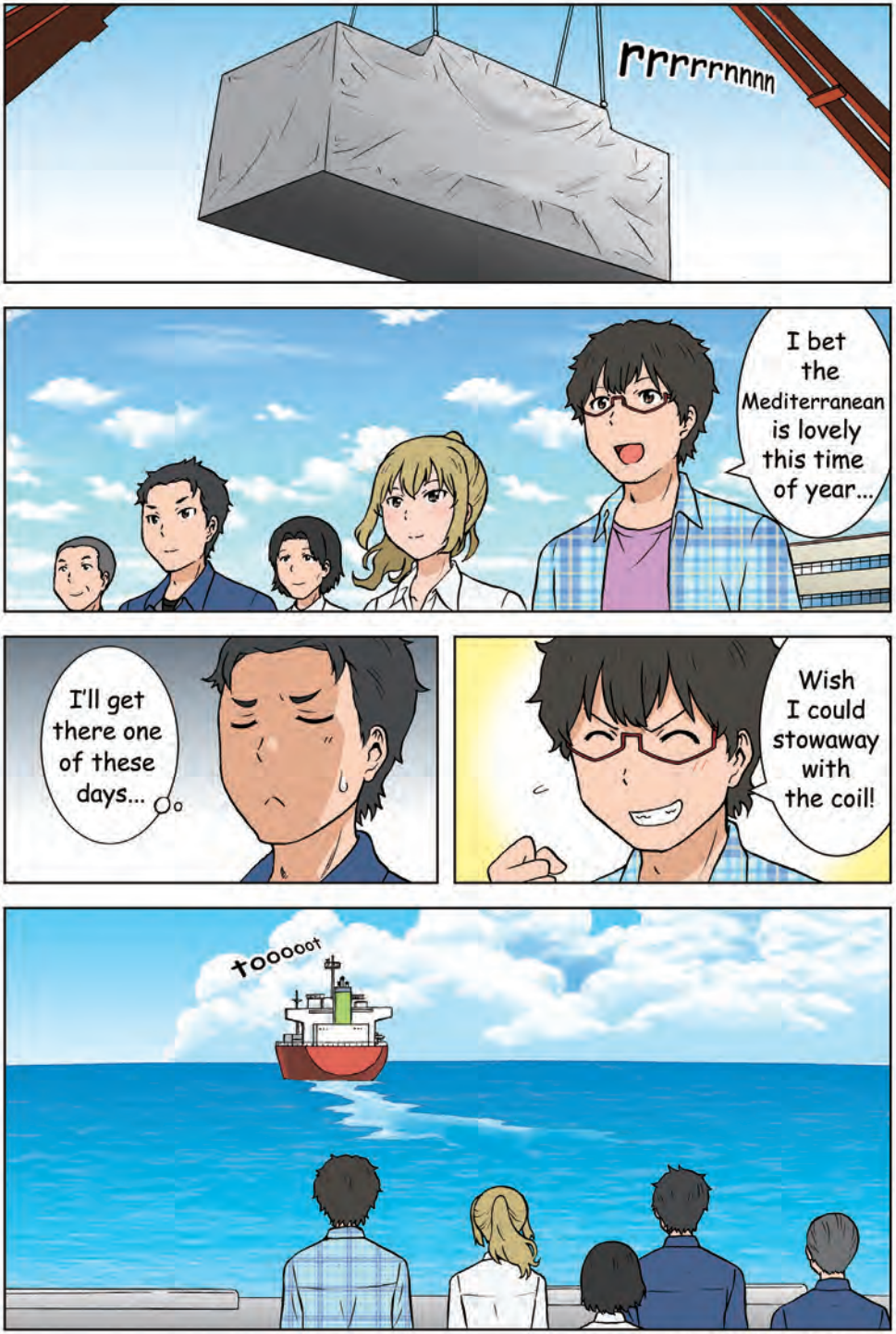

FRANCE
JAPAN
By boat, of course.
All the way to the closest port to ITER in the Mediterranean.


Yeah, but what about after that?
I remember it was a bit of a ways from the port to ITER.
I don't see how you're going to get it there using the local roads...
La Roque d'Anthéron
Charleval
Rognes
Lambesc
La Barben
Berre l'Etang


Au contraire


You what !?
We built an entire new road just to transport all the ITER components.


104-km-long, it can support up to 900 tonnes.
rumble
rumble
ITER continually pushes the limit of human achievement.



This story is fiction based on actual events

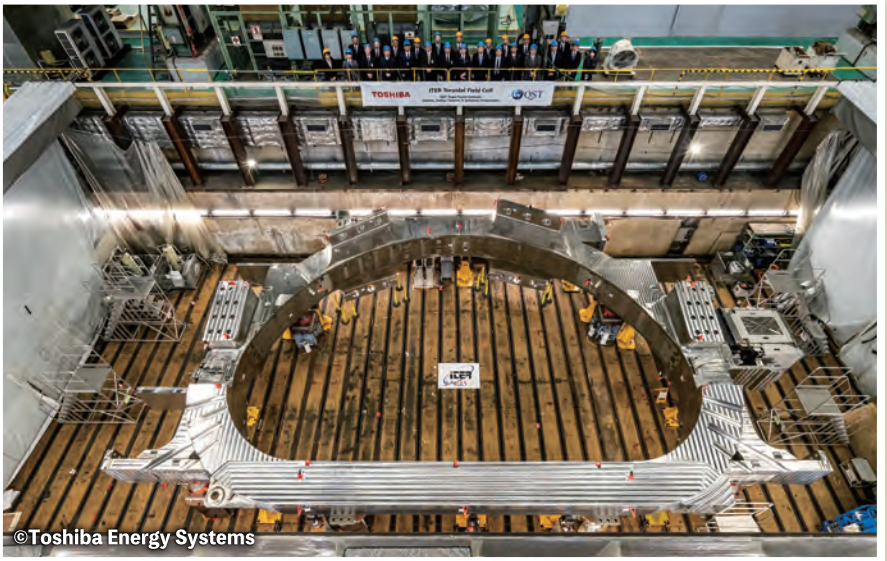
to be continued ···

ITER component procured by Japan:

Toroidal Field (TF) Coils

One of the largest components in the ITER device.

The first TF coil was completed in January 2020. To celebrate this momentous occasion, a ceremony was held by its manufacturer, Mitsubishi Heavy Industries Ltd.



The culmination of a ten-year collaboration between QST and Toshiba Energy Systems & Solutions Corporation, a ceremony for the fourth and final Toshiba-manufactured TF coil was held on February 21, 2023.

How were such massive components transported from Japan to France?

Transporting the TF Coils

Via a meticulously planned logistics operation over land and sea.

In August 2021, a cargo ship carrying two TF coils embarked on its journey from Japan to its final destination near the ITER site. A single TF coil is enormous, standing 17 meters tall, 9 meters wide, and weighing 320 tonnes (400 tonnes if we include their transport frame). Because of their immense size and weight, the coils had to be loaded using specialized cranes.

ITER Japan News

ITER Japan News provides the latest on the activities of the Domestic Agency in Japan, from progress on Japanese components to press reports, award recipients, and more.

At the Port of Yokohama, TF Coil No. 3 (TF10), manufactured by Toshiba Energy Systems & Solutions Corporation, was loaded onto the ship. The next port of call was Kobe, where TF Coil No. 6 (TF02), produced by Mitsubishi Heavy Industries Ltd., was loaded.

Photo: TF02 (Unit No. 6) on the upper deck, TF10 (Unit No. 3) on the lower deck.

After departing Japan, the ship traveled approximately 19,000 km (see page 33) before arriving at the Port of Fos-sur-Mer in France. Once unloaded, the coils were transported overland to the ITER site using heavy-duty trailers.

National Institutes for
Quantum Science and Technology
Naka Institute for Fusion Science and Technology

ITER Japan Domestic Agency

A small Sun on Earth

ITER

イーター

～The Spirit of Monozukuri: Gyrotrons～

CHARACTERS

TAIYO TENNO

As a student he met Soléane, and ever since has developed a strong interest in ITER.
This spring, he graduated from university and entered the workforce.

MIRAI MITSUHASHI

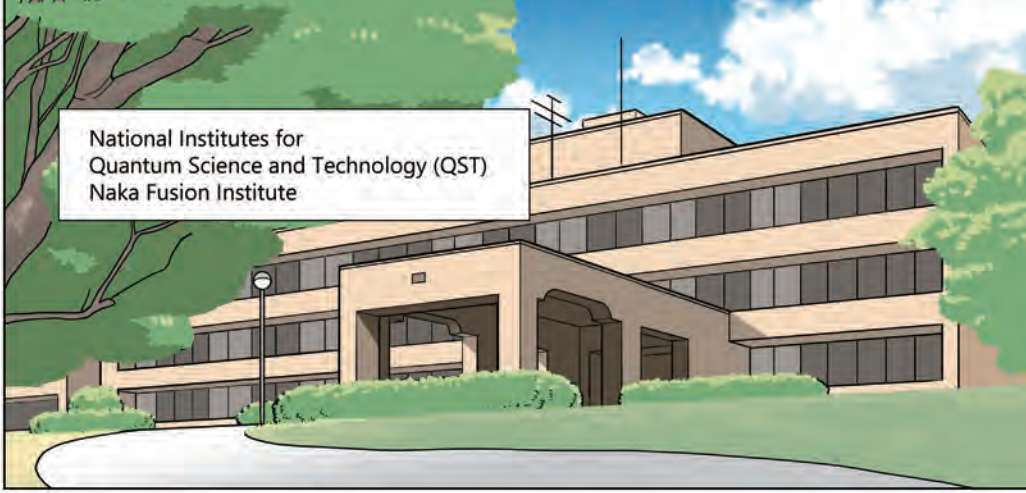
Administrative staff at QST (National Institutes for Quantum Science and Technology), the Japanese Domestic Agency of the ITER project.

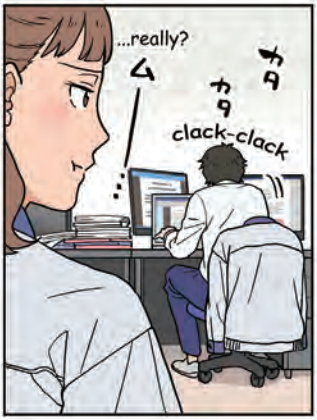
RENJI GŌDA

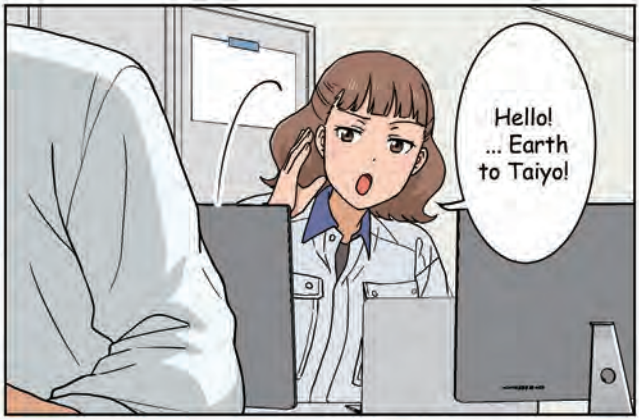
QST employee in charge of R&D for the gyrotrons, part of a radiofrequency heating system used in ITER.

SOLÉANE

A French researcher working at ITER in Saint-Paul-les-Durance. Currently lives in Aix-en-Provence. She was the one who initially got Taiyo interested in ITER.

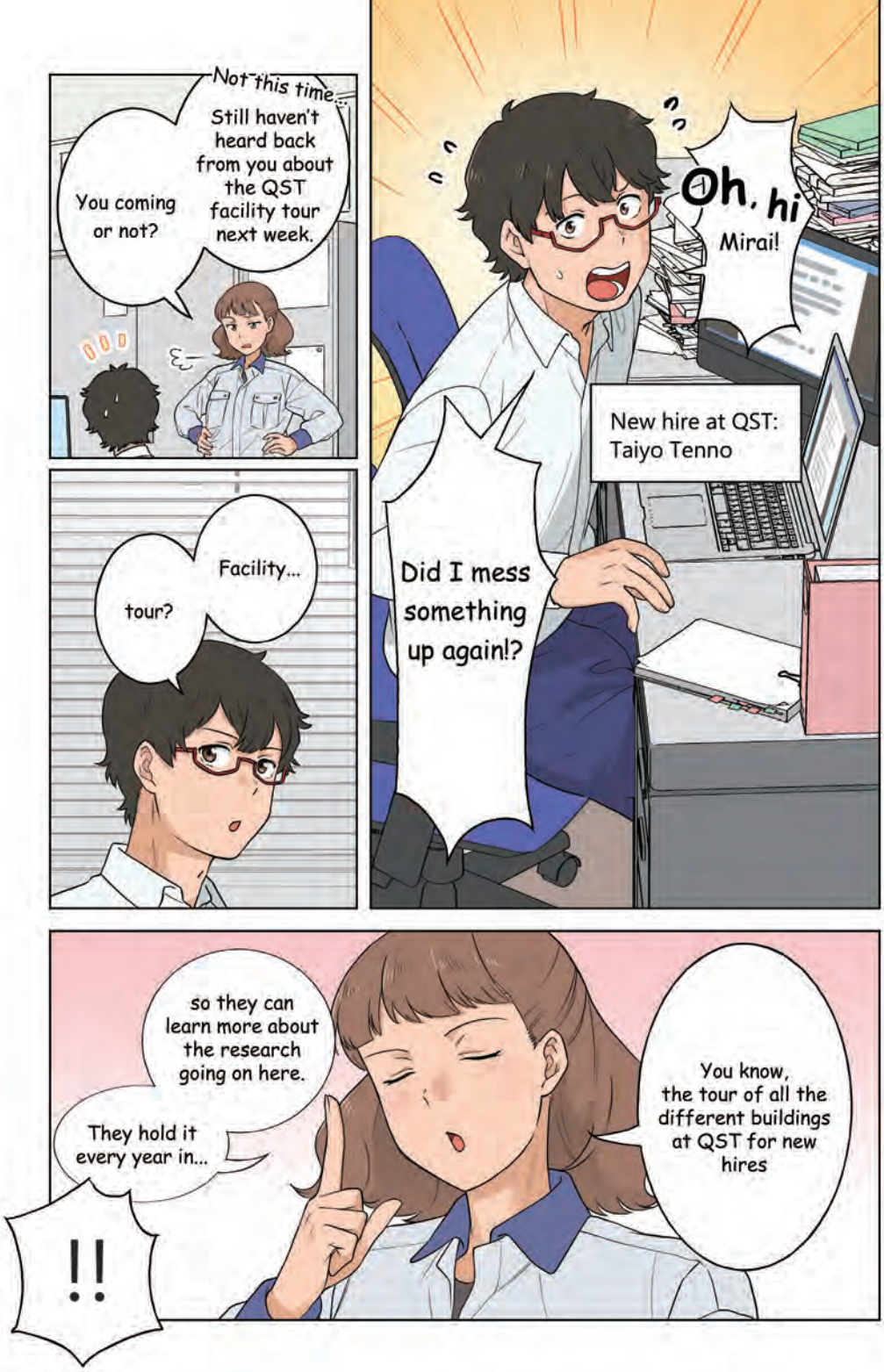

National Institutes for
Quantum Science and Technology (QST)
Naka Fusion Institute


...really?
clack-clack


Hello!
... Earth
to Taiyo!

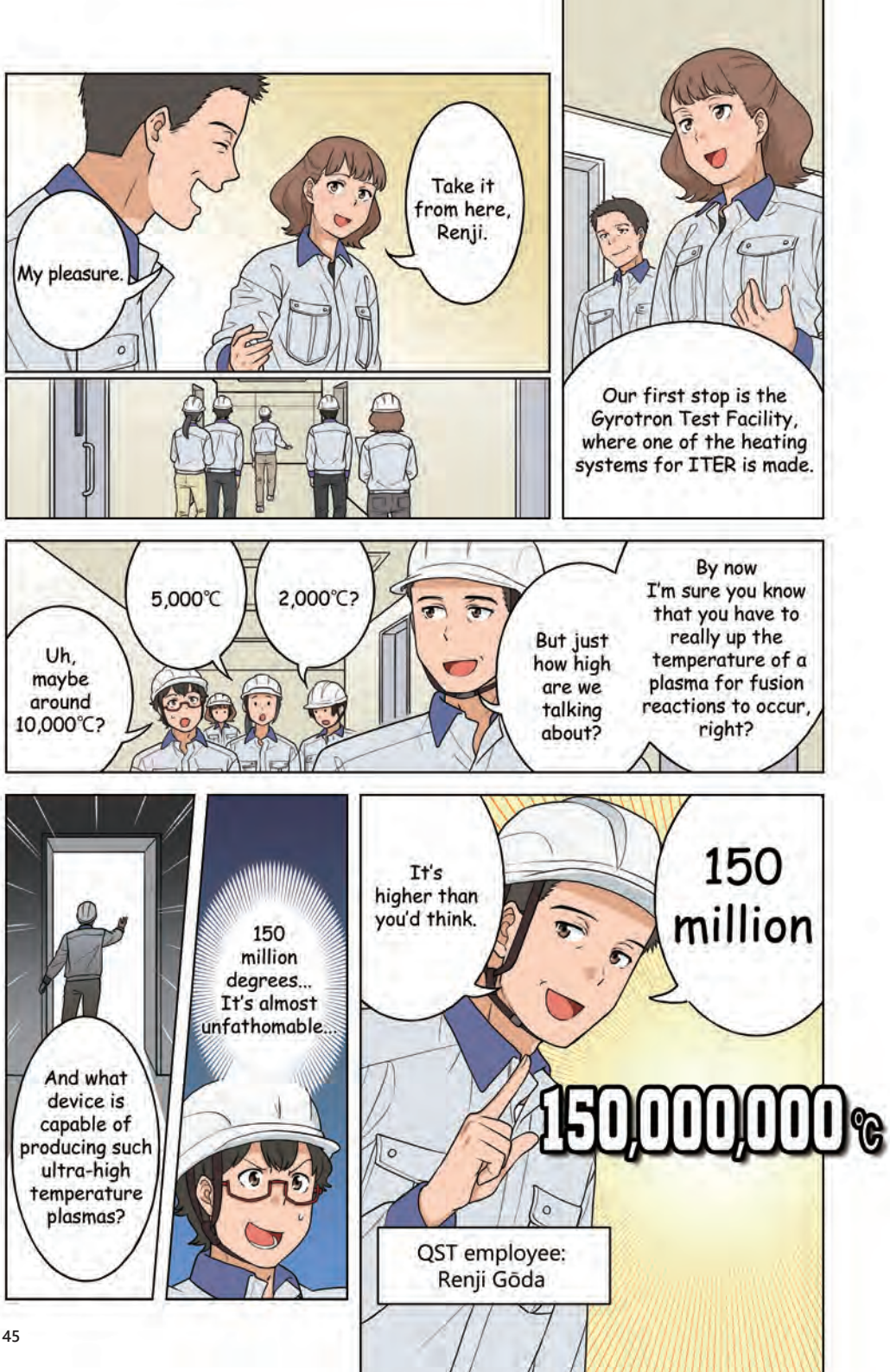

Hey!
Taiyo!
You got a sec?
!!


footsteps
footsteps


Not this time...
Still haven't heard back from you about the QST facility tour next week.
You coming or not?
Oh, hi Mirai!
New hire at QST: Taiyo Tenno
Did I mess something up again!?
Facility...
tour?
You know, the tour of all the different buildings at QST for new hires
so they can learn more about the research going on here.
They hold it every year in...
!!

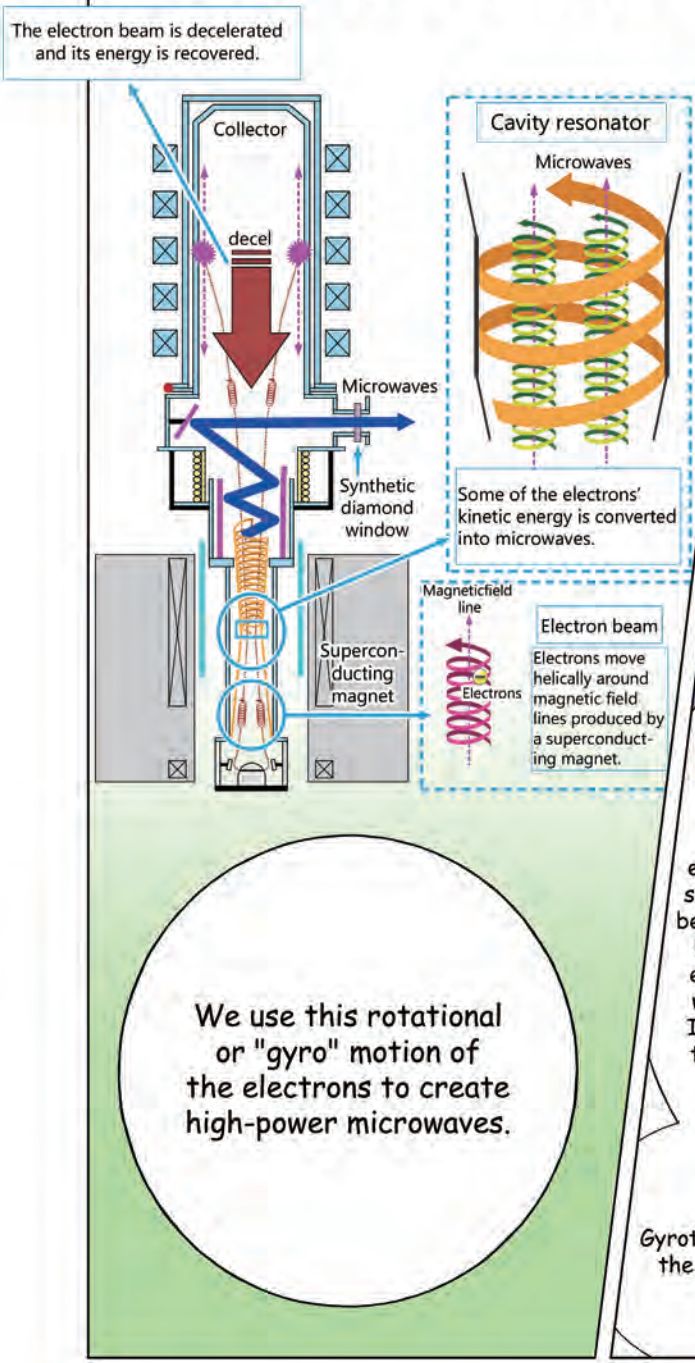

surprised
びくっ
I wouldn't miss it for the world!!!
Count me in!
This is my chance to see all the Japanese tech for ITER with my own eyes!
The time has finally come!
Alright then... Don't forget to sign up.
I'll be giving the tour.
nearly gave me a heart attack...
1 week later
This place is huge you need a bus to go around.

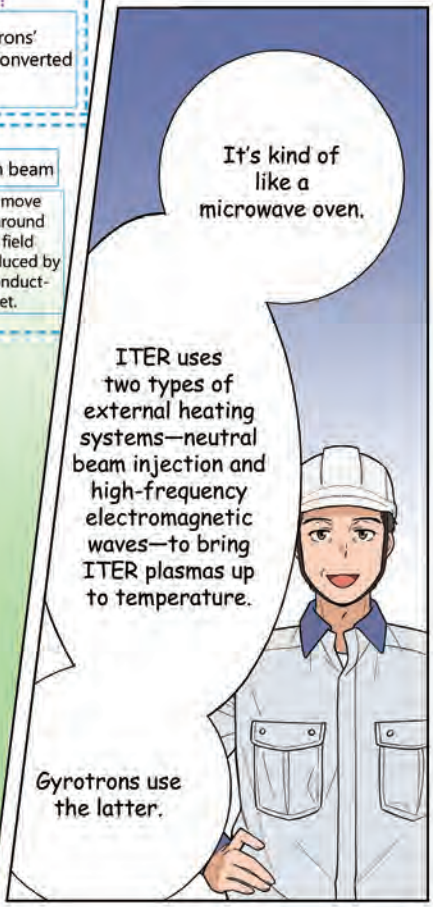

So this is where the magic happens...
Today I'll be taking you around to several ITER-related facilities here at the Naka Fusion Institute.
May I have your attention please!
I'd like to thank you all for coming.

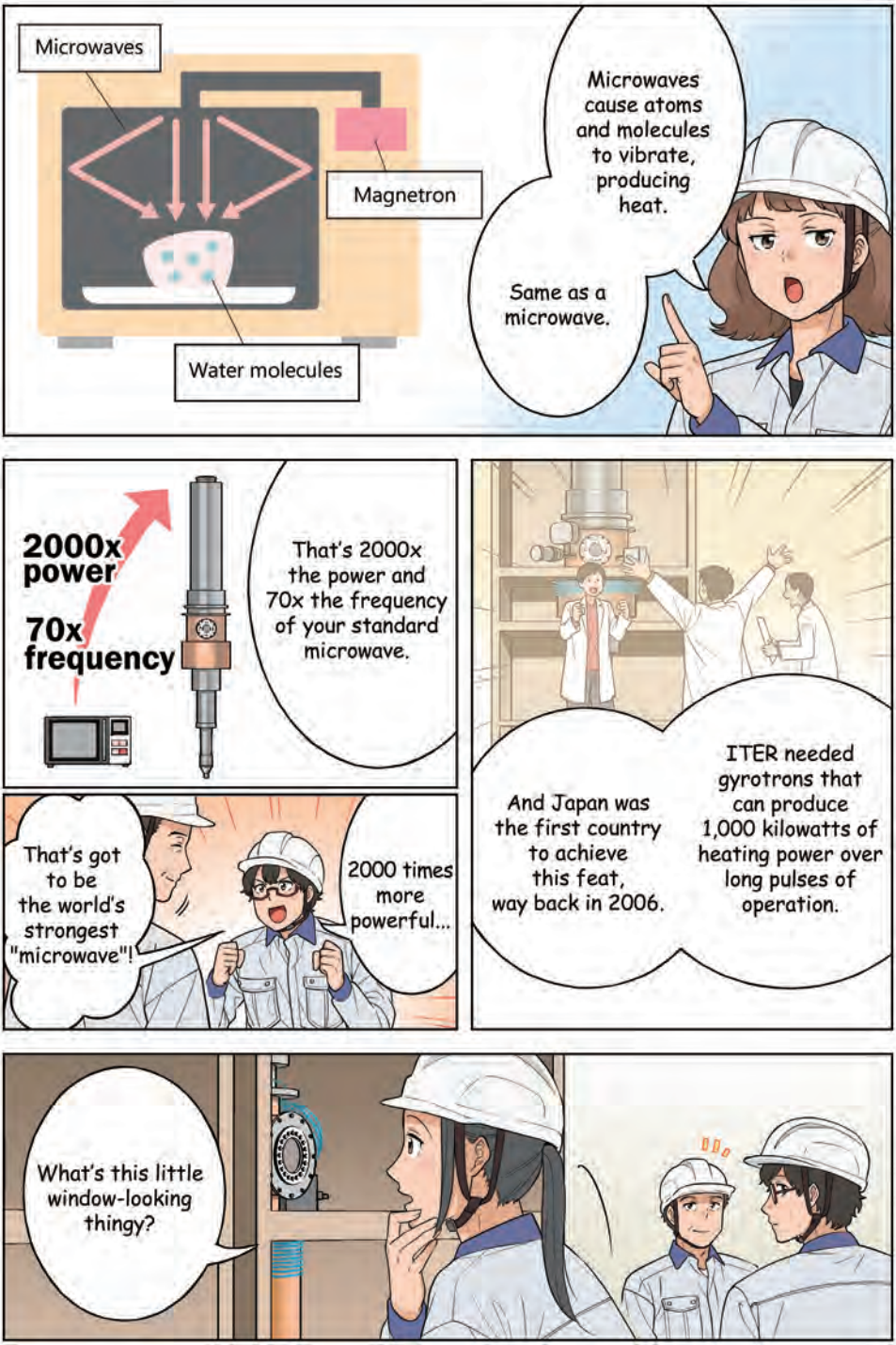

My pleasure.
Take it from here, Renji.
Our first stop is the Gyrotron Test Facility, where one of the heating systems for ITER is made.
Uh, maybe around 10,000℃?
5,000℃
2,000℃?
But just how high are we talking about?
By now I'm sure you know that you have to really up the temperature of a plasma for fusion reactions to occur, right?
And what device is capable of producing such ultra-high temperature plasmas?
150 million degrees... It's almost unfathomable...
It's higher than you'd think.
150 million
150,000,000℃
QST employee: Renji Gōda


It's called a gyrotron!
!!

Gyrotrons Basics



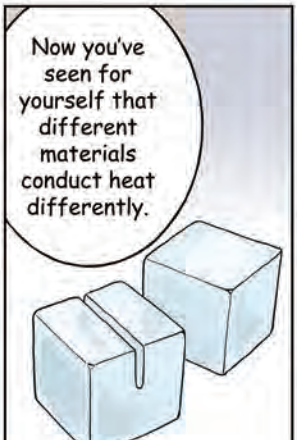


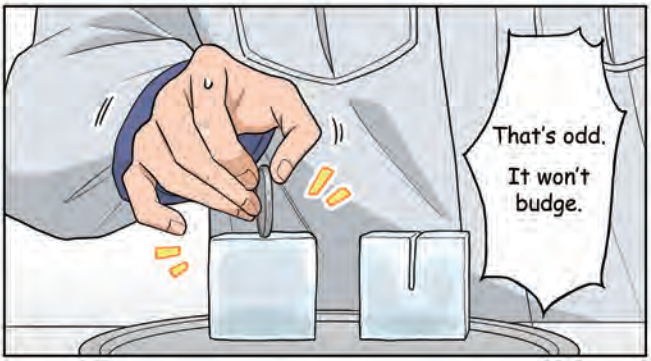

Microwaves
Magnetron
Water molecules
Microwaves cause atoms and molecules to vibrate, producing heat.
Same as a microwave.
2000x power
70x frequency
That's 2000x the power and 70x the frequency of your standard microwave.
That's got to be the world's strongest "microwave"!
2000 times more powerful...
And Japan was the first country to achieve this feat, way back in 2006.
ITER needed gyrotrons that can produce 1,000 kilowatts of heating power over long pulses of operation.
What's this little window-looking thingy?


DIAMOND!?
That "window" is made of diamond.


Cuts like butter!
smooth
スーー
Whoa! It slides right through.
Now try it with a coin.

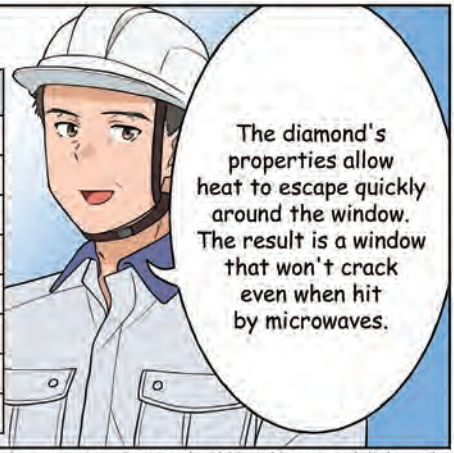

Yes, diamond.
Here, try cutting the ice with it.
For ice-cutting experiment, we're reusing damaged and unusable items.


Now you've seen for yourself that different materials conduct heat differently.

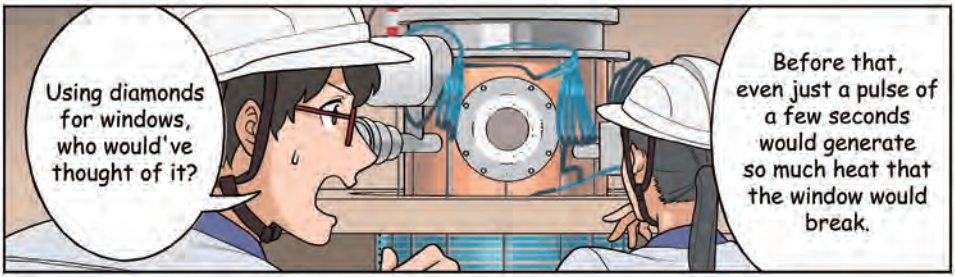

That's odd. It won't budge.

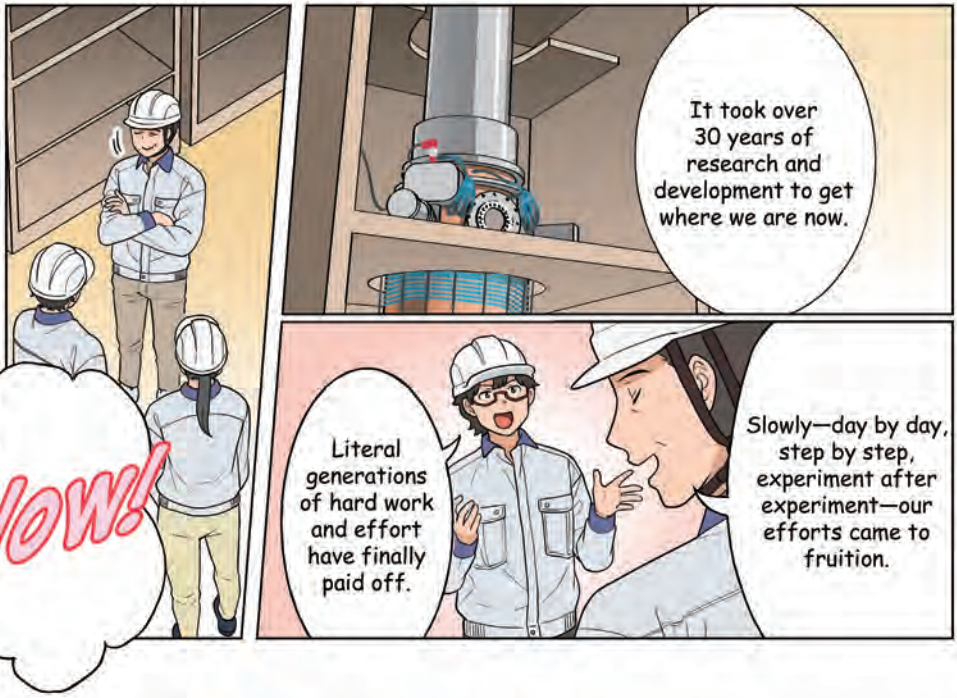
Thermal conductivity of metals

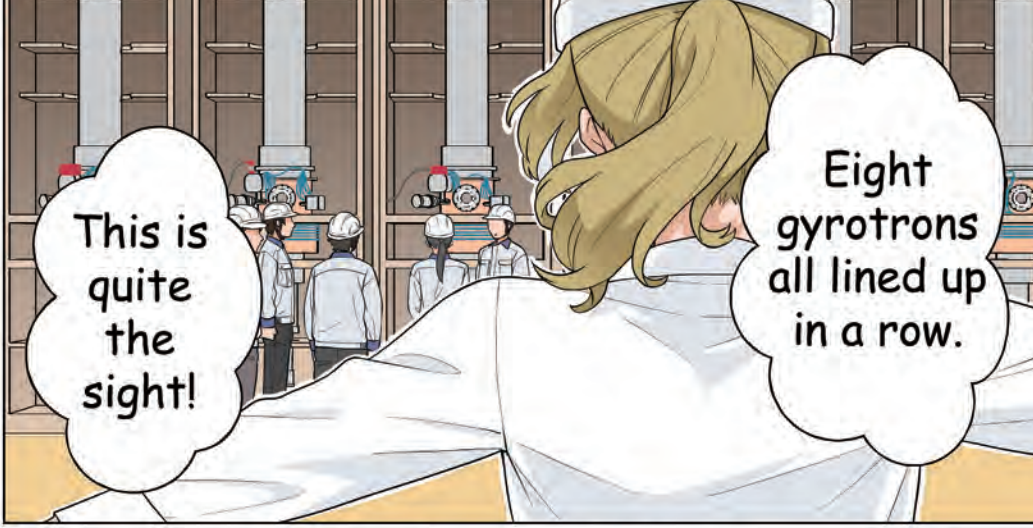
Metal	Thermal conductivity (W/m K)
Diamond	1000 ～ 2000
Silver	420
Copper	398
Gold	320
Aluminum	236
Iron	90.9
Glass	1
Water	0.6



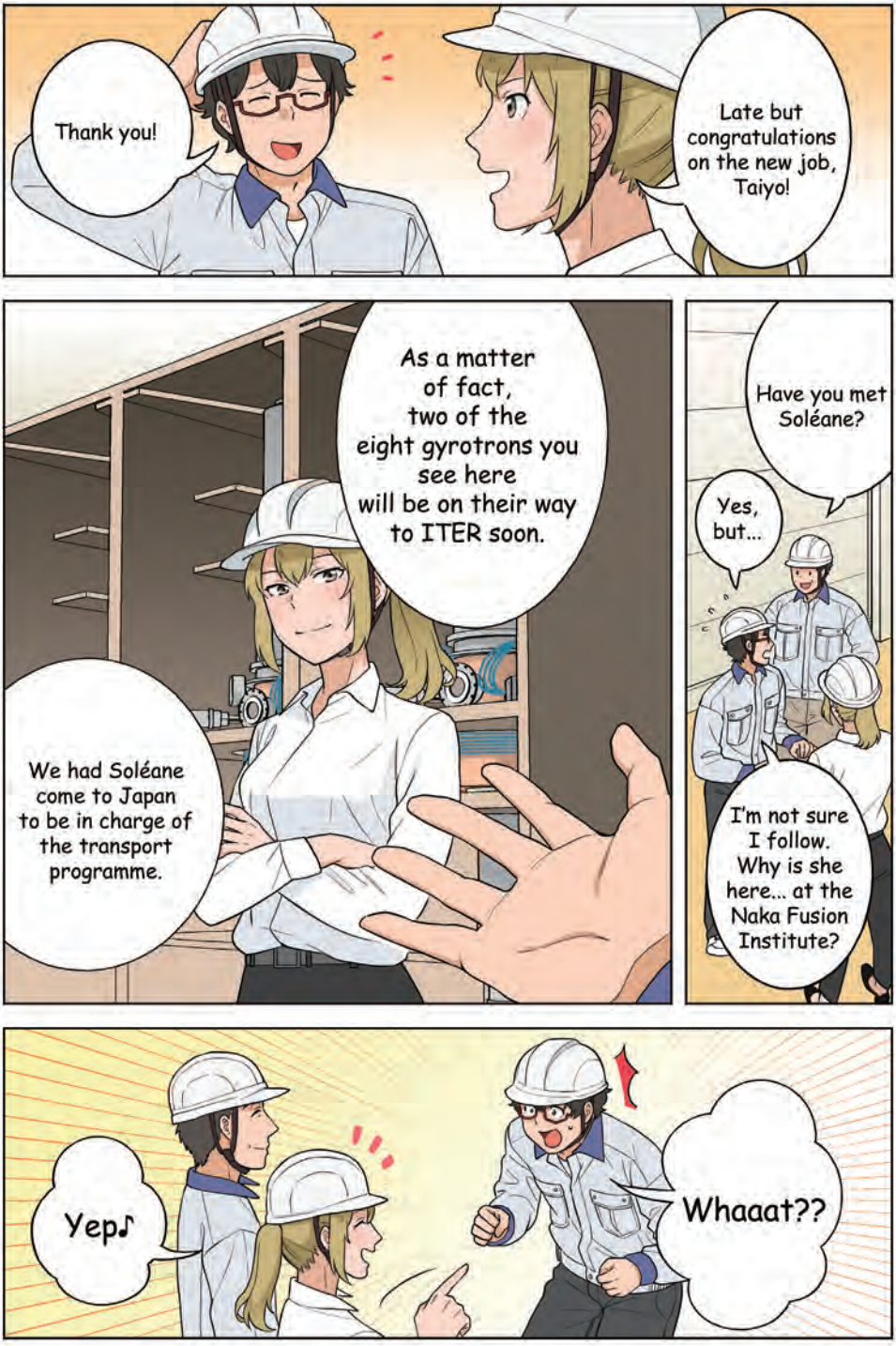
*The artificial diamond window used in the gyrotron was first installed on a gyrotron in Japan in 1997 and is now a global standard.

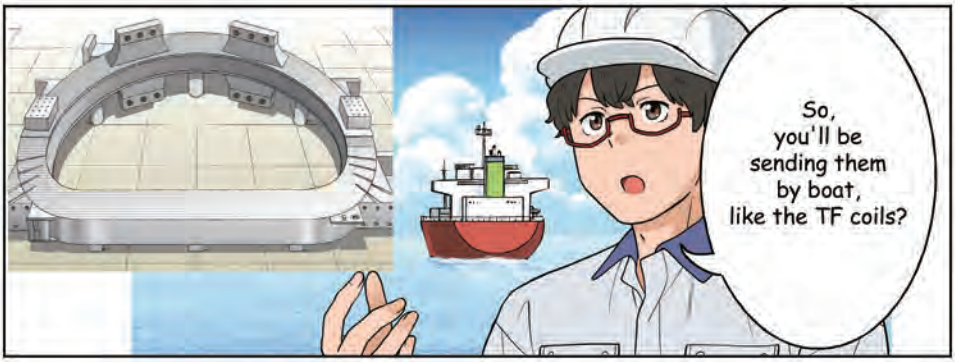


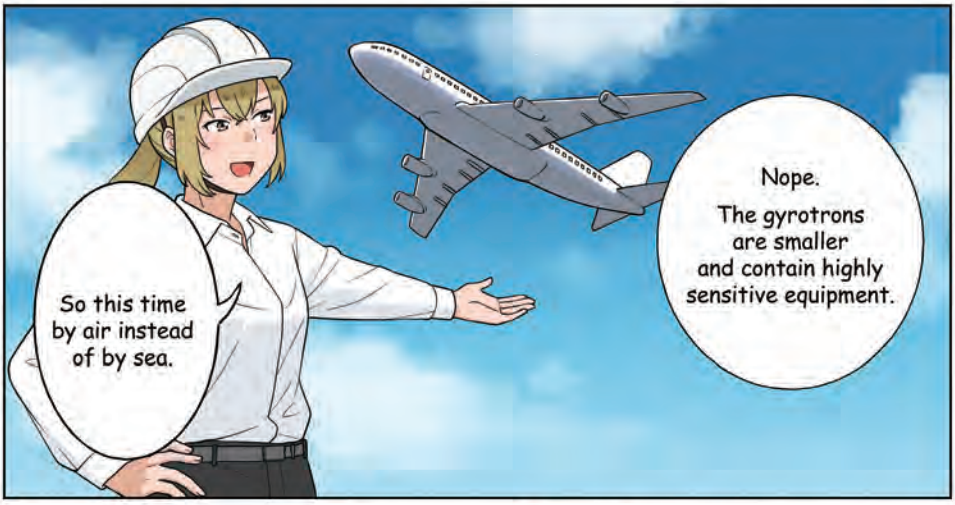


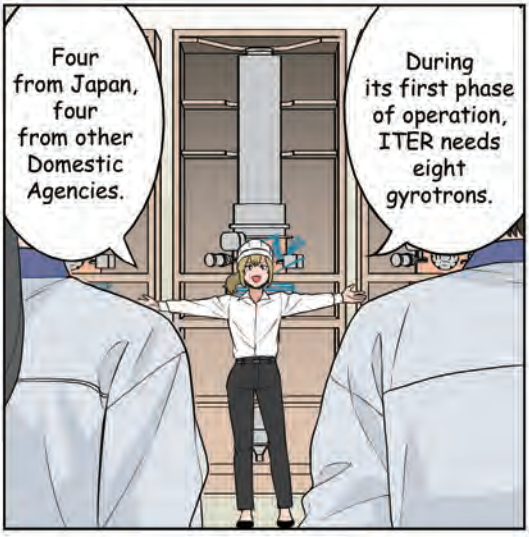

This is quite the sight!
Eight gyrotrons all lined up in a row.

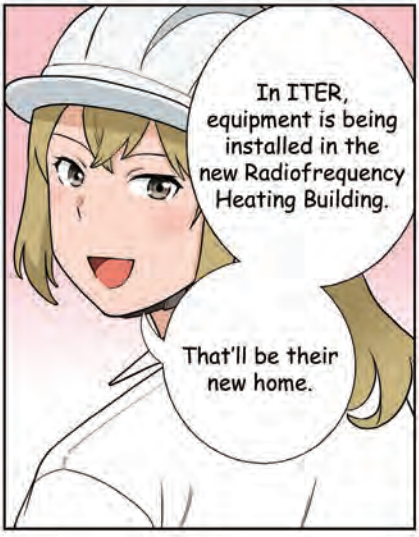

Japan was on top of their game manufacturing these gyrotrons.
That voice... (it can't be)
jolt
ばっ
Huh?
Salut Taiyo.
How have you been?
SOLÉANE!?

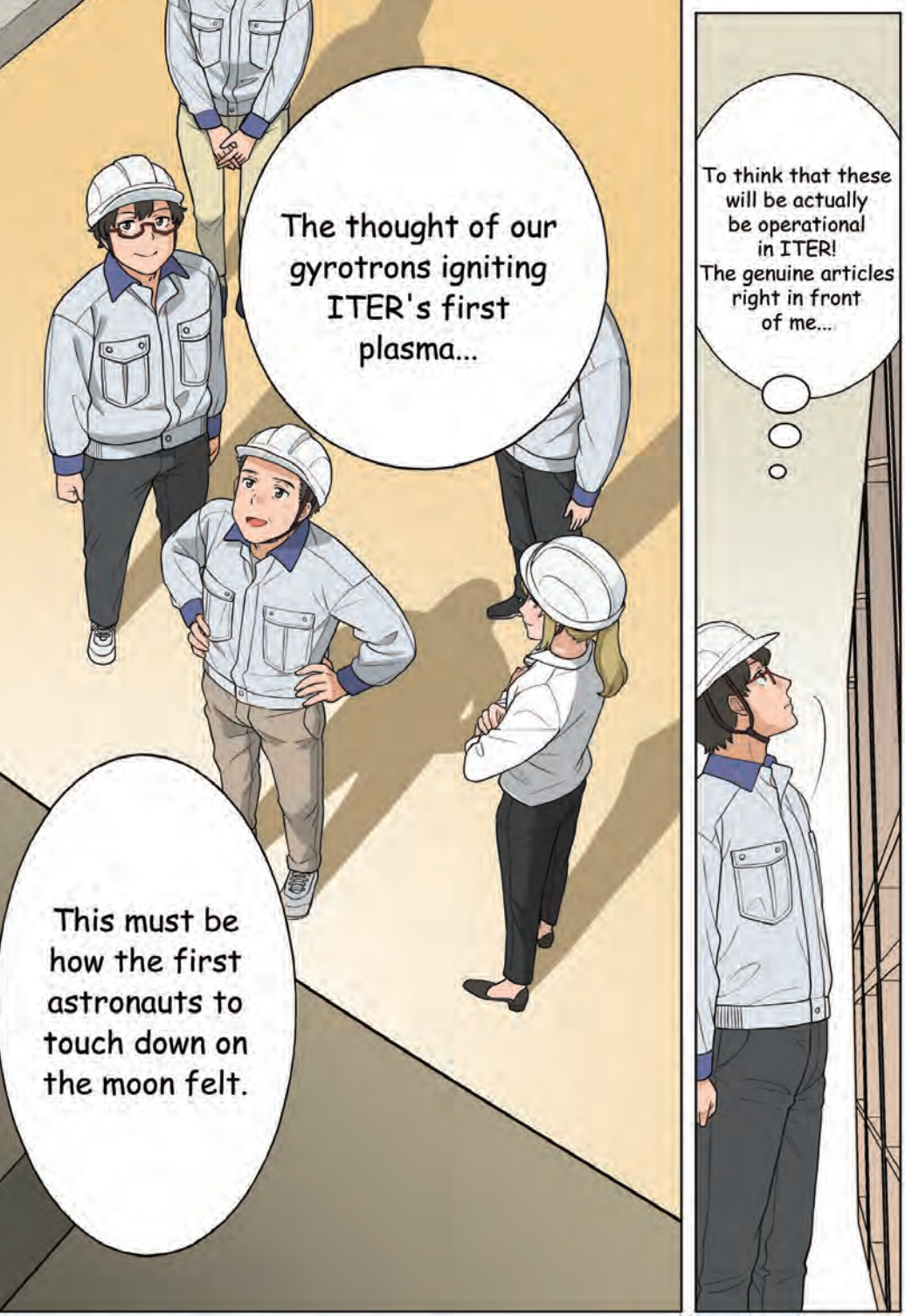

Thank you!
Late but congratulations on the new job, Taiyo!
As a matter of fact, two of the eight gyrotrons you see here will be on their way to ITER soon.
We had Soléane come to Japan to be in charge of the transport programme.
Have you met Soléane?
Yes, but...
I'm not sure I follow. Why is she here... at the Naka Fusion Institute?
Yep♪
Whaaat??

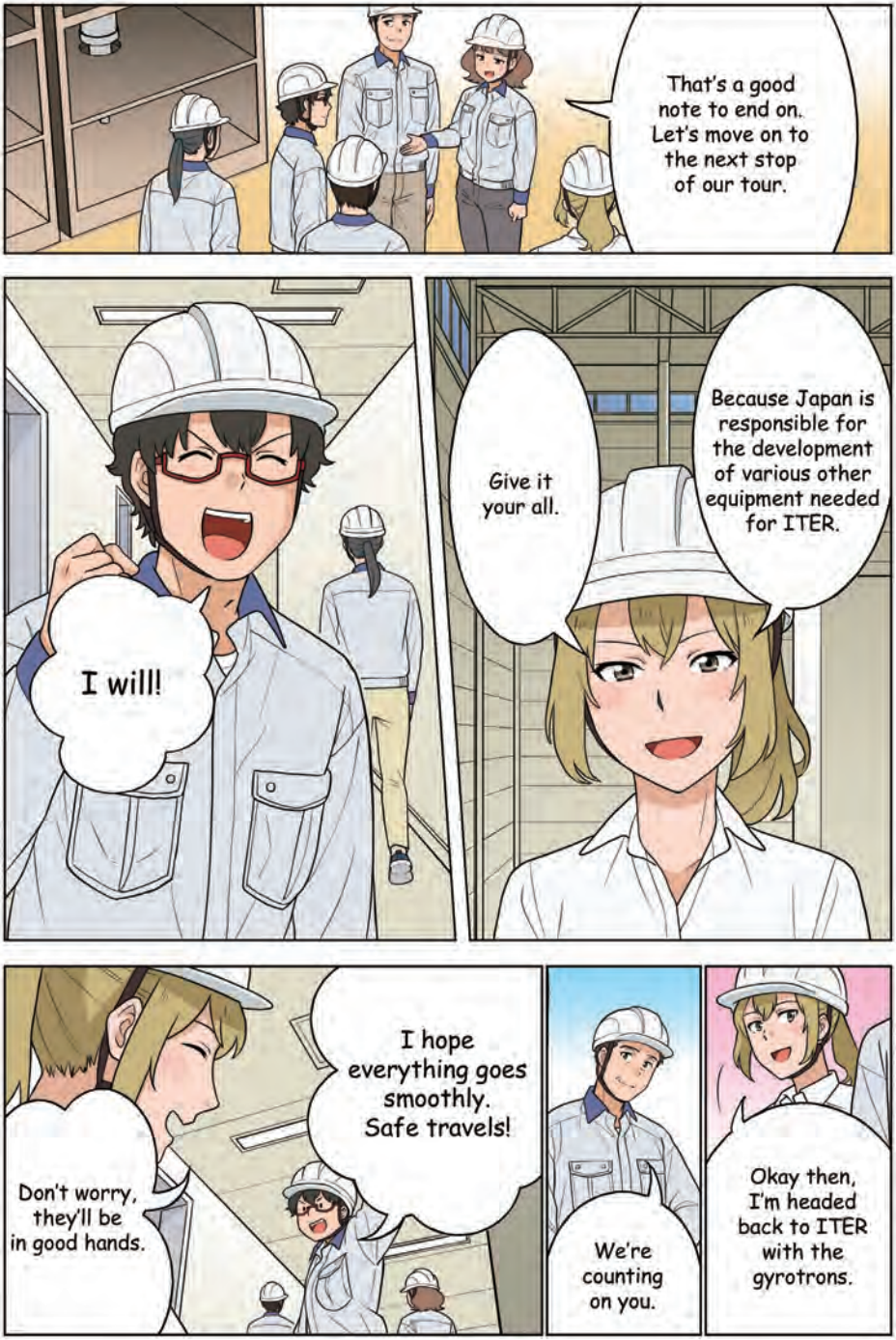

So, you'll be sending them by boat, like the TF coils?

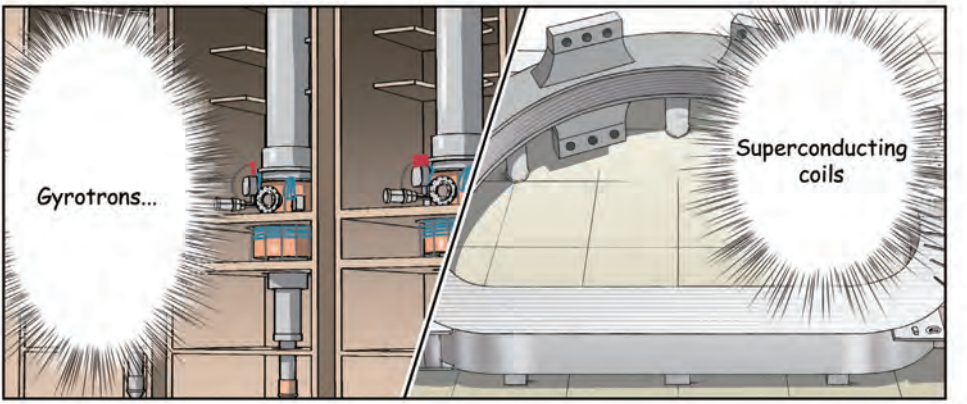

Nope.
The gyrotrons are smaller and contain highly sensitive equipment.
So this time by air instead of by sea.


Four from Japan, four from other Domestic Agencies.
During its first phase of operation, ITER needs eight gyrotrons.


In ITER, equipment is being installed in the new Radiofrequency Heating Building.
That'll be their new home.


The thought of our gyrotrons igniting ITER's first plasma...
This must be how the first astronauts to touch down on the moon felt.
To think that these will be actually be operational in ITER! The genuine articles right in front of me...


That's a good note to end on. Let's move on to the next stop of our tour.
Because Japan is responsible for the development of various other equipment needed for ITER.
Give it your all.
I will!
I hope everything goes smoothly. Safe travels!
Don't worry, they'll be in good hands.
We're counting on you.
Okay then, I'm headed back to ITER with the gyrotrons.


Gyrotrons...
Superconducting coils


Cutting-edge technology from all over the world is going into the ITER project.
Tech developed right here in Japan out on the world stage...
It's humbling to think about.

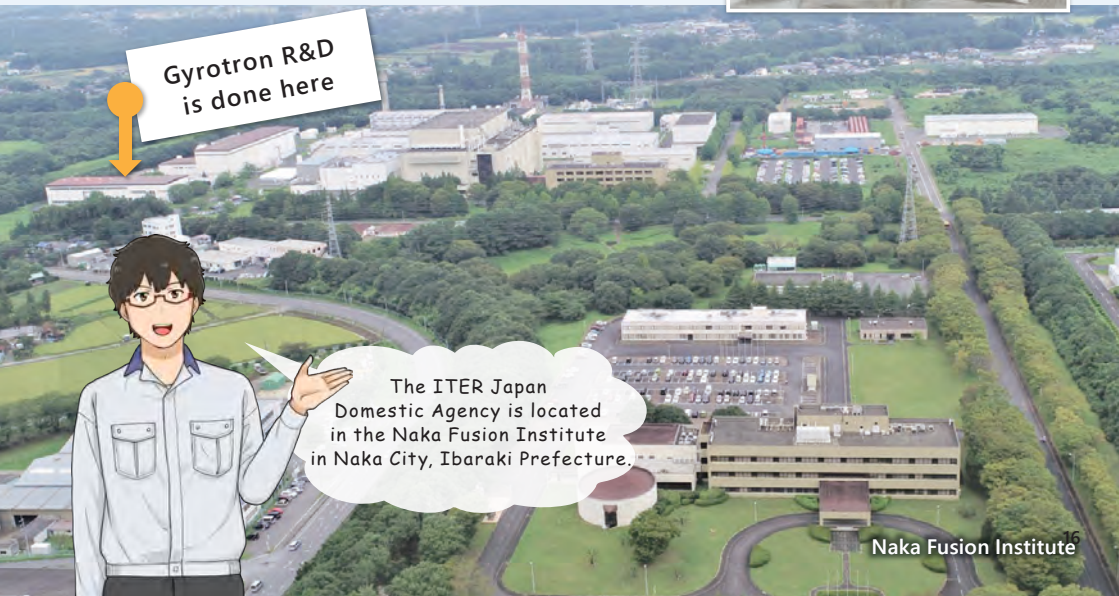
ITER component procured from Japan: Gyrotrons

Members of the RF Heating Technology Group in front of the 8 completed gyrotrons

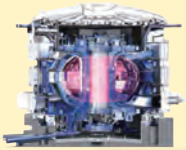
In April 2021, all eight of the Japanese gyrotrons for ITER were completed, two of which were transported by air and delivered to the ITER site in 2022.

These gyrotrons will play an important role in generating ITER's first plasma.

For more information, see the ITER Japan News article"The first two gyrotrons arrive at the ITER Organization"



Naka Fusion Institute



Progress in ITER Assembly

Components procured by the various ITER Domestic Agencies are steadily arriving at the ITER site.

This photo shows a “sub-sector” being lowered into the tokamak pit. Each sub-sector weighs a whopping 1,380 tonnes and requires extremely high manufacturing precision as, once all nine sub-sectors are assembled together, form the perfectly symmetrical, donut-shaped plasma chamber—the heart of ITER.

Next door to the tokamak building is the behemoth assembly hall—97 meters long, 60 meters wide, and 60 meters high. This is where the massive components, which appear small in comparison, are pre-assembled before being installed into the tokamak pit.

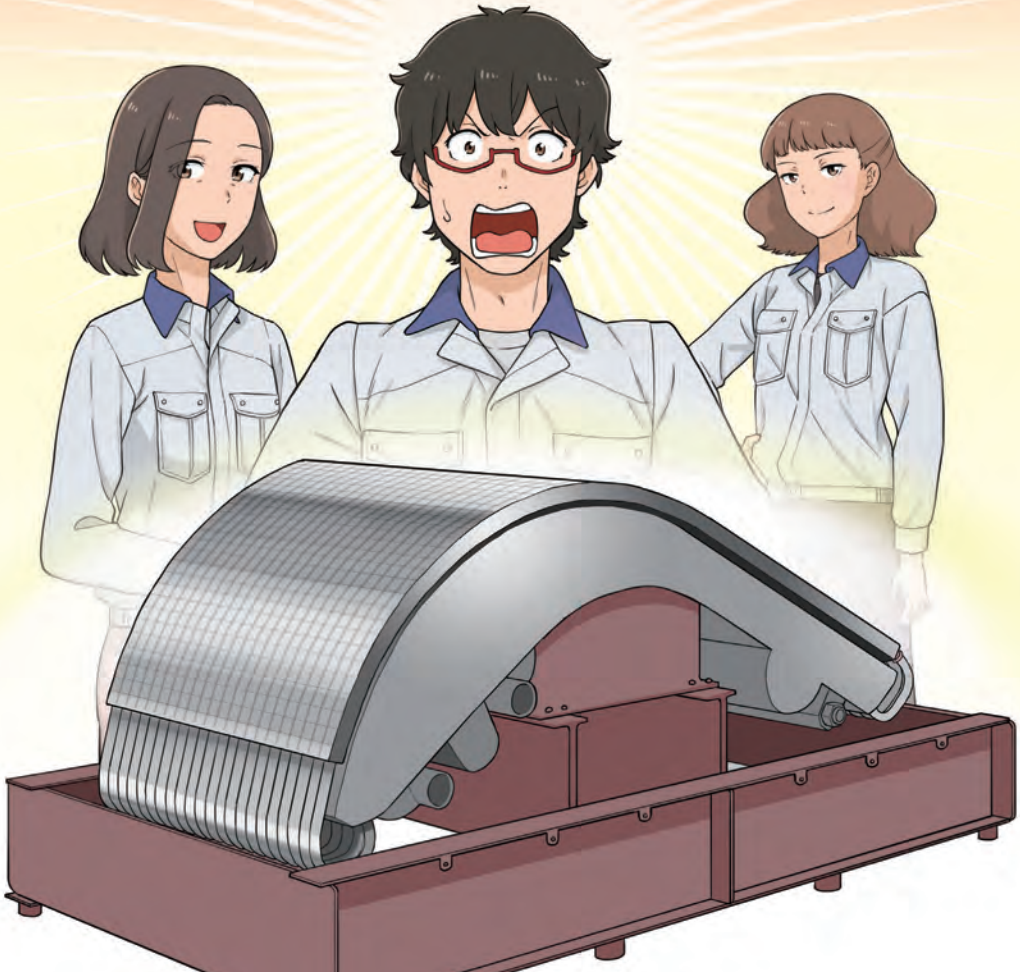
National Institutes for
Quantum Science and Technology
Naka Institute for Fusion Science and Technology

ITER Japan Domestic Agency

A small Sun on Earth

ITER (イーター)

～ The Spirit of Monozukuri: Divertor ～



CHARACTERS

TAIYO TENNO

New recruit at QST (National Institutes for Quantum Science and Technology), the Japanese Domestic Agency of the ITER project. He is on a whirlwind tour of the ITER-related facilities at QST's Naka Fusion Institute.

MIRAI MITSUHASHI

Veteran QST staff member. She is in charge of leading the tour of QST facilities for new hires.

MAKO KAWAI

Researcher at QST, responsible for the development of the components for ITER's divertor.

Group leader ŌHATA

Researcher at QST and a kind-hearted boss.

Company M

In charge of manufacturing the divertor.

Company Y

Specializing in metal alloys and tasked with manufacturing the copper piping.

Company A

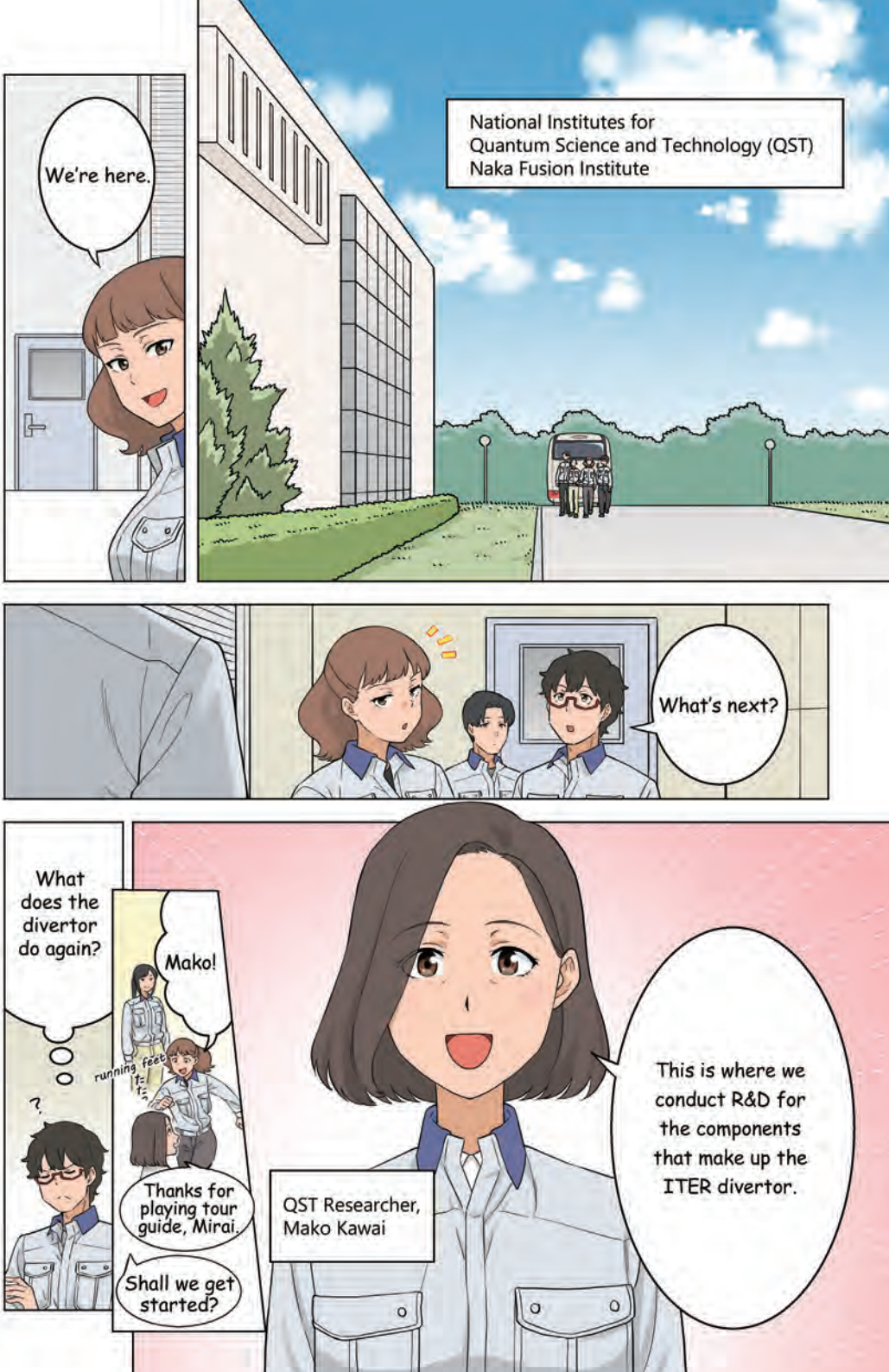
Tasked with preparing the tungsten materials.

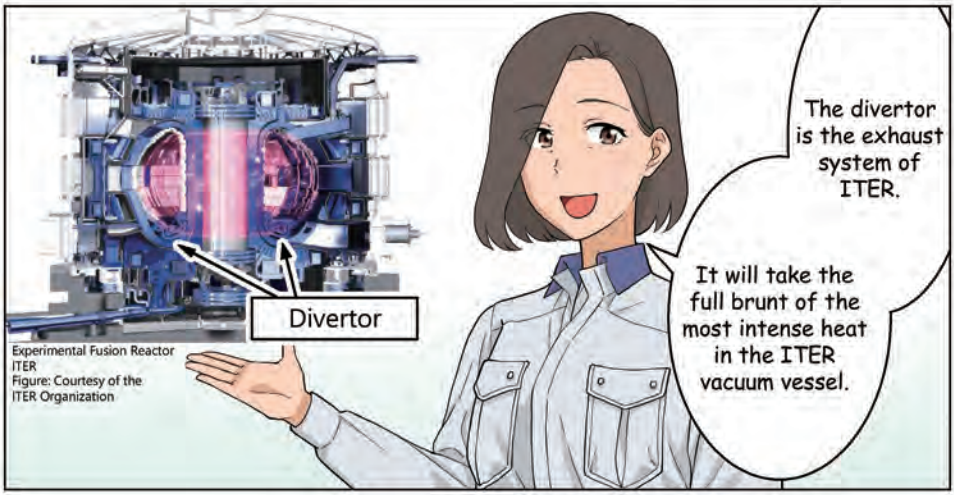
Company N

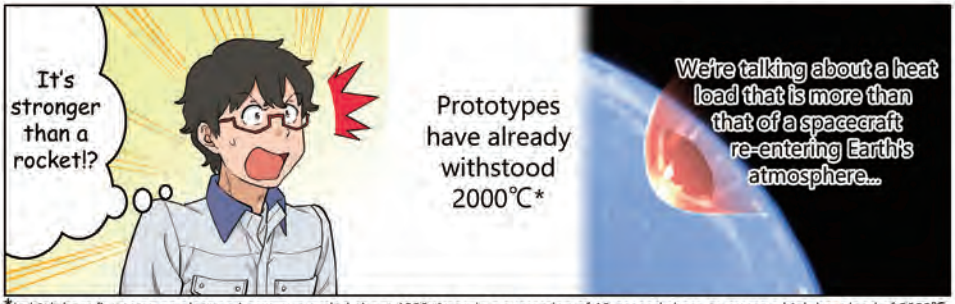
Tasked with the tungsten bonding process.

Our story so far...

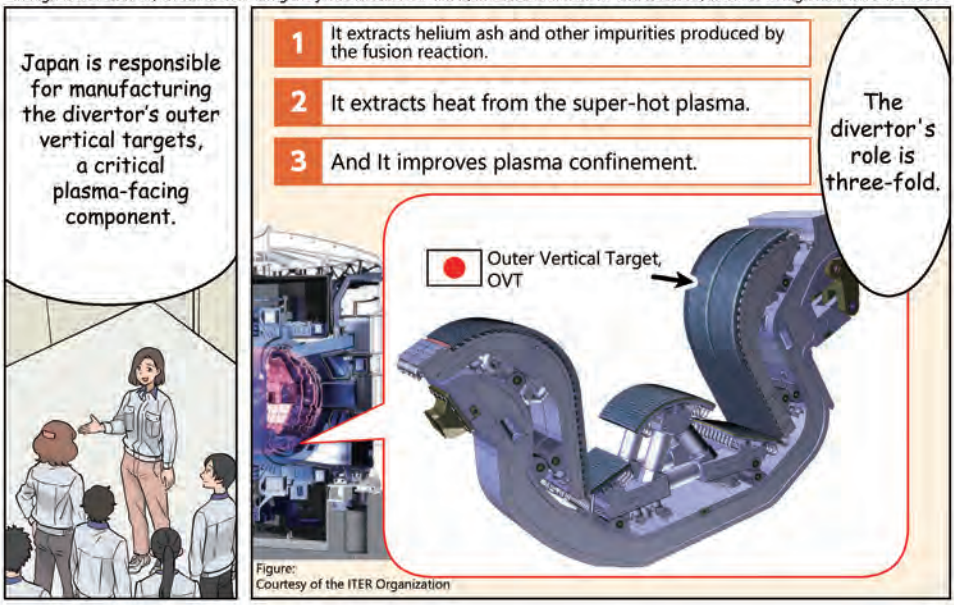
Our protagonist, Taiyo, who met Soléane when he was a student and ever since became fascinated with ITER, has graduated from university and is now an administrative staff member at QST. He is taking part in a tour of QST's Naka Fusion Institute as part of his training for new hires, led by QST veteran staff member, Mirai. In the previous issue, we learned about the "gyrotrons," one of the systems used to heat the plasma in ITER. In this issue, we will visit the R&D facility for the "divertor," a system that is essential for maintaining the plasma in ITER.

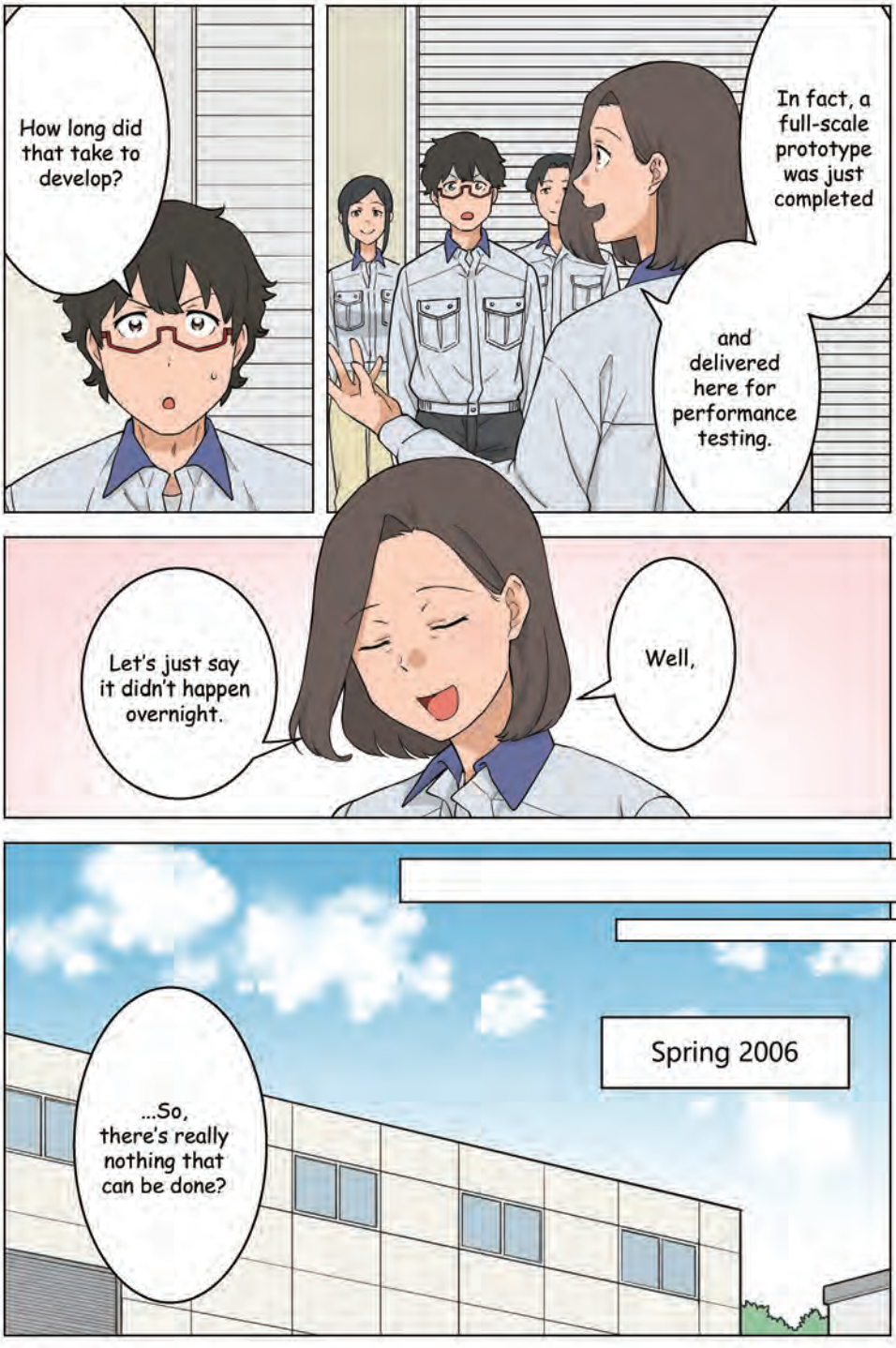

We're here.
National Institutes for
Quantum Science and Technology (QST)
Naka Fusion Institute
What's next?
What does the divertor do again?
Mako!
running feet
Thanks for playing tour guide, Mirai.
Shall we get started?
QST Researcher,
Mako Kawai
This is where we conduct R&D for the components that make up the ITER divertor.

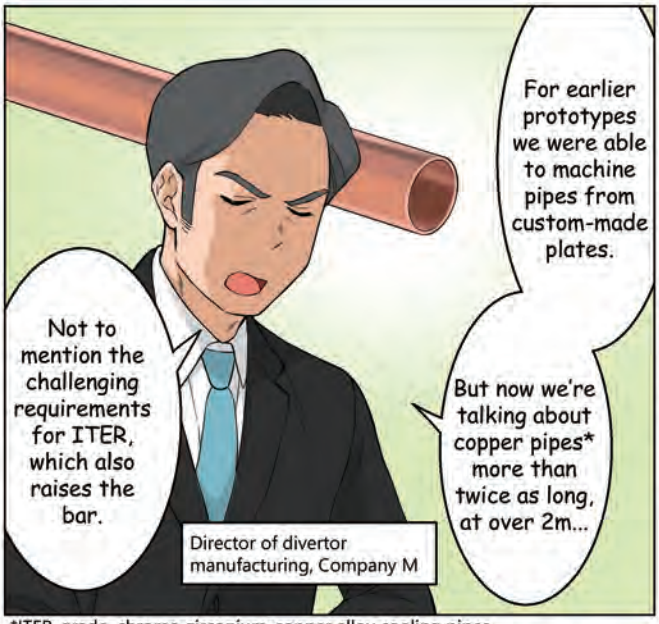




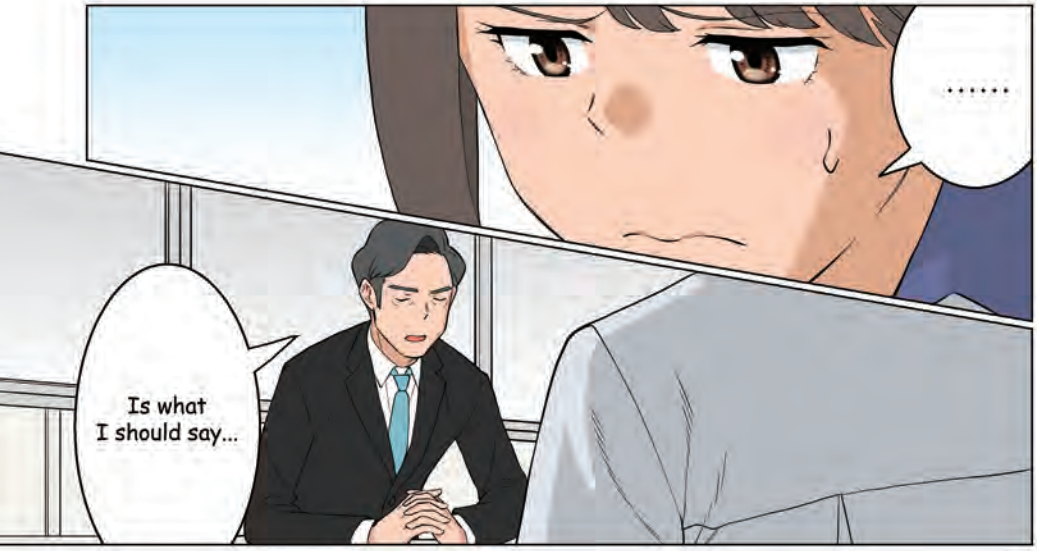
*In high heat flux tests, an electron beam gun cycled about 1000 times, in a succession of 10-second shots, to create a high heat load of 2000℃

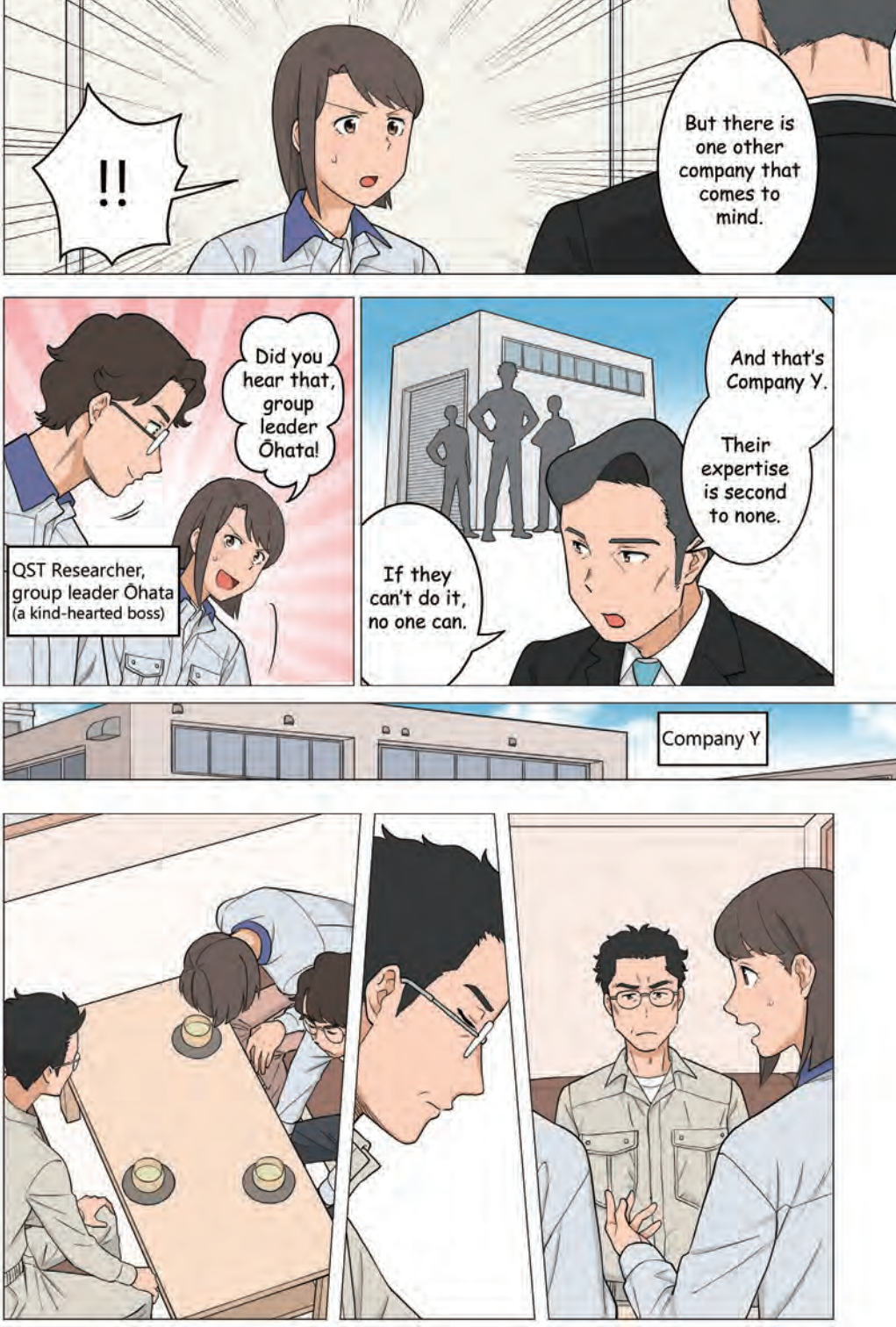


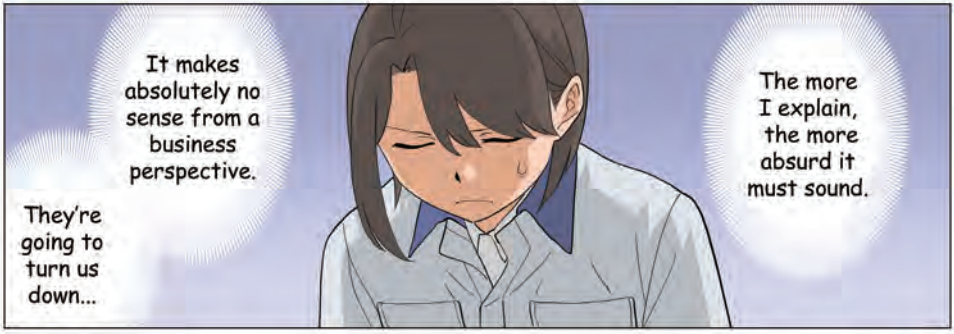

How long did that take to develop?
In fact, a full-scale prototype was just completed
and delivered here for performance testing.
Well,
Let's just say it didn't happen overnight.
Spring 2006
...So, there's really nothing that can be done?

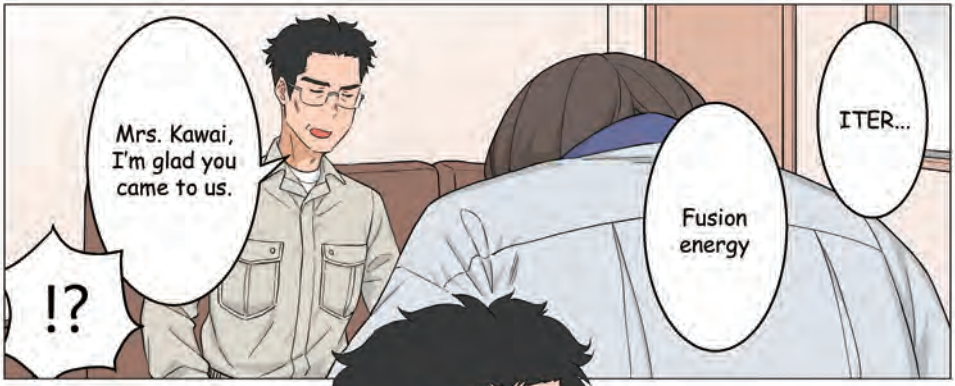


*ITER-grade, chrome-zirconium-copper alloy cooling pipes



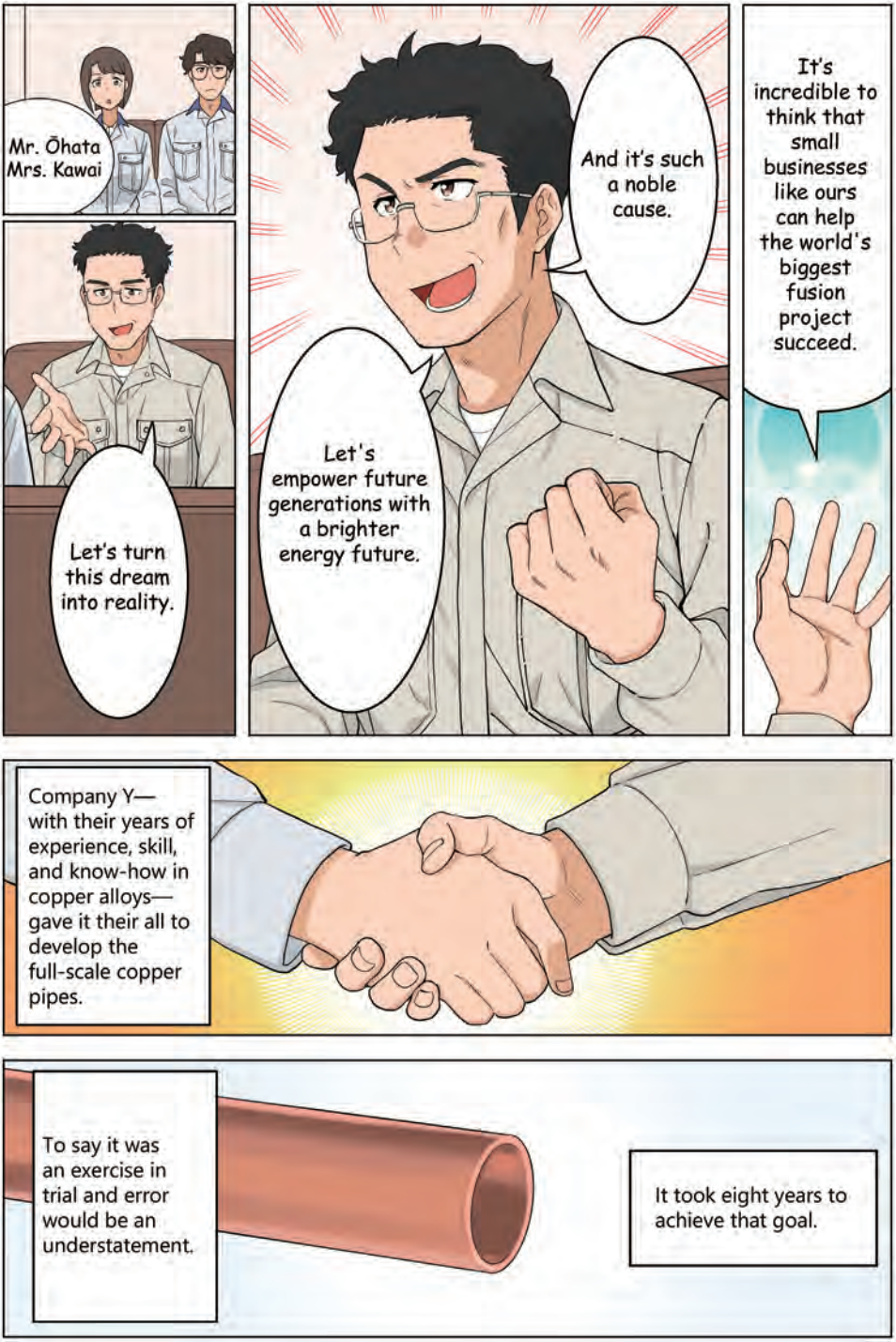

!!
But there is one other company that comes to mind.
Did you hear that, group leader Ōhata!
QST Researcher, group leader Ōhata (a kind-hearted boss)
And that's Company Y.
Their expertise is second to none.
If they can't do it, no one can.
Company Y

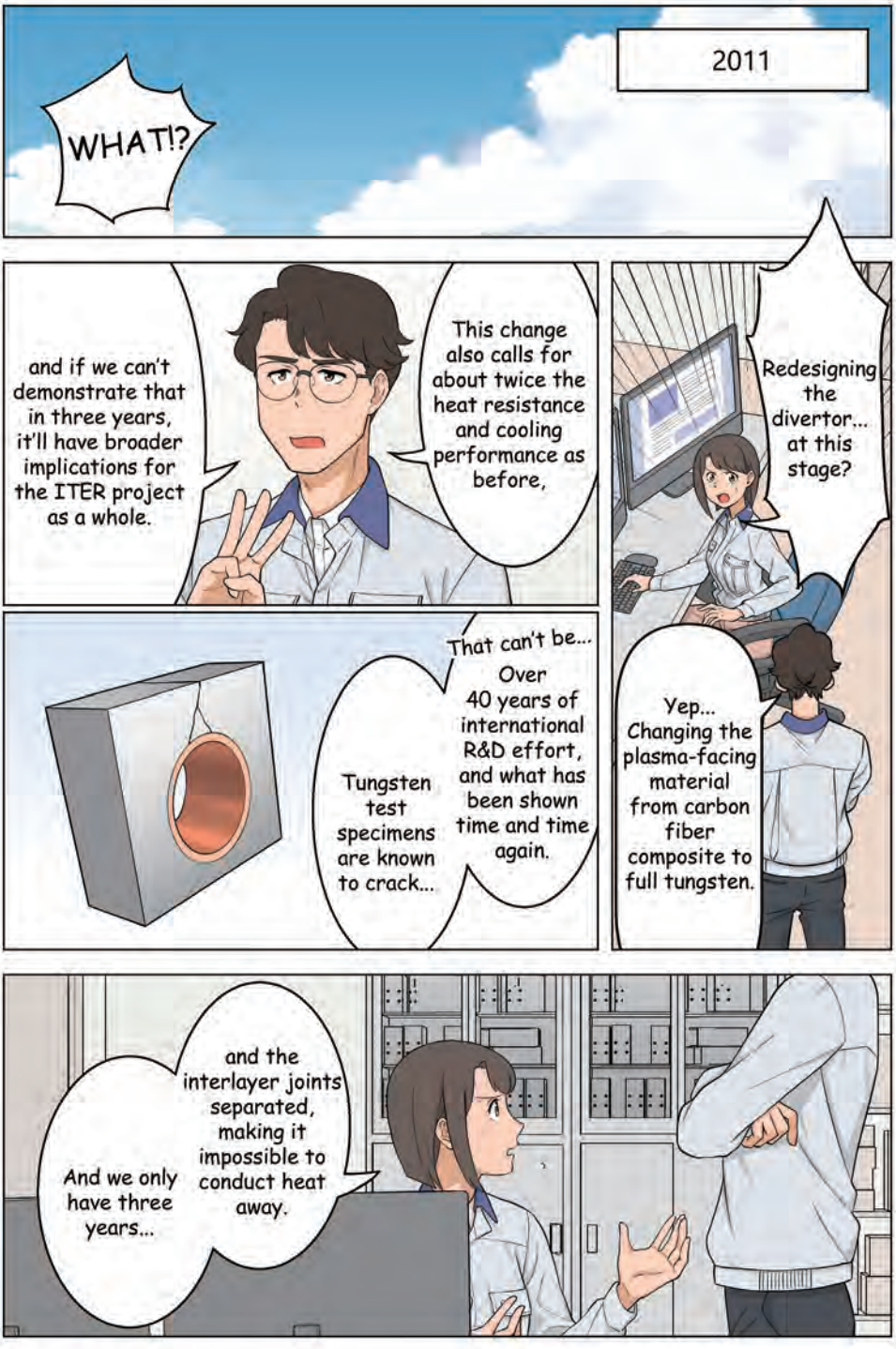

It makes absolutely no sense from a business perspective.
They're going to turn us down...
The more I explain, the more absurd it must sound.


Mrs. Kawai, I'm glad you came to us.
!?
Fusion energy
ITER...


You really mean it!?
Director of Company Y's special copper alloy factory, Shigejiro Hagino
In fact, it'd be an honor.
If we can assist you in any way, we'd be more than happy to help.


You can count on us!
I'll need all hands on deck...
Boss!


Mr. Ōhata
Mrs. Kawai
Let's turn this dream into reality.
Let's empower future generations with a brighter energy future.
And it's such a noble cause.
It's incredible to think that small businesses like ours can help the world's biggest fusion project succeed.
Company Y—with their years of experience, skill, and know-how in copper alloys—gave it their all to develop the full-scale copper pipes.
To say it was an exercise in trial and error would be an understatement.
It took eight years to achieve that goal.

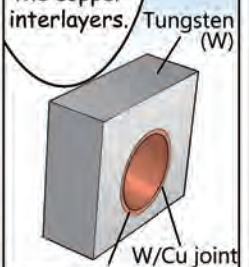

2011
WHAT!?
and if we can't demonstrate that in three years, it'll have broader implications for the ITER project as a whole.
This change also calls for about twice the heat resistance and cooling performance as before,
Redesigning the divertor... at this stage?
Yep... Changing the plasma-facing material from carbon fiber composite to full tungsten.
That can't be...
Over 40 years of international R&D effort, and what has been shown time and time again.
Tungsten test specimens are known to crack...
and the interlayer joints separated, making it impossible to conduct heat away.
And we only have three years...

If they joined forces, it could work.

We'll source the tungsten from Company A, and let Company N take care of the bonding process.

We'd need stronger tungsten blocks.

And a more precise method for bonding the copper interlayers.



Hold on a second...

You do know they're rival companies, right?

We can't possibly ask them to...

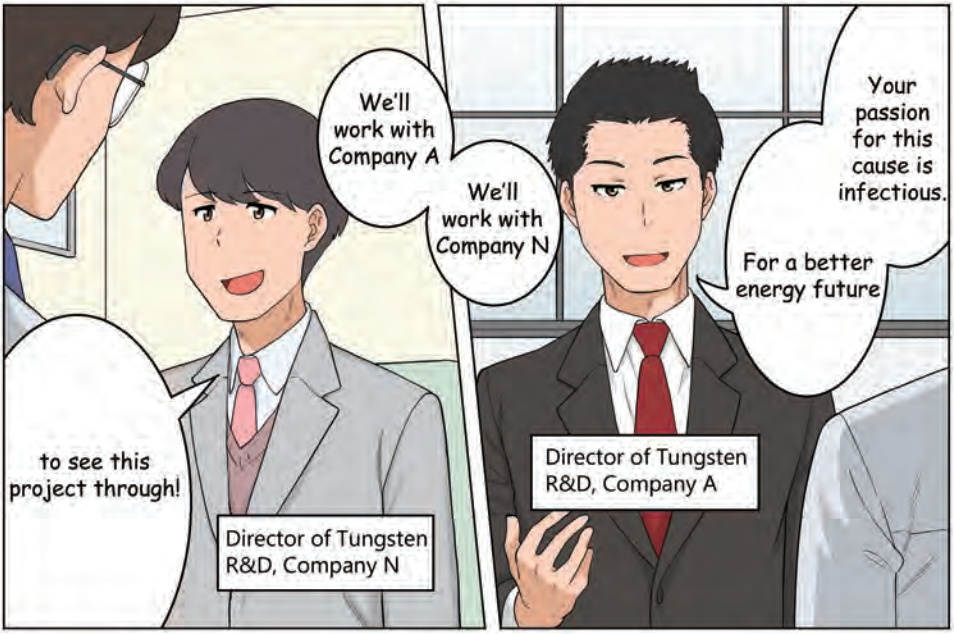
はっ hmm

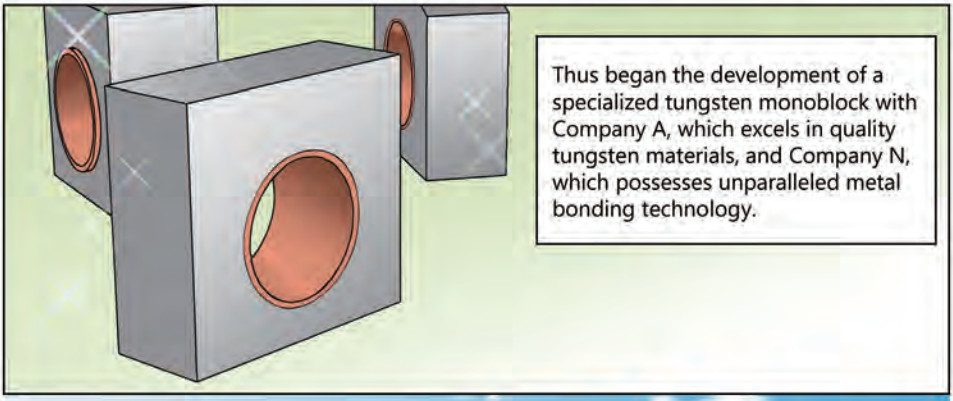
That's where we come in!

Group leader Ōhata...

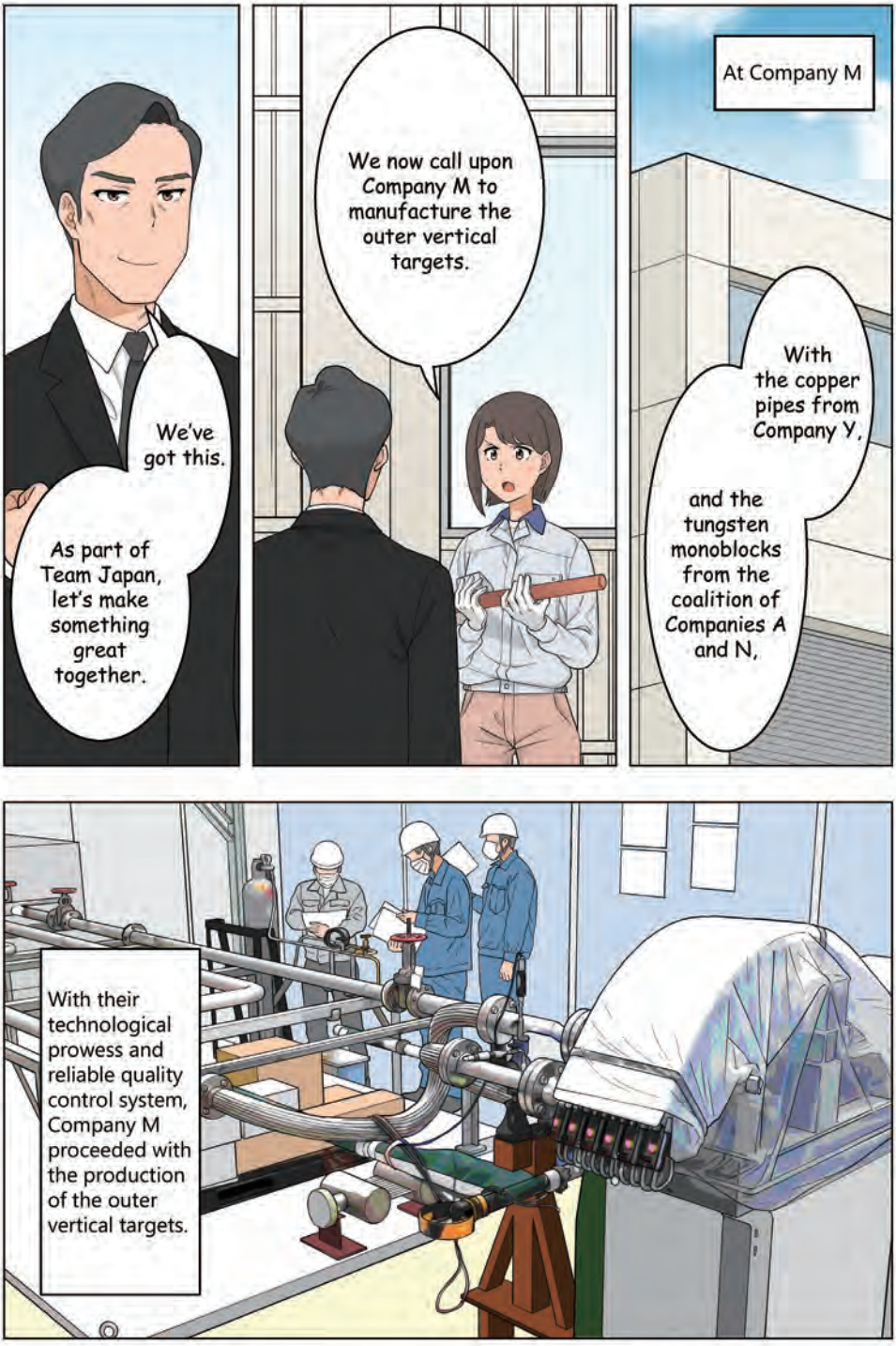
We've got to win them over to the ITER cause by showing them how committed we are—just like we did with the copper piping.


I'll get in touch with both companies right away.
All right let's do this.
カタ
カタ
カタ
カタ
typing sounds
typing sounds

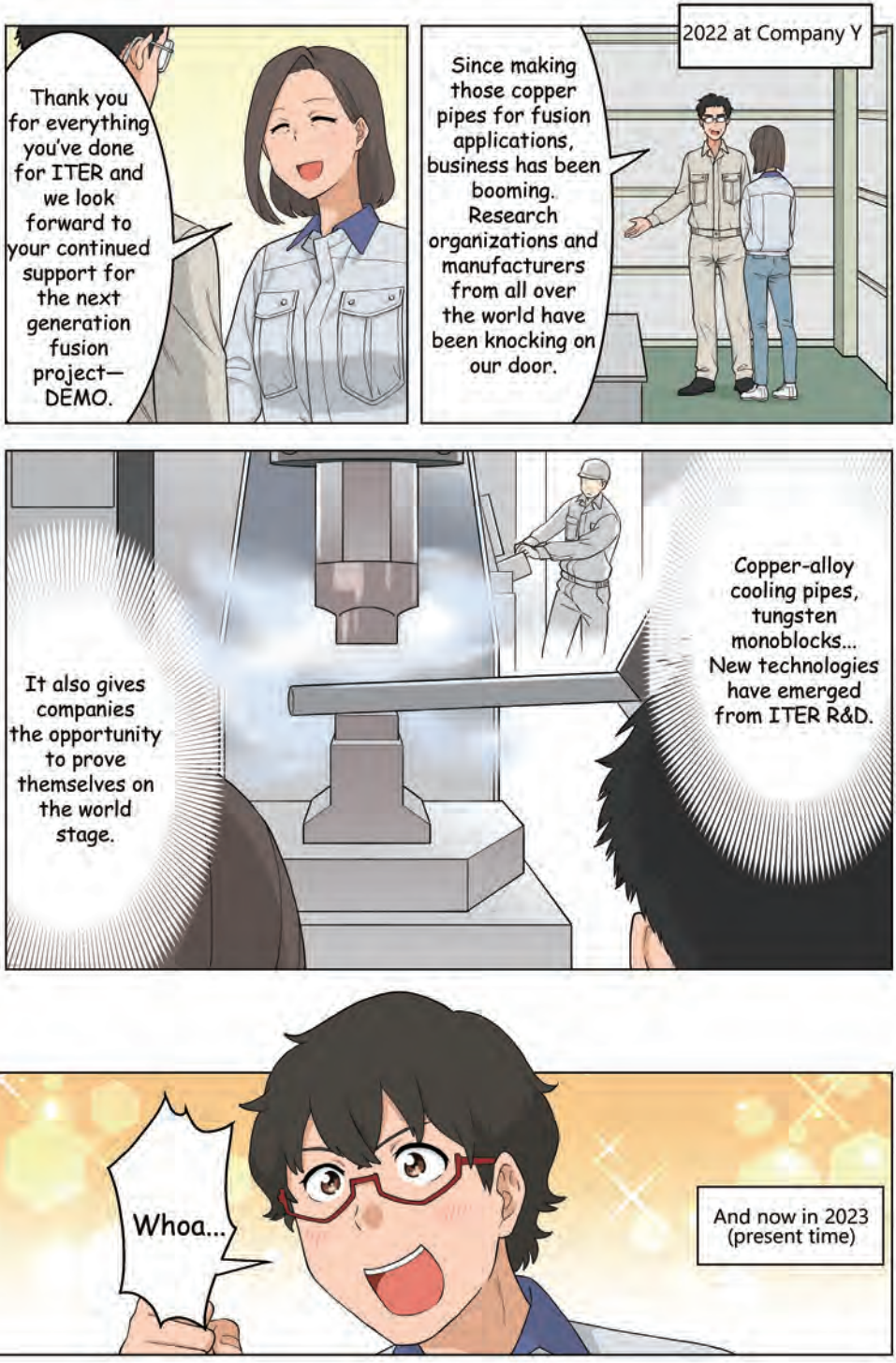

We'll work with Company A
We'll work with Company N
Your passion for this cause is infectious.
For a better energy future
to see this project through!
Director of Tungsten R&D, Company N
Director of Tungsten R&D, Company A

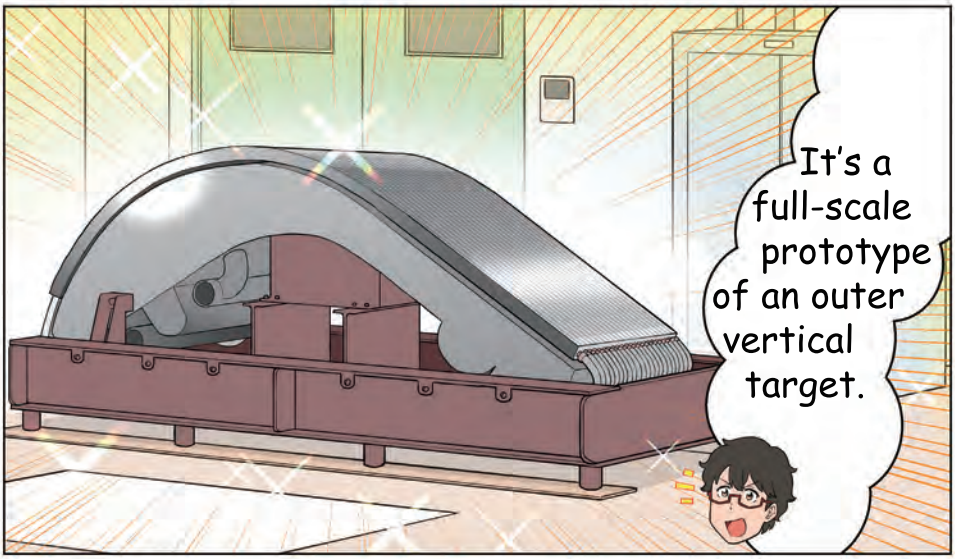

Thus began the development of a specialized tungsten monoblock with Company A, which excels in quality tungsten materials, and Company N, which possesses unparalleled metal bonding technology.

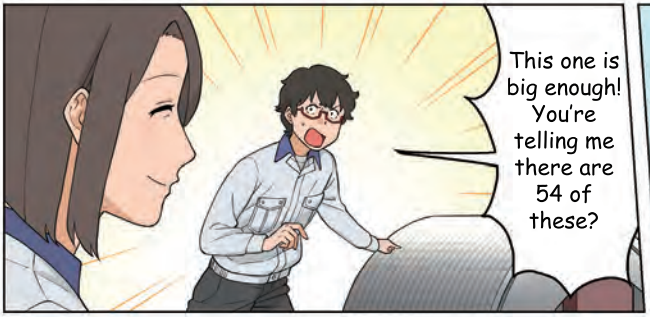

Three years later


At Company M
With the copper pipes from Company Y,
and the tungsten monoblocks from the coalition of Companies A and N,
We now call upon Company M to manufacture the outer vertical targets.
We've got this.
As part of Team Japan, let's make something great together.
With their technological prowess and reliable quality control system, Company M proceeded with the production of the outer vertical targets.

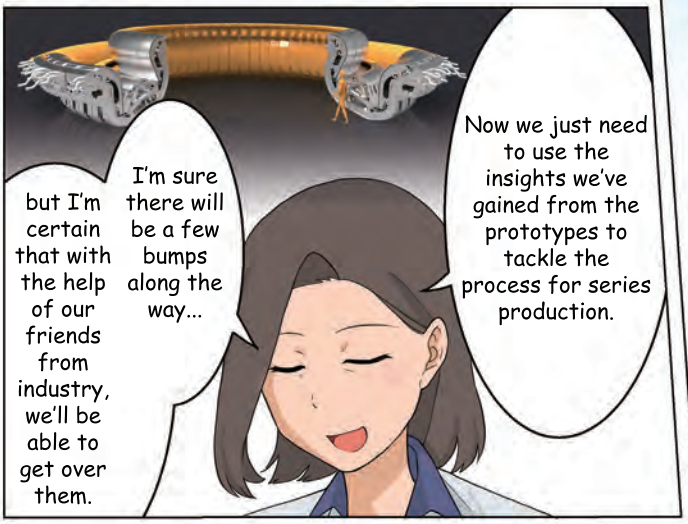

2013
The material for the divertor targets was officially changed to tungsten after successful experiments.
I'm ho-me!
2016
Japan's full-tungsten prototype plasma-facing units first to pass ITER's high heat flux tests.
Entrance ceremony
2021
Company A builds a new plant for the series production of tungsten monoblocks.
2020
Full-scale prototypes are manufactured.


Thank you for everything you've done for ITER and we look forward to your continued support for the next generation fusion project—DEMO.
2022 at Company Y
Since making those copper pipes for fusion applications, business has been booming. Research organizations and manufacturers from all over the world have been knocking on our door.
Copper-alloy cooling pipes, tungsten monoblocks... New technologies have emerged from ITER R&D.
It also gives companies the opportunity to prove themselves on the world stage.
Whoa...
And now in 2023 (present time)


It's a full-scale prototype of an outer vertical target.


This one is big enough! You're telling me there are 54 of these?


These will eventually be attached to 54 divertor cassettes, which will all go in ITER's vacuum vessel.


Now we just need to use the insights we've gained from the prototypes to tackle the process for series production.
I'm sure there will be a few bumps along the way...
but I'm certain that with the help of our friends from industry, we'll be able to get over them.

To be continued

This story is fiction based on real events.

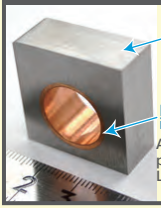
ITER component procured from Japan: Divertor (certain parts)

Members of the Plasma Facing Component Technology Group with an outer vertical target prototype

QST has been developing full-scale prototypes and the process for the series production of the outer vertical targets for ITER's divertor.
In April 2023, the manufacture of a full-scale prototype, which began in June 2020 with Mitsubishi Heavy Industries, Ltd., was completed and delivered for final acceptance testing at QST's Naka Fusion Institute.
(right: high-temperature helium leak tests)

Please visit our ITER Japan News website for more information.
"ITER Divertor Outer Vertical Target (OVT) Prototype in Final Acceptance Tests"

Tungsten monoblocks

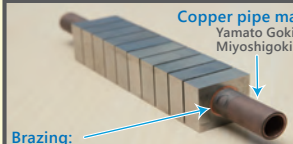


Production of tungsten materials:
A.L.M.T. Corp.

Bonding of copper interlayer (for brazing):
A.L.M.T. Corp. manufacturing partner: Nippon Tungsten Co., Ltd.

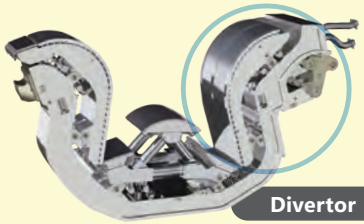
Copper pipes

ITER-grade, chrome-zirconium-copper alloy cooling pipes



Copper pipe manufacturing:
Yamato Gokin Co., Ltd./
Miyoshigokinkogyo Co., Ltd.

Brazing:
Mitsubishi Heavy Industries, Ltd. manufacturing partners:
Osaka Yakin Kogyo Co., Ltd & Metal Technology Co., Ltd.
Hitachi Ltd. manufacturing partner: Metal Technology Co., Ltd.

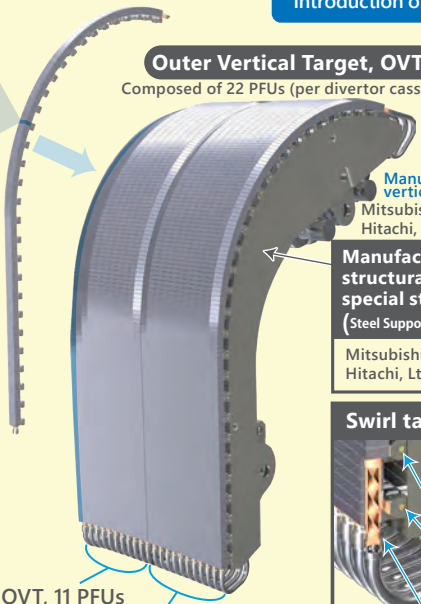


Divertor

Plasma-Facing Unit, PFU

Design and manufacture of ITER components procured from Japan
"Introduction of partner companies"

Outer Vertical Target, OVT
Composed of 22 PFUs (per divertor cassette)



Left OVT, 11 PFUs

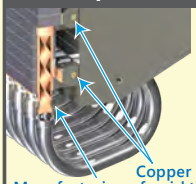
Right OVT, 11 PFUs

Manufacturing of outer vertical targets:
Mitsubishi Heavy Industries, Ltd.
Hitachi, Ltd.

Manufacture of box-shaped structural supports made of special stainless steel, XM-19 (Steel Support Structure, SSS)

Mitsubishi Heavy Industries, Ltd.
Hitachi, Ltd.

Swirl tape



Copper pins

Manufacturing of swirl tape:
Kikuchi Metal Factory Co., Ltd.

Information about living in southern France

Discover modes of transportation, accommodations,and tourist spots around ITER!

Life at ITER

Wondering where you'd live if you joined the ITER Organization?
Check out our guide to local hotels and apartment-style accommodations.

Aix-en-Provence Area Map

Aix is a vibrant university town and is popular with younger staff and business travelers alike. It's just a 30 to 40-minute drive from the ITER Organization.

Manosque Area Map

Manosque is home to the Ecole Internationale Provence-Alpes-Cote d'Azur (EIPACA) and is a popular choice for staff relocating with their families.

Liaison Office

Providing support to Japanese staff at the ITER Organization in their daily lives.

Introduction to the Liaison Office

Click here for information on the Liaison Office's services and staff.

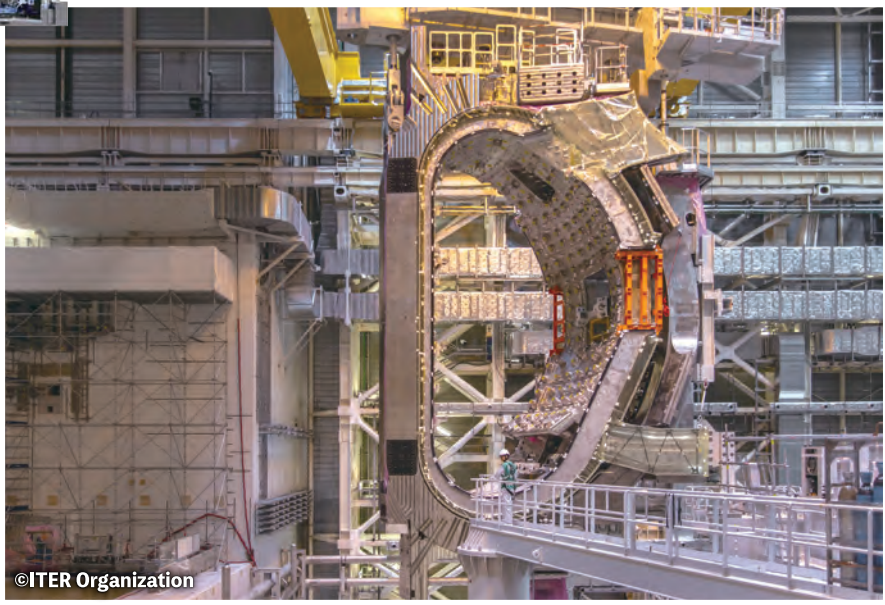
Located on the premises of the ITER Organization, the ITER Japan Liaison Office assists Japanese staff with local administrative and day-to-day affairs so they can concentrate on their work with confidence and peace of mind.

From ideas for how to spend your days off to where you can find Japanese food locally, we share a wealth of knowledge!

Check out the Liaison Office Staff Blog!

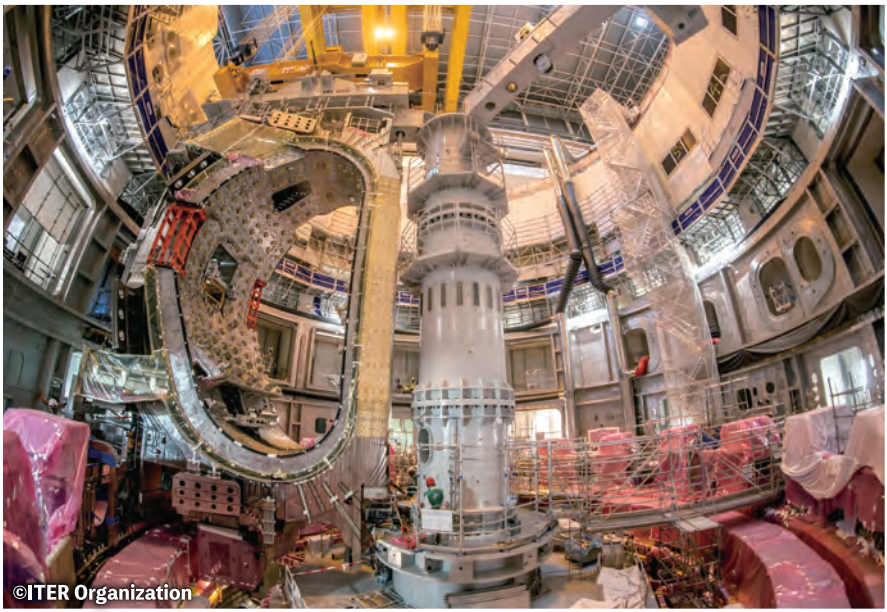
Our blog brings you the Provençal charm of southern France—its seasonal shifts, local flavors, and laid-back lifestyle.

ITER Assembly Progress



A sub-sector being transferred from the Assembly Hall to the Tokamak Pit (April 2025)

An 18-meter-tall sub-sector is lifted over the wall of the assembly hall into the tokamak pit. A worker in green monitors the clearance between the sub-sector and the wall.



Tokamak Pit (April 2025)

The sub-sector on the left is one of nine segments that, like the reverse of peeling an orange, will come together to form the ITER machine.

ITER Site (May 2025)
©ITER Organization

A small Sun on Earth
ITER ～4 volumes in one epic omnibus～

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ITER Comic
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