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High-fidelity computational studies of roughness effects on high-pressure turbine performance

Melbourne Energy Institute Symposium
December 8, 2023

T. O. Jelly

Outline



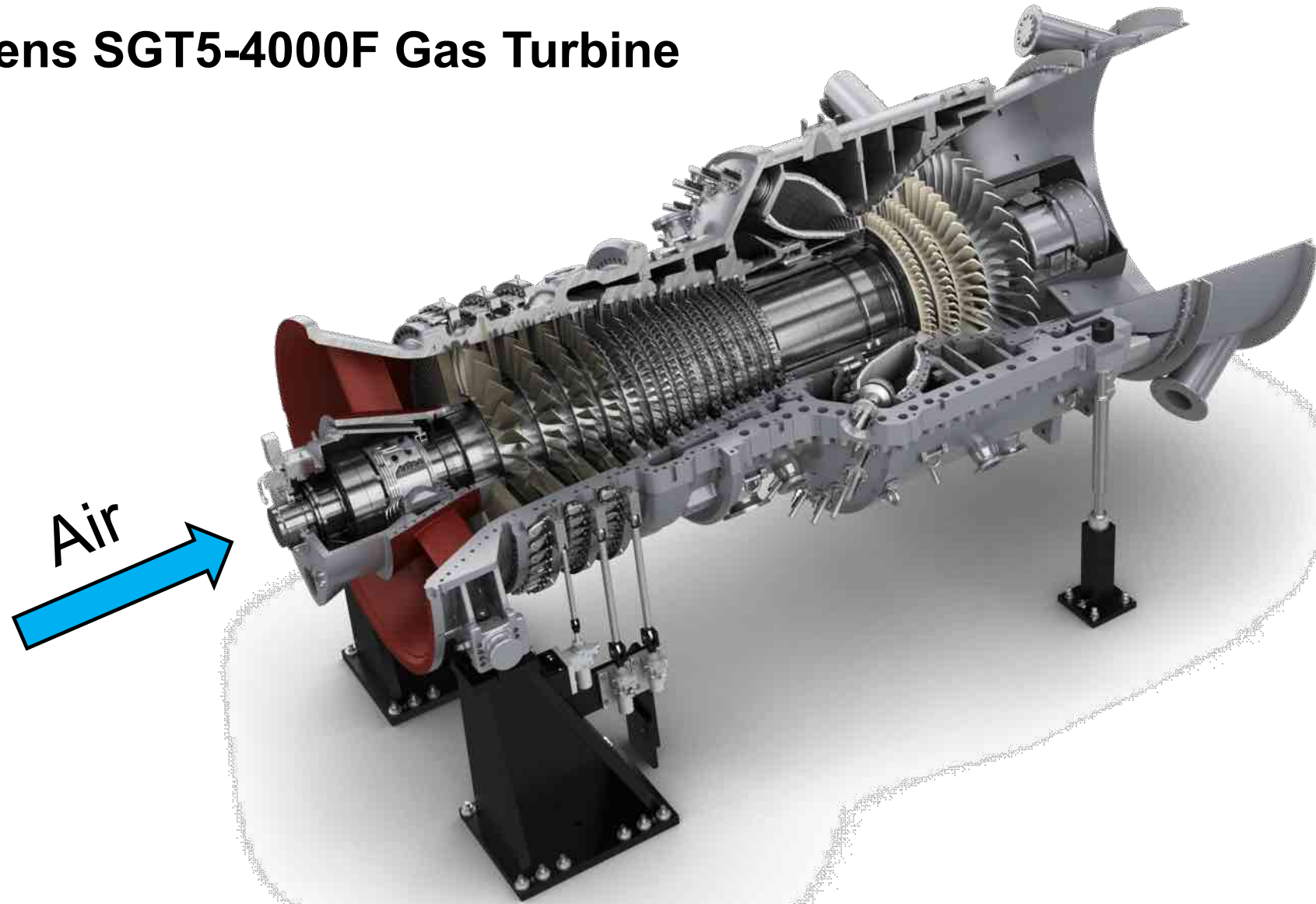
Turbines – What are they & why can't we live without them?

Surface roughness – Where does it come from & why does it matter?

Research activities – Computer simulations of flow over rough turbine blades.

Industrial impact – Partnership with GE Aerospace (world-leading turbine manufacturer).

Siemens SGT5-4000F Gas Turbine



Cambridge
Dictionary

Turbine: *“a machine through which liquid or gas flows and turns a special wheel with blades in order to produce power.”*

Tallawarra B Power Station, Illawarra, NSW



Key facts:

Fuel: [Hydrogen/gas blend](#)

Generating units: General Electric 9F.05 Gas Turbine

Capacity: 316 MW (~ 60,000 homes)

Commissioned: 2022

Cost: ~\$400M AUD.



Tallawarra B Power Station, Illawarra, NSW



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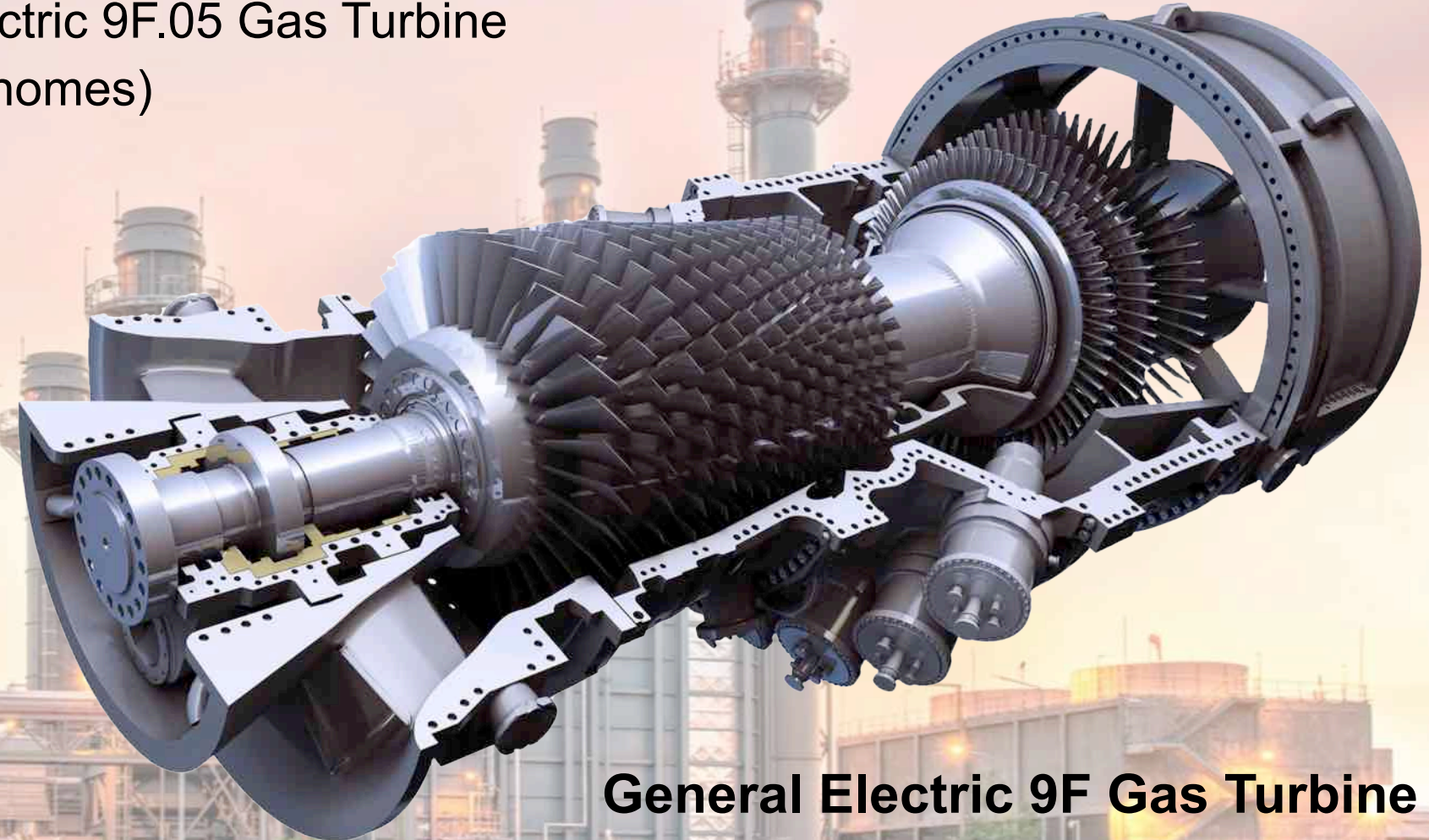
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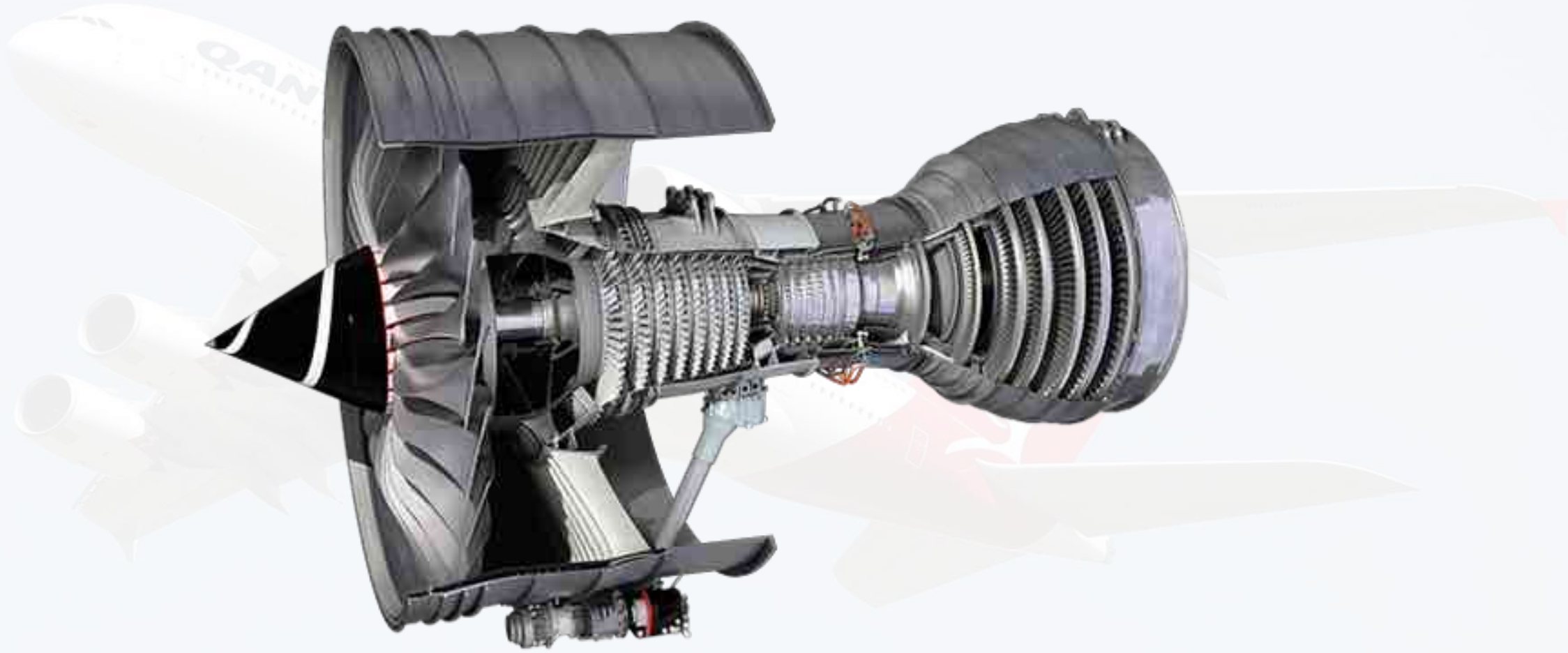


General Electric 9F Gas Turbine

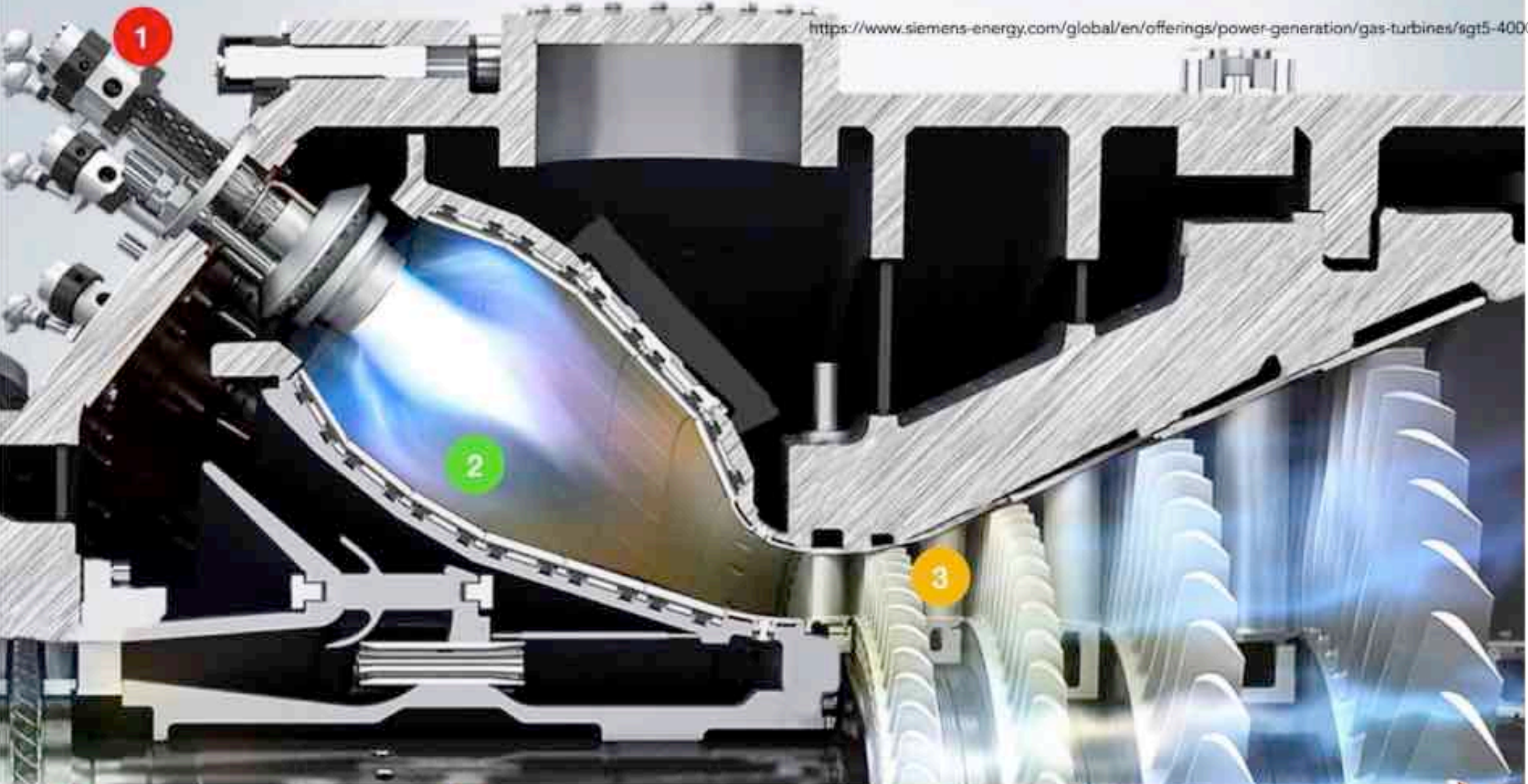
Aviation sector employs ~ 700,000 workers and accounts for ~ 5% of GDP



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Rolls-Royce Trent 900 Gas Turbine Engine



1 Fuel injectors

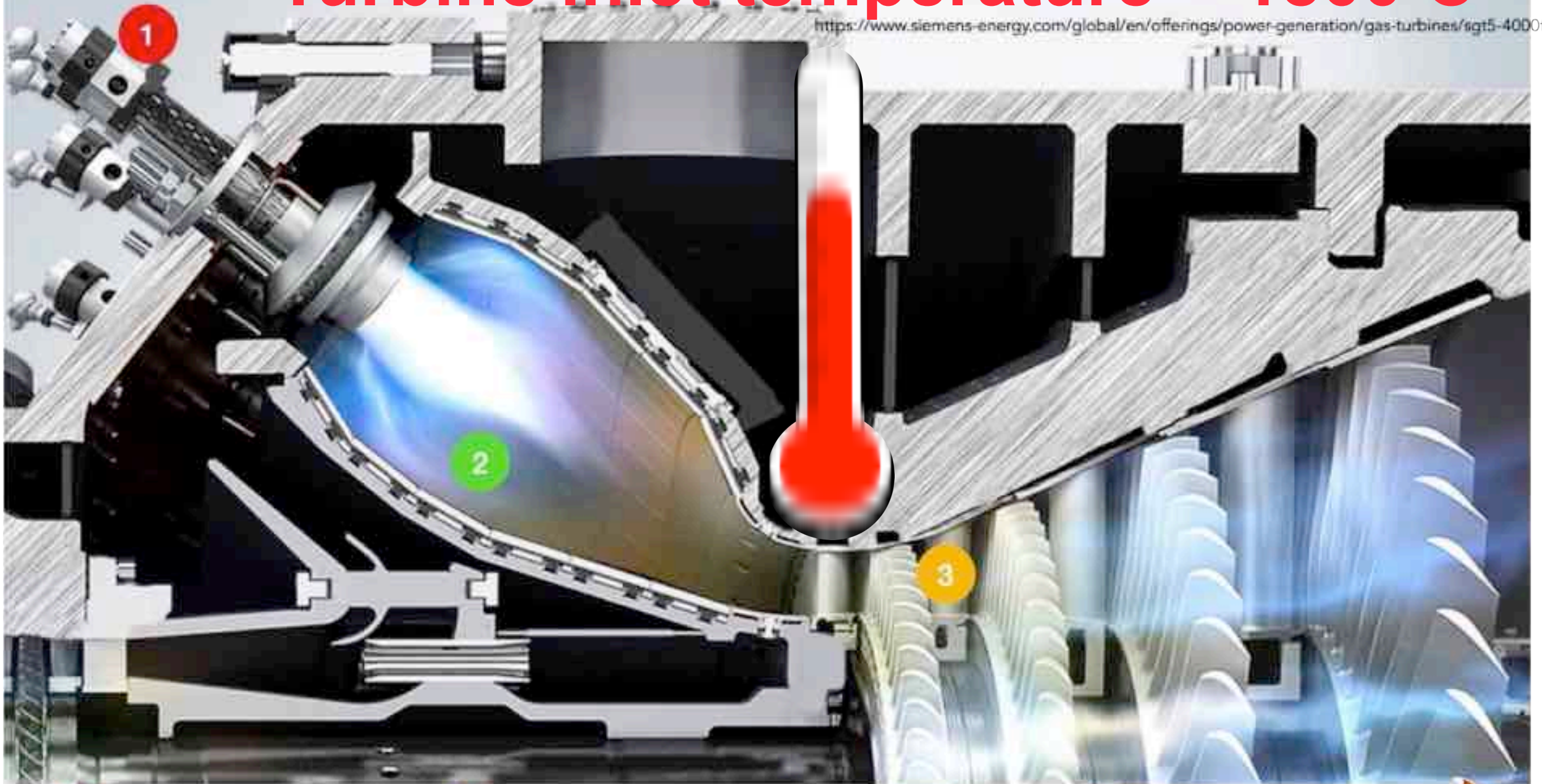
2 Combustion chamber

3 Turbine

Hot gas stream

Turbine inlet temperature = 1800 C

<https://www.siemens-energy.com/global/en/offerings/power-generation/gas-turbines/sgt5-400of.html>



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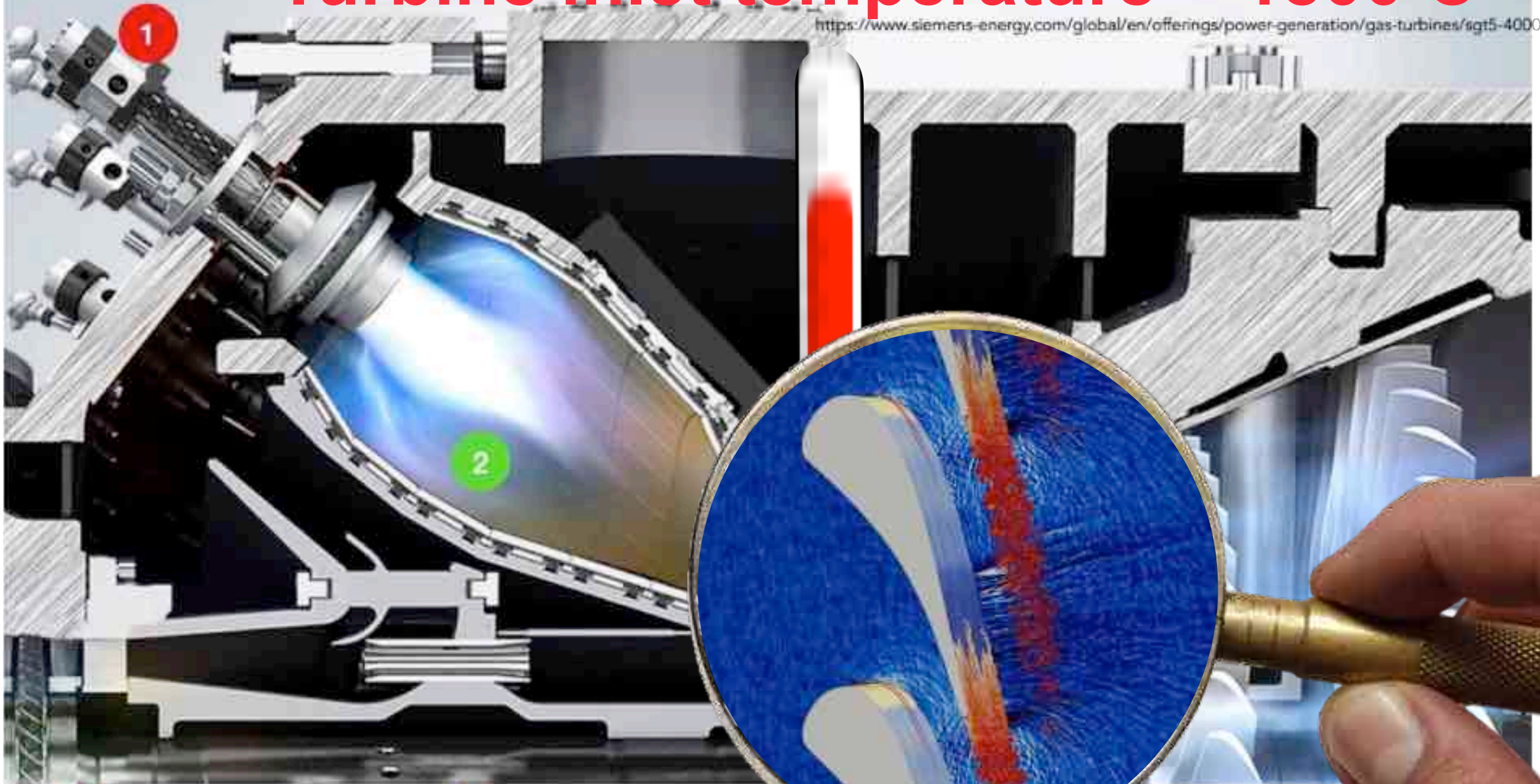
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1 Fuel injectors

2 Combustion chamber

Hot gas stream

Blade surface roughness resulting from in-service wear and / or the manufacturing process **reduces the fuel efficiency** of turbines.



“As-built”



Polished

Surface roughness effects on turbine performance are far from understood and **no models exist that are generally applicable and accurate.**

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Oak Ridge National Laboratory, TN, USA

FRONTIER

FIRST TO BREAK THE
EXASCALE BARRIER AND
FASTEST COMPUTER
IN THE WORLD

1.1
EXAFLOPS

FRONTIER CAN DO MORE
THAN **1 QUINTILLION**
CALCULATIONS PER SECOND.

1
SECOND

IF EACH PERSON ON EARTH
COMPLETED **ONE CALCULATION**
PER SECOND, IT WOULD TAKE MORE
THAN **4 YEARS** TO DO WHAT AN EXASCALE
COMPUTER CAN DO IN **1 SECOND**.

700
PETABYTES

FRONTIER'S ORION STORAGE
SYSTEM HOLDS **35 TIMES** THE
AMOUNT OF DATA HOUSED IN
THE LIBRARY OF CONGRESS.

8,000
POUNDS

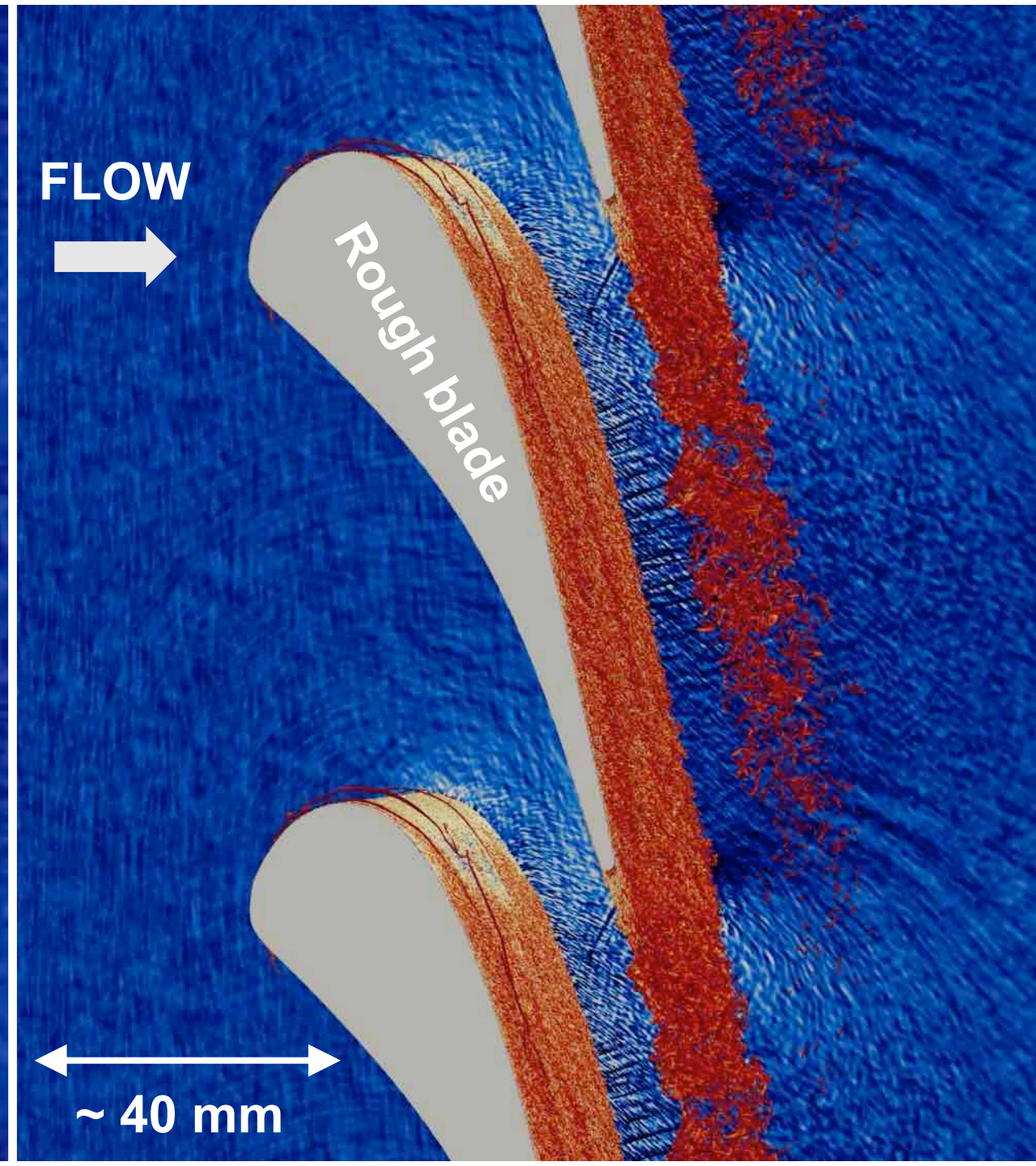
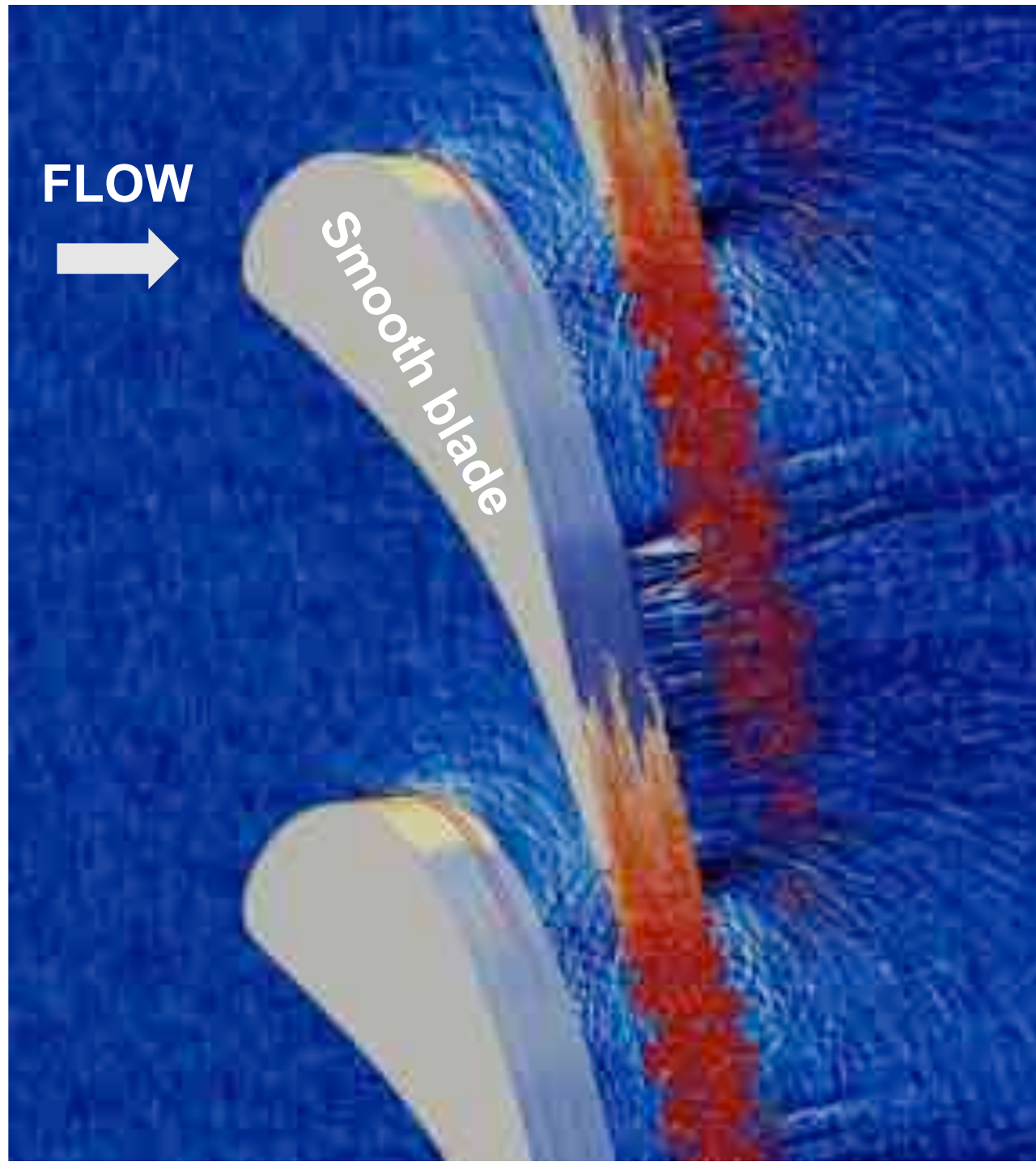
EACH CABINET WEIGHS
THE EQUIVALENT OF A
FULL-SIZE PICKUP TRUCK.

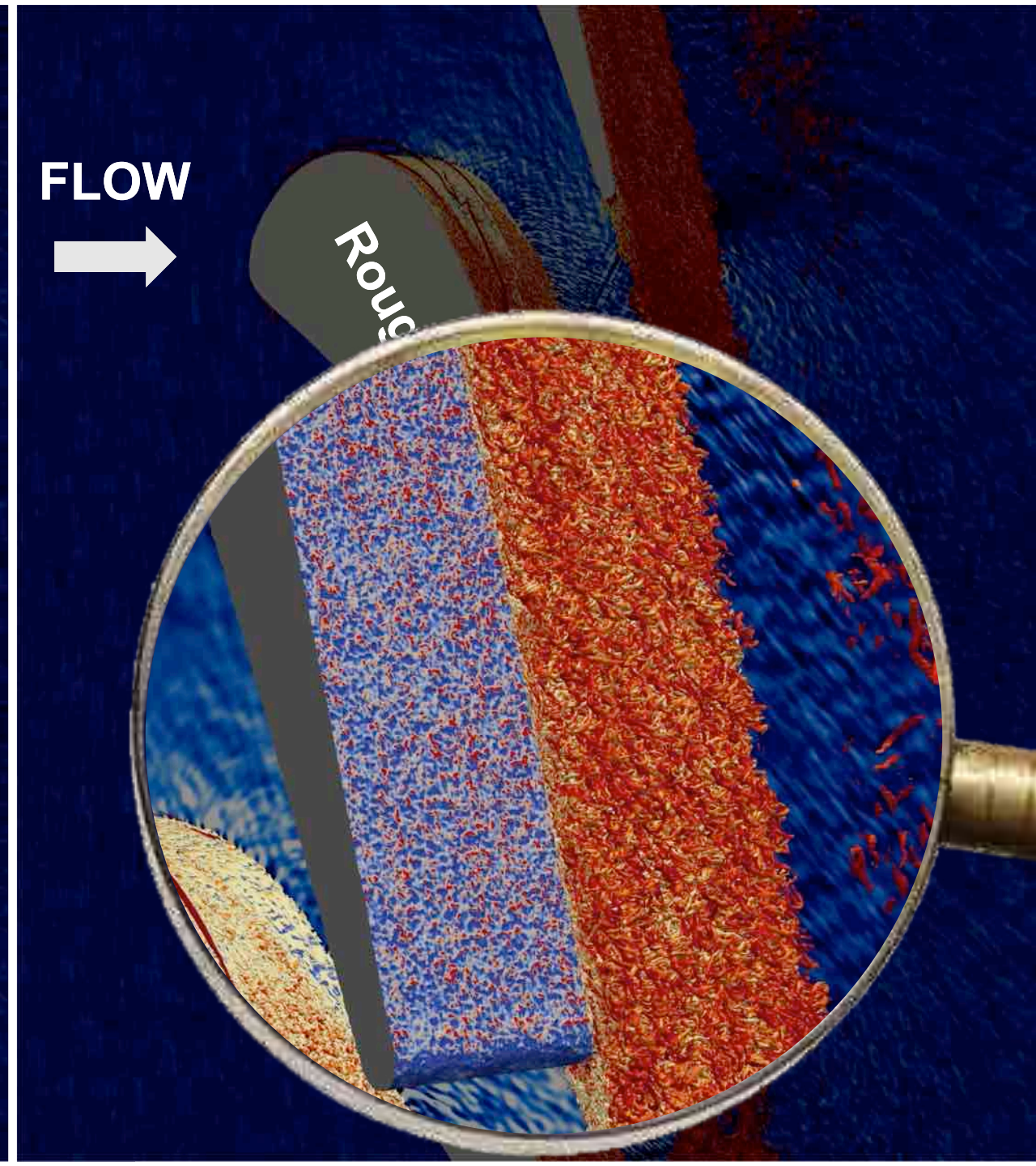
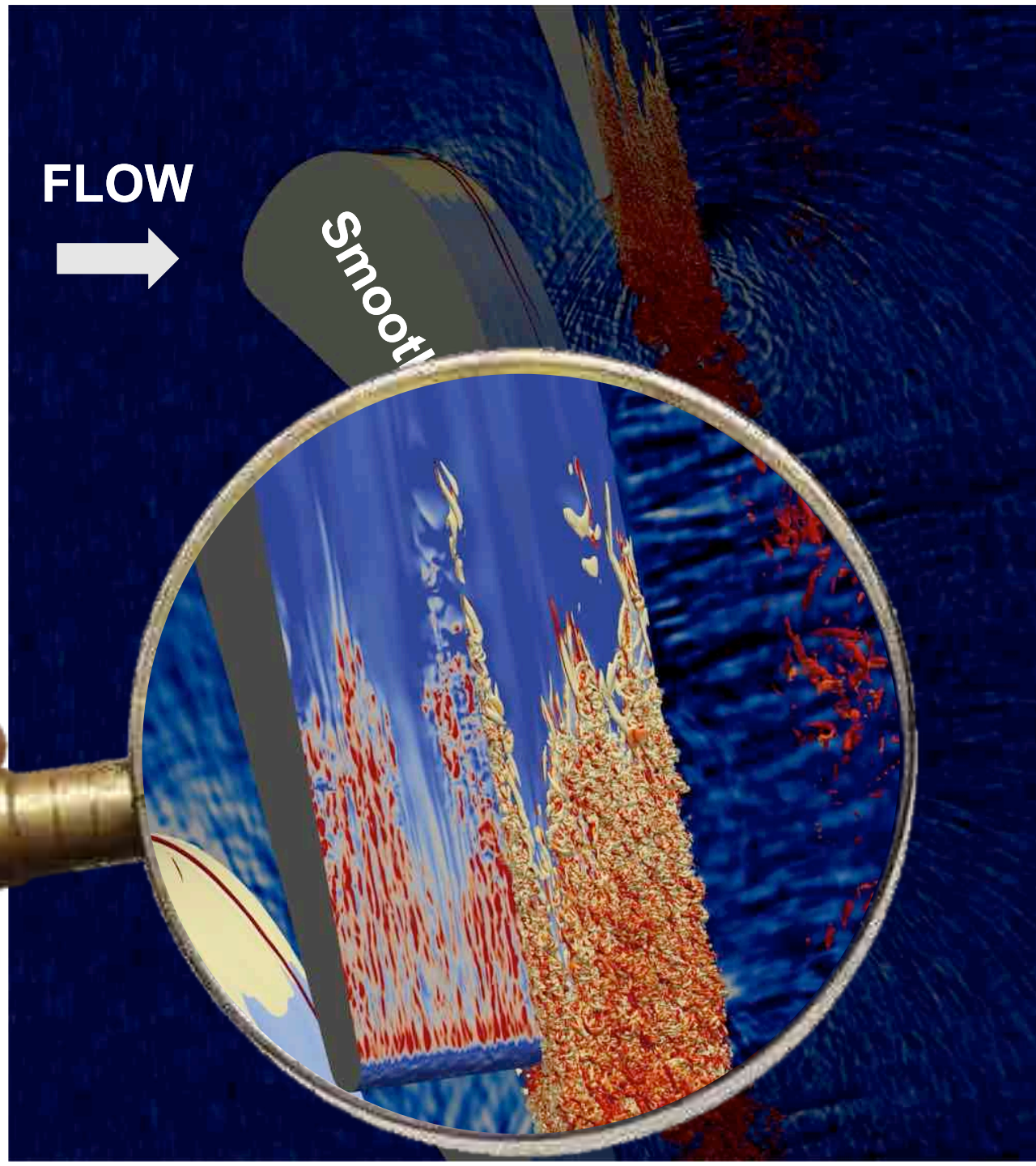
6,000
GALLONS

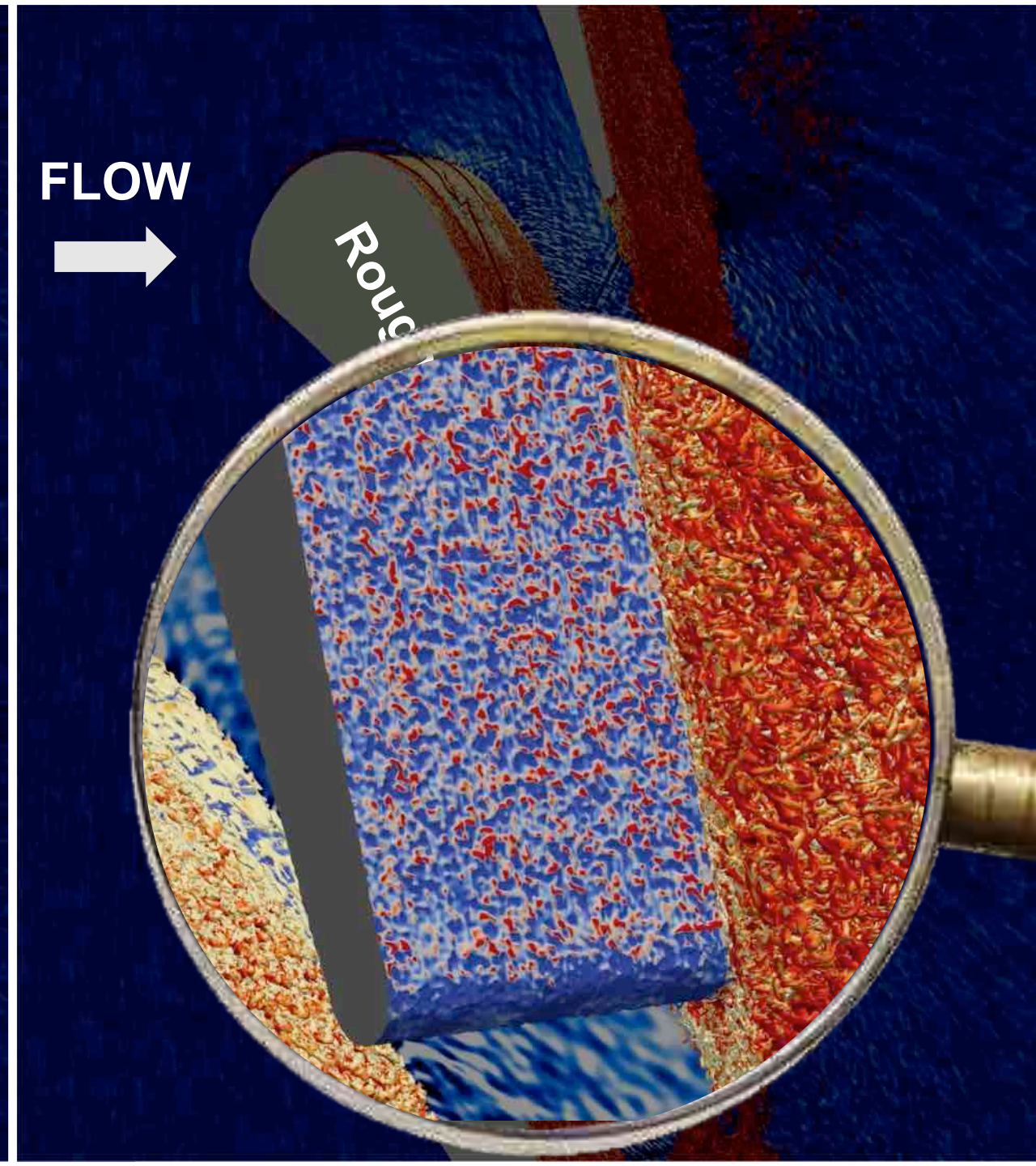
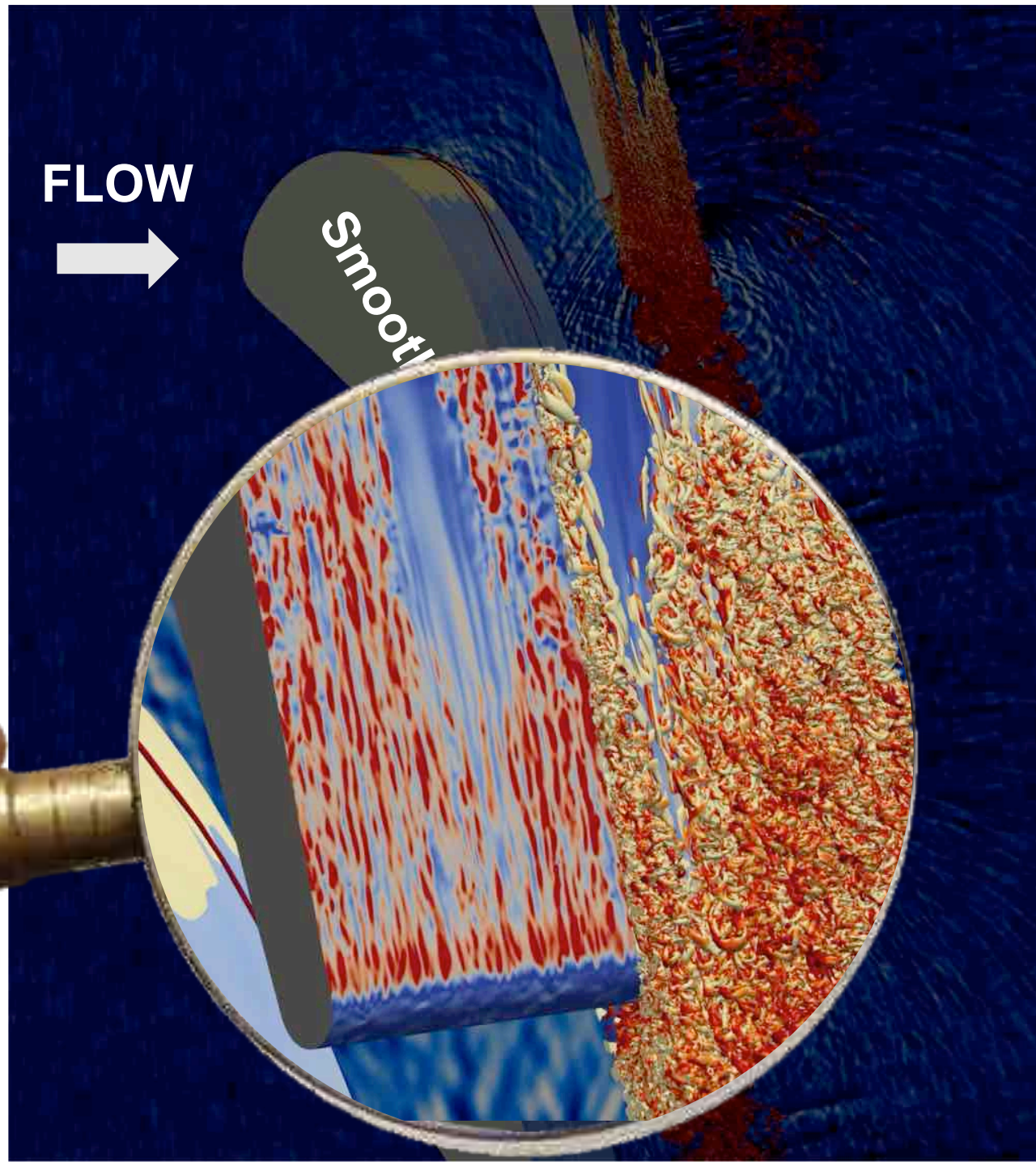
OF WATER IS MOVED THROUGH
THE SYSTEM PER MINUTE BY
FOUR **350-HORSEPOWER PUMPS**.
THESE POWERFUL PUMPS COULD FILL AN
OLYMPIC-SIZED SWIMMING POOL
IN ABOUT **30 MINUTES**.

40
MEGAWATTS

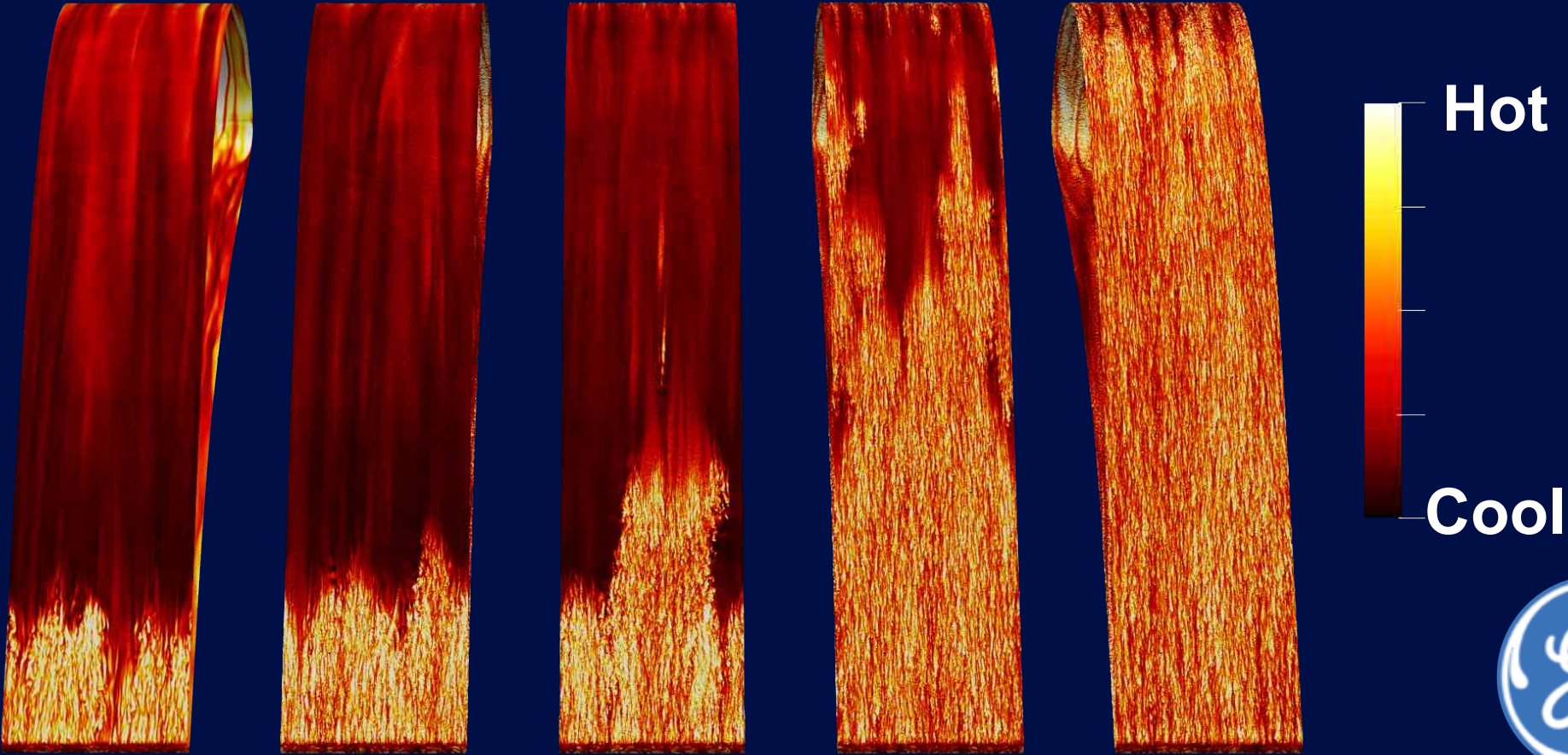
FRONTIER'S MECHANICAL
PLANT CAN COOL THE
EQUIVALENT POWER DEMAND OF
ABOUT **30,000 U.S. HOMES**.







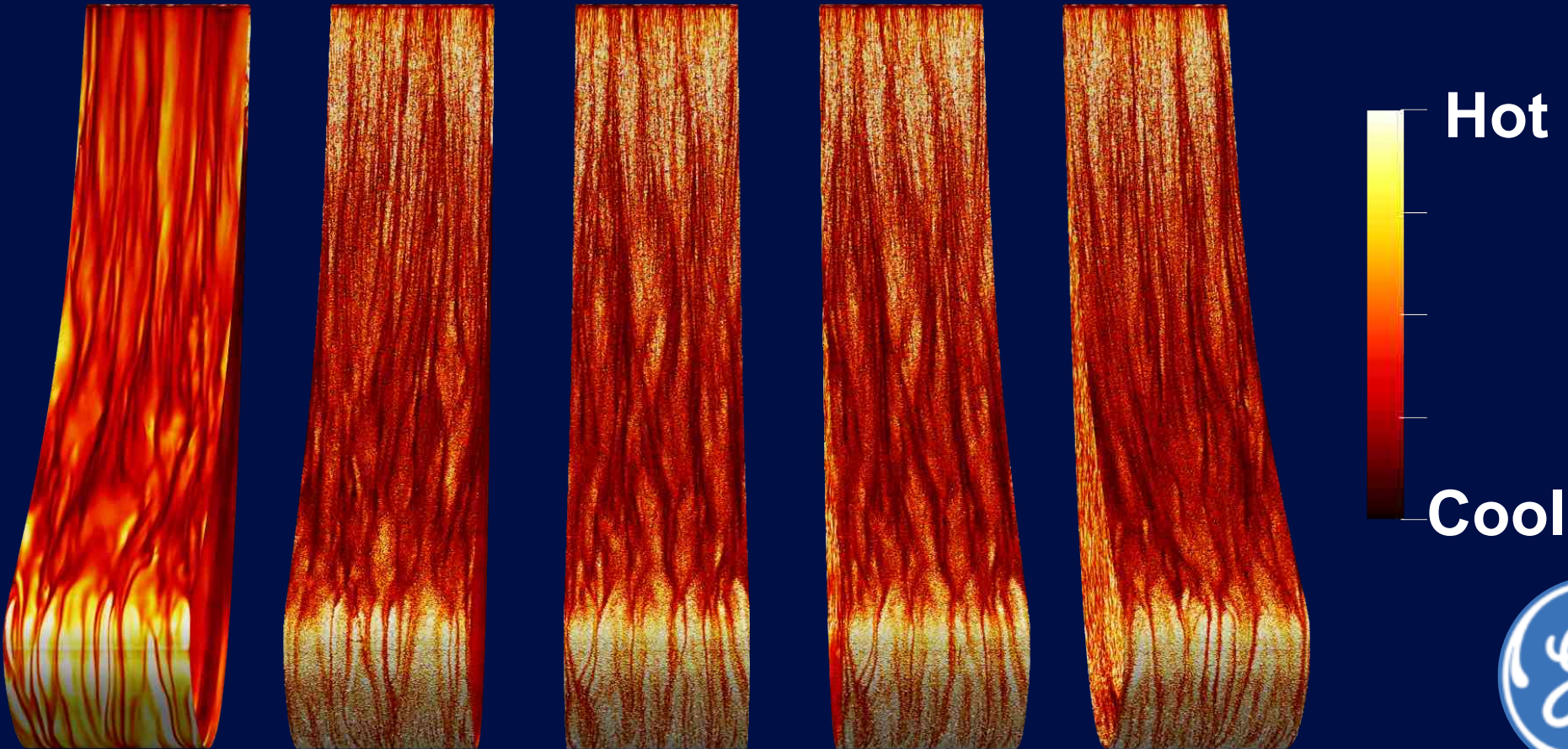
Systematic studies of roughness effects on turbine blade heat transfer



Fundamental research

Outcomes for industry

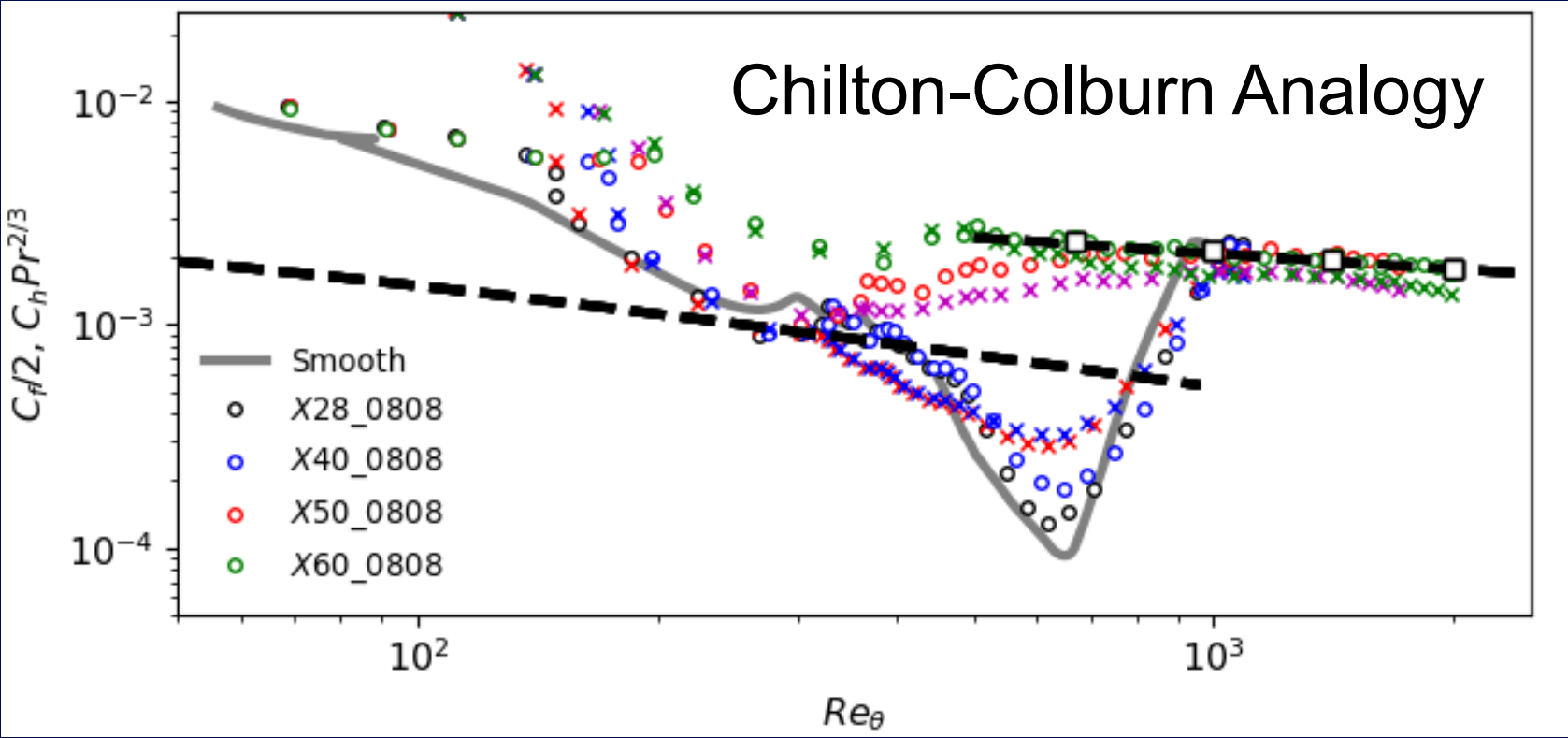
Systematic studies of roughness effects on turbine blade heat transfer



Fundamental research

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Fundamental research

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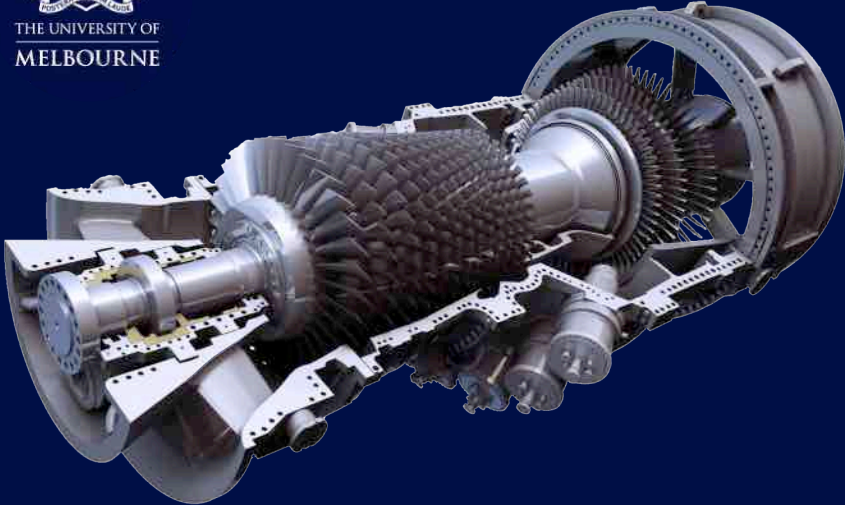
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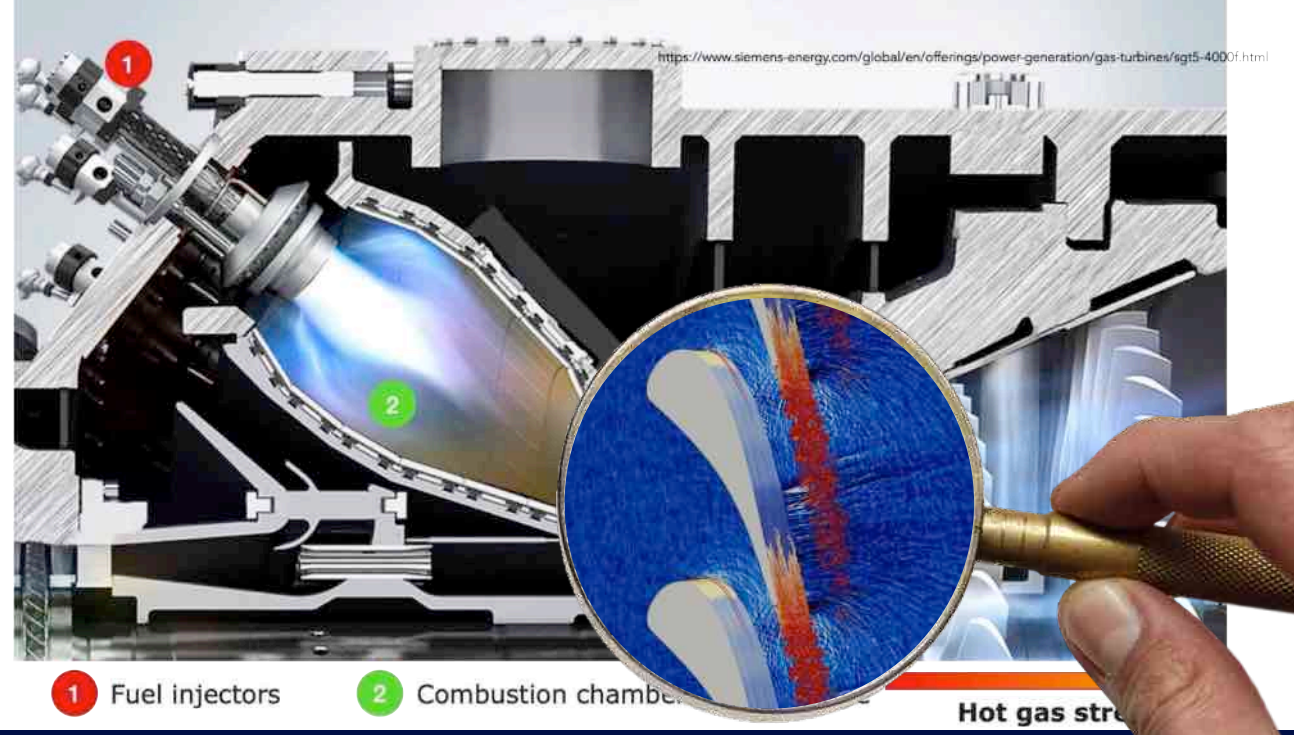
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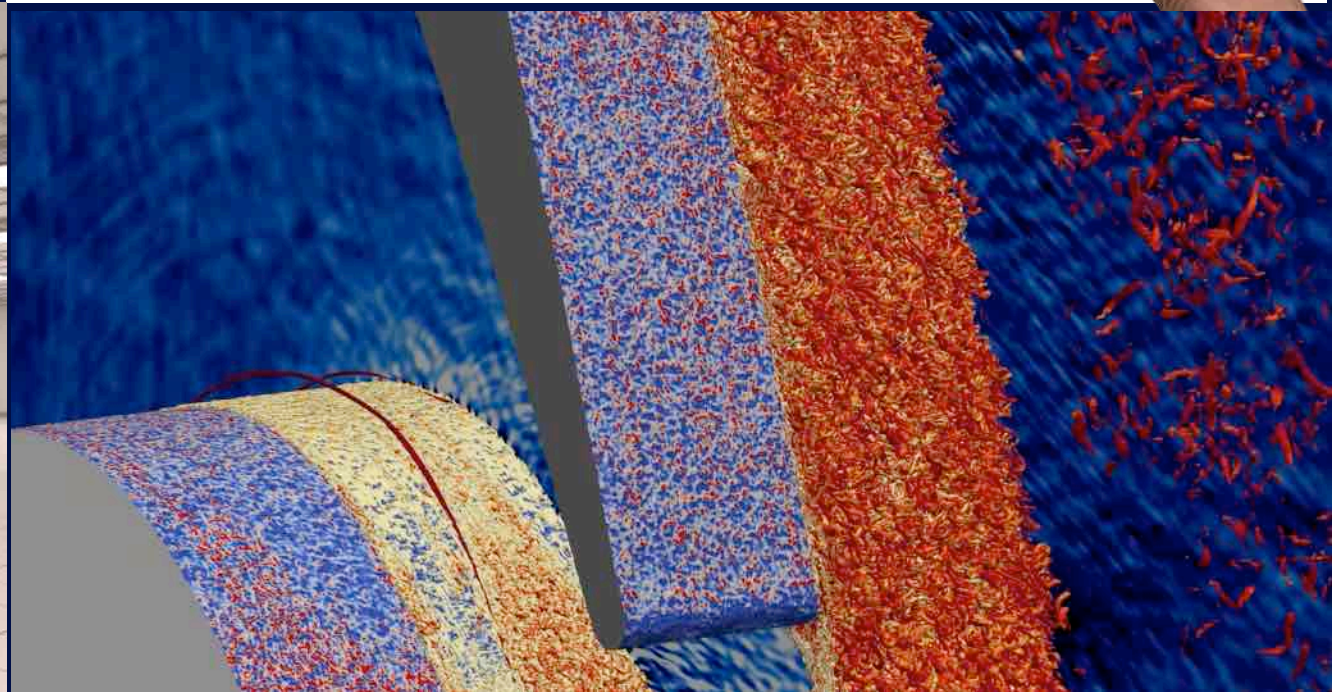
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H
Hydrogen
100%



1 Fuel injectors 2 Combustion chamber Hot gas stream





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Thank you for your attention