COMSOL CONFERENCE
2016 MUNICH

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An Application Built with the COMSOL Multiphysics® Software for Managing Computational Sequences in Thermal Fluid Applications

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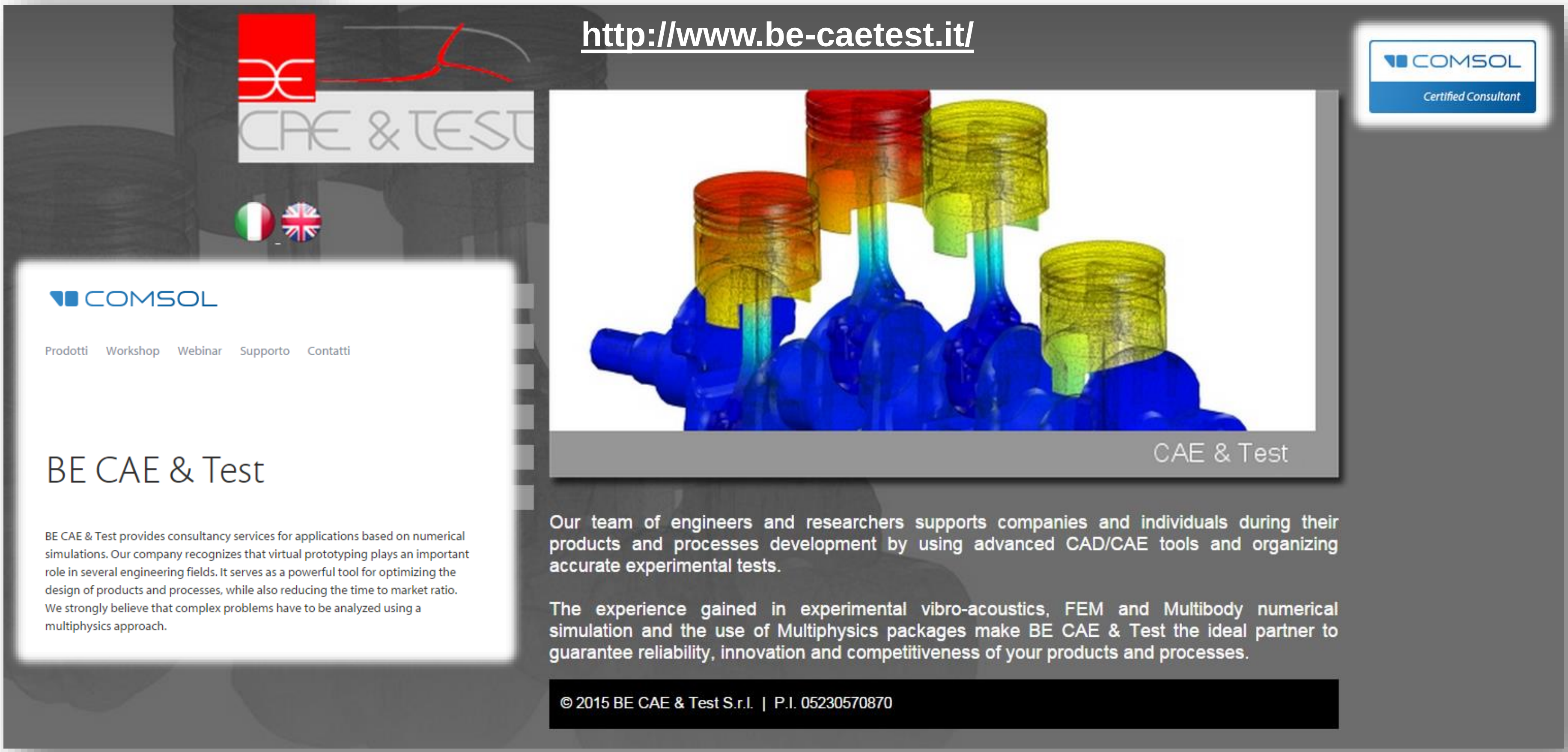
COMSOL Certified Consultant

http://www.be-caetest.it

BE CAE & Test (http://www.be-caetest.it) provides consultancy services in several industrial sectors by using innovative **CAD/CAE modelling tools** and carrying out **experimental campaigns**

The company collaborates with **industrial partners** and **research centers** in several technologic fields



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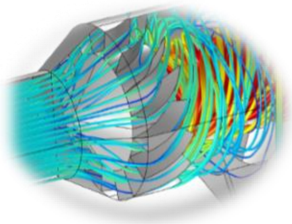
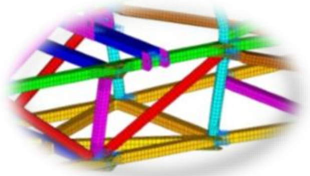
multiphysics

➢ Fluid dynamics and thermal analyses



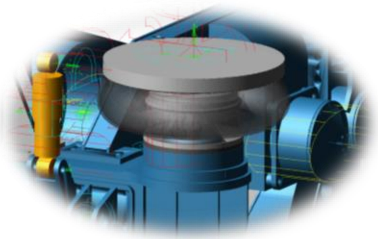
- Environmental energetics (HVAC, thermal comfort, IAQ)
- Industrial energetics (Thermal design, energy conversion, reacting flows)

➢ Structural analyses



- Linear and non-linear statics, dynamic and vibro-acoustics analyses in industrial and civil applications

➢ System dynamics and Multi-Body analyses

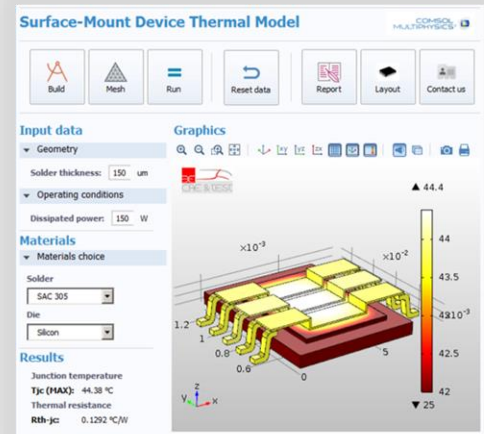


- Vehicle and rail dynamics (handling, ride comfort)
- Kinematics, dynamics, rigid and flexible bodies analyses of mechanisms

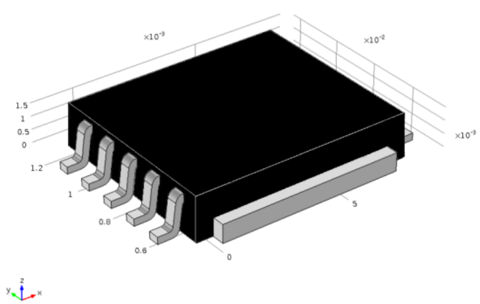
➢ Experimental testing

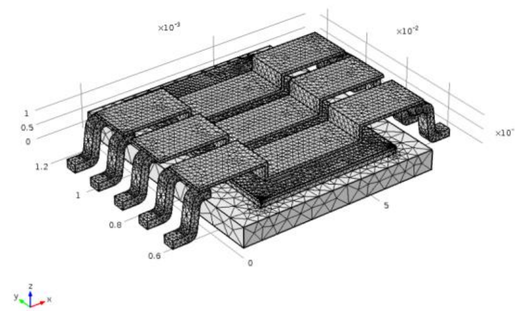
- Ride comfort (NVH), modal analyses
- Vibro-acoustics

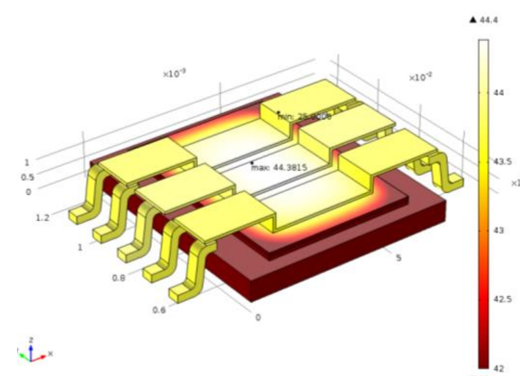
- **BE CAE & Test** strongly supports the concept **«FROM MODEL TO APP»**



FROM MODEL TO APP





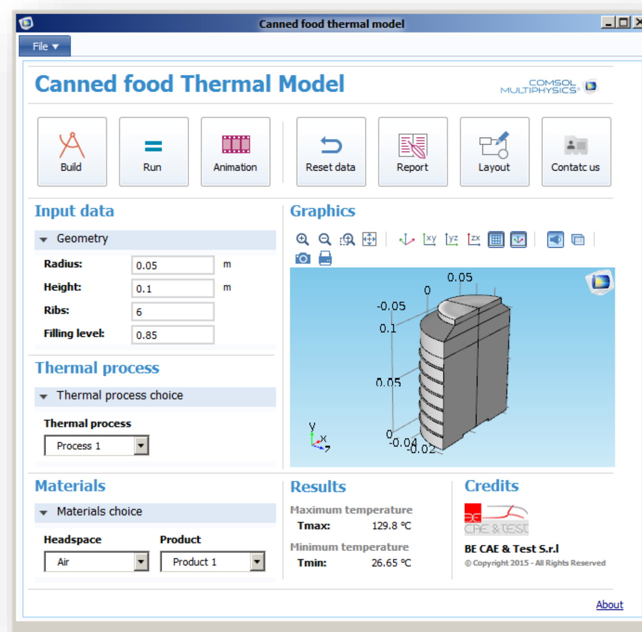


- **Why building a COMSOL App*?**

  *"… Apps mark a **revolutionary page in** the history of mathematical **modeling** and numerical simulation: these specialized and <u>**user-friendly tools bring the power of numerical simulation to a larger group of users…**</u>."*

  *"… <u>people</u> with no prior experience from FEA or mathematical modeling <u>can **access, exploit, and benefit from analysis…"**</u>*

  *"…simulation apps can create <u>**more business opportunities with customers**</u>. Beyond simply providing them with a technical report, you are also <u>supplying them with an interactive tool…they can use to **investigate the problem on their own** …"</u>*



*Extract from COMSOL Press Release «Simulation Apps Pave New Frontier for Virtual Prototyping of Surface-Mount Devices»
https://www.comsol.com/press/news/article/3231/

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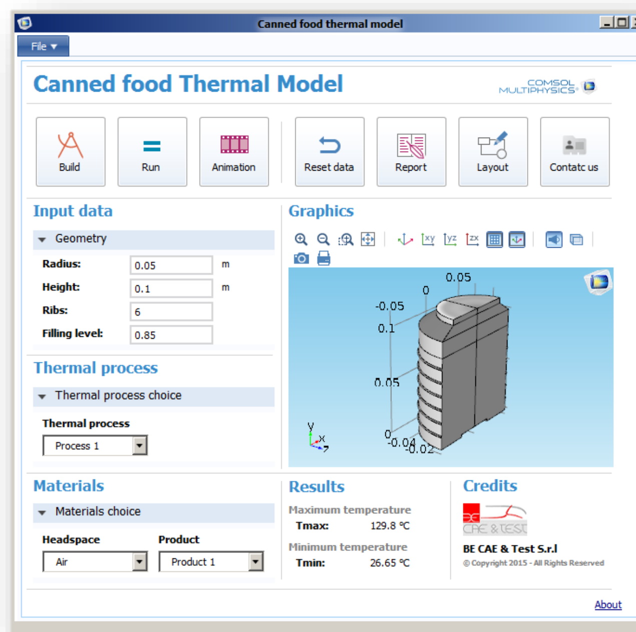
  *"…simulation apps can create **more business opportunities with customers**. Beyond simply providing them with a technical report, you are also supplying them with an interactive tool…they can use to **investigate the problem on their own** …"*

FOCUS ON CUSTOMER

Can the model developer have a benefit for himself by using the Application Builder?

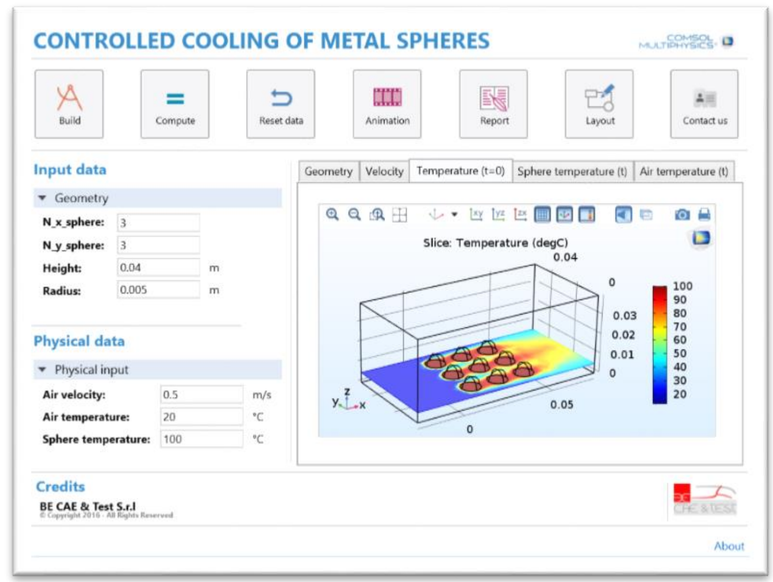
- Try to **use the Application Builder to make our work** easier
- **Automating models by** using **the Application Builder**



Introduction / *Motivation*

- We built a demo Comsol App to investigate this opportunity:

An Application Built with the COMSOL Multiphysics® Software for Managing Computational Sequences in Thermal Fluid Applications



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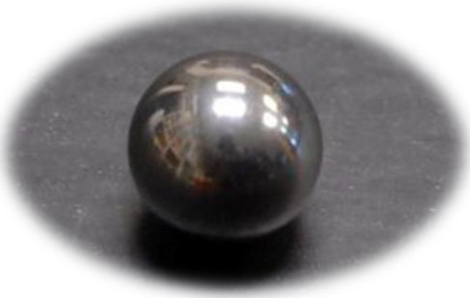
HEAT TREATING

Heat treating is a group of **industrial processes** used **to alter** the physical **properties of a material**. The most common application is **metallurgical**.



Heat treatment **involves** the **use of <u>heating or chilling</u>**, normally to extreme temperatures, to achieve a desired result such as hardening or softening of a material.

<u>Thermal management is strongly required.</u>

MODELLING & SIMULATION

- Optimizing the heating/cooling equipment.
- Monitoring the time evolution of the pieces “core” temperature as a function of :
  - Size;
  - Constituting material;
  - Relative position of the pieces in the cooling equipment;
  - Magnitude of the cooling forced flow.;
  - ….

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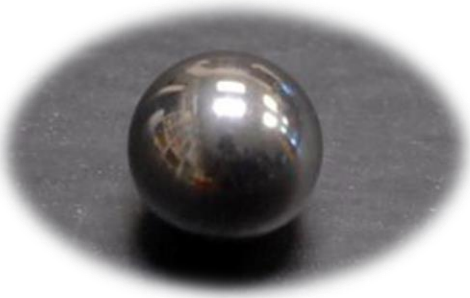
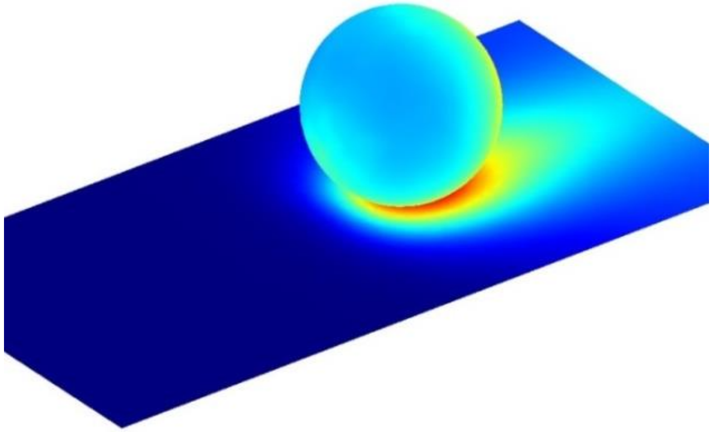


MODELLING & SIMULATION

Very usually, it is required to **simulate a transient thermal analysis** in a **forced permanent flow** and starting from an **initial thermal state**.



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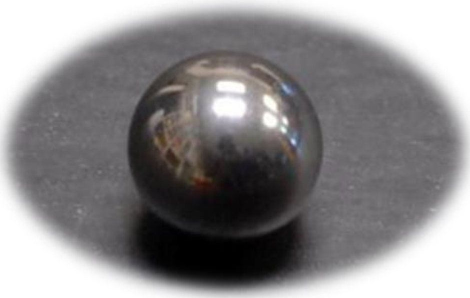
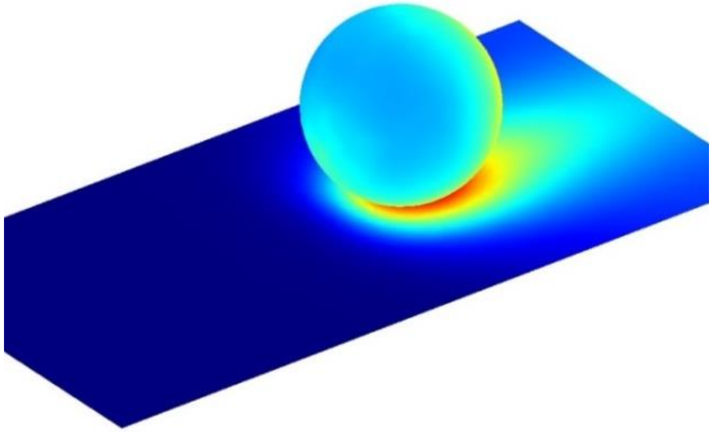


MODELLING & SIMULATION

This kind of study can be carried out by **three steps**:

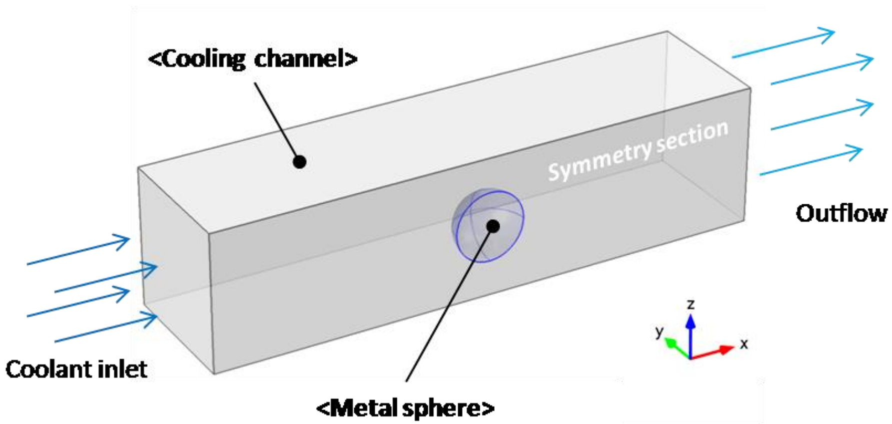
1. **Fluid dynamical** solution of the **permanent velocity field**;
2. **Steady thermal simulation** of temperature at the begin of the cooling process;
3. **Transient thermal analysis** during the cooling process.

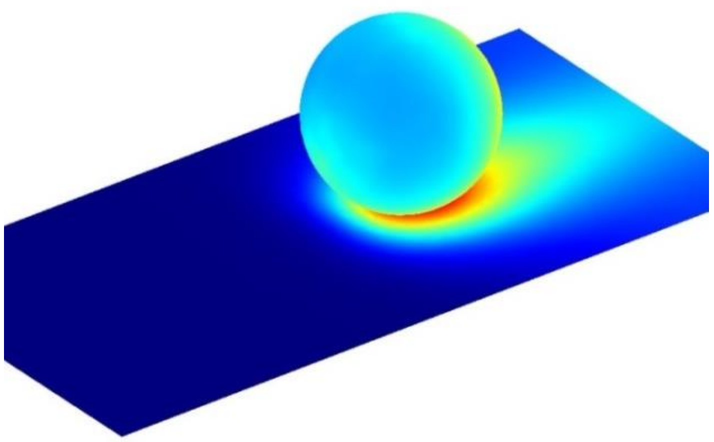


Application / *Modelling*

Assumptions / constraints / modelling steps

- Solving the **steady fluid dynamical** flow
- Set a chosen **temperature** value at the solid-fluid interface of the cooled objects to get consistent initial thermal state for the process
- Solving the **thermal steady state by** using the velocity field as transport field
- Set a a continuity thermal condition at the solid-fluid interface
- Solving the **transient analysis** using the velocity field as transport field and the thermal steady state as initial condition





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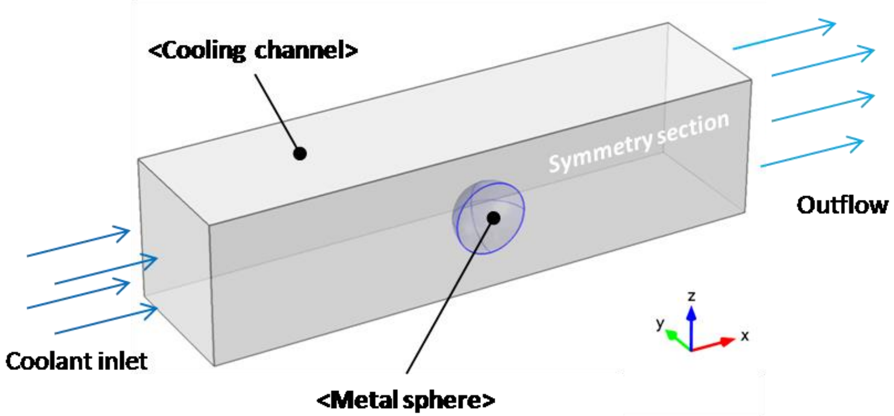
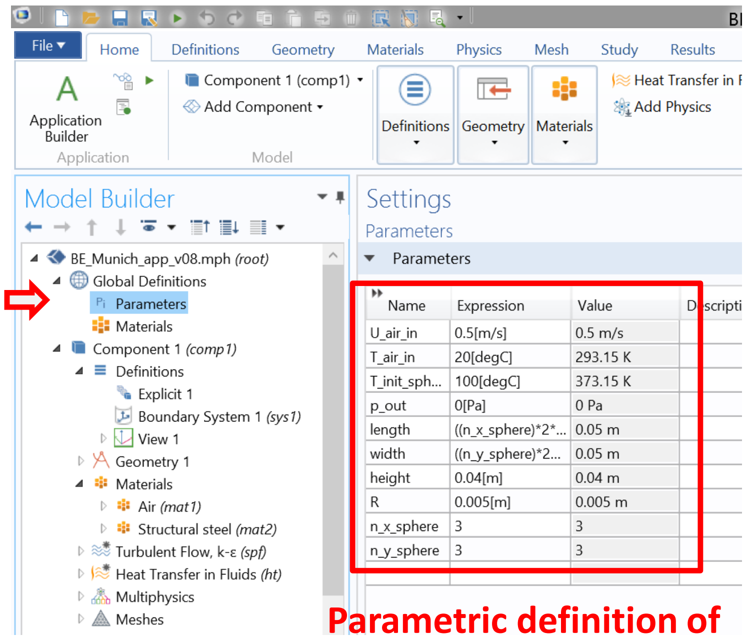
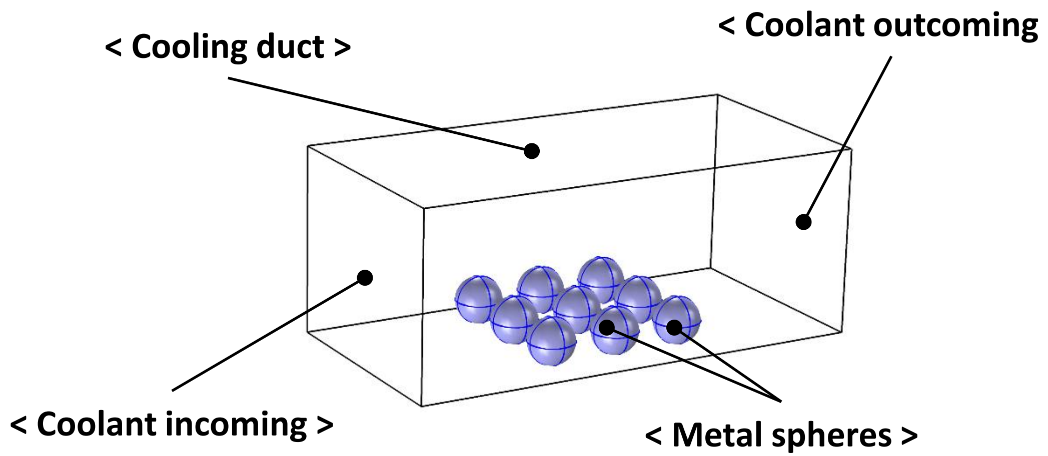
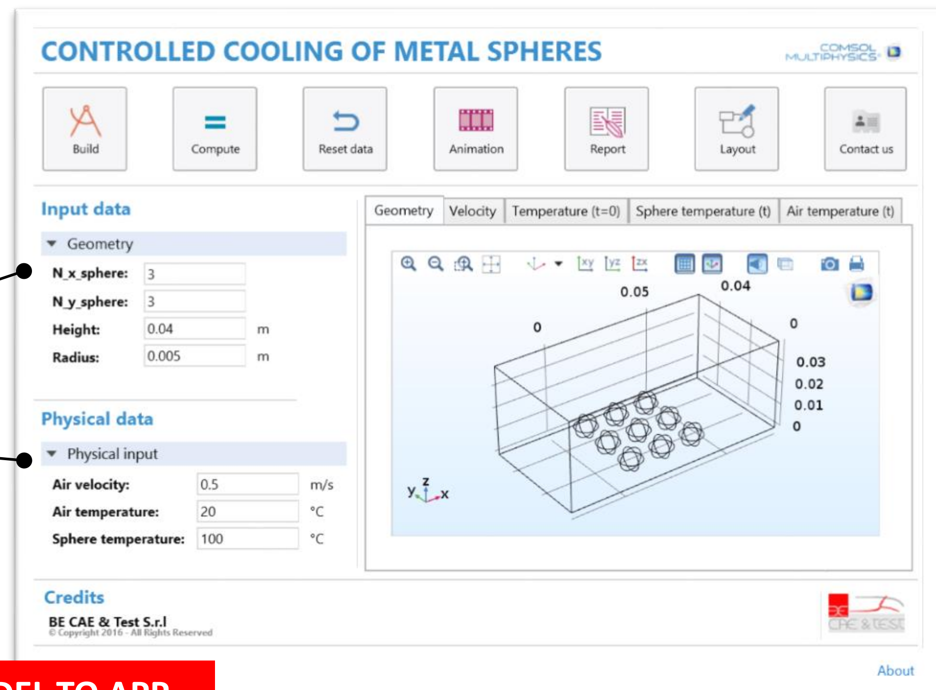


CAN A **COMSOL APP** HELP US TO **AUTOMATICALLY MANAGE** THE SEQUENCE OF SEVERAL COMPUTATIONALS STEPS TO BE RUN BY USING **DIFFERENT PHYSICAL AND SOLVING SETTINGS** ?



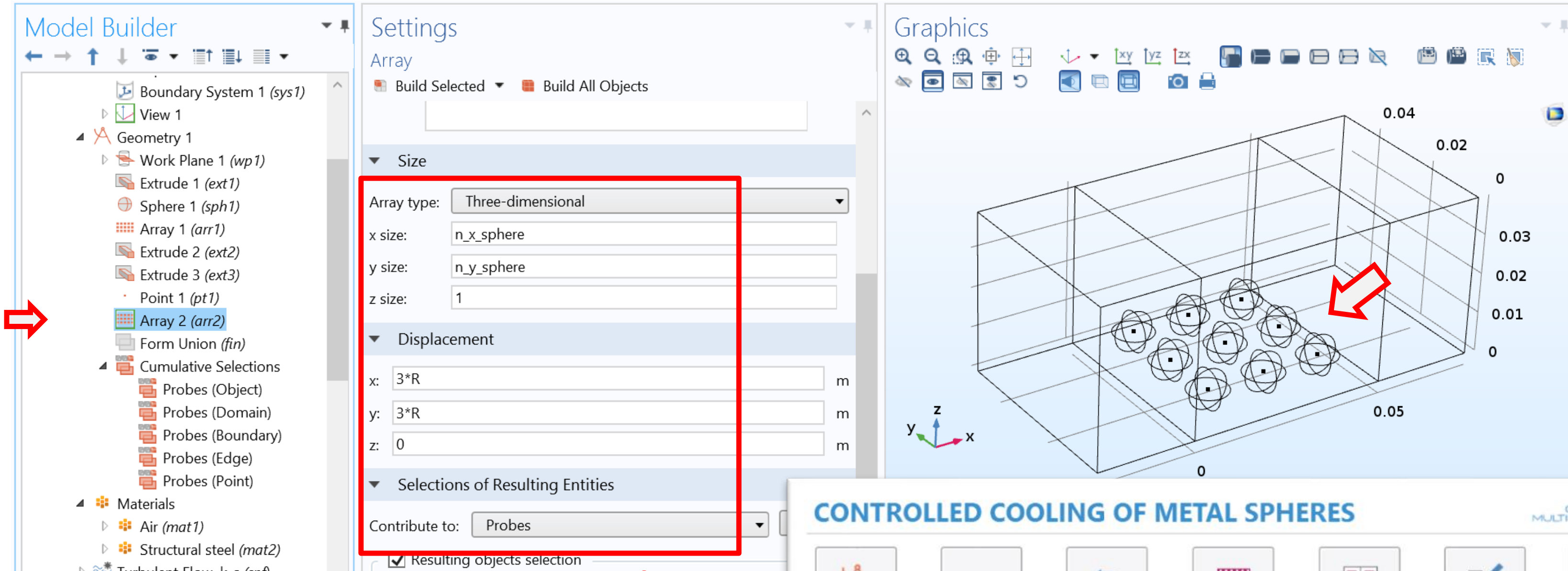
Parametric definition of geometric and process input



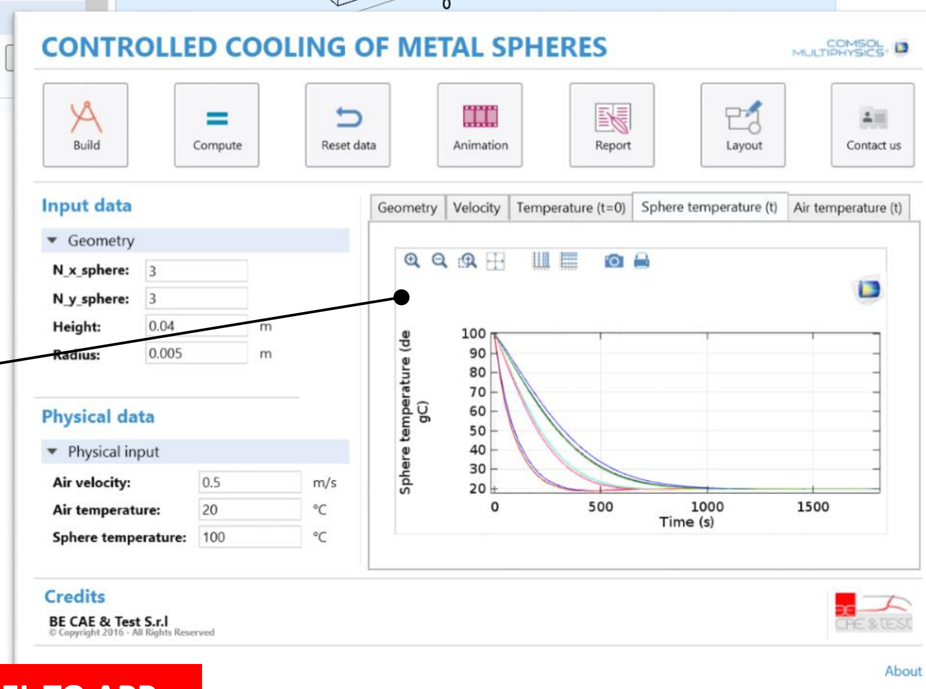


Parametric set-up

- **Geometrical (**spheres number and dimension, duct dimensions**)**
- **Functional** (Coolant flowrate and temperature, initial spheres temperature)



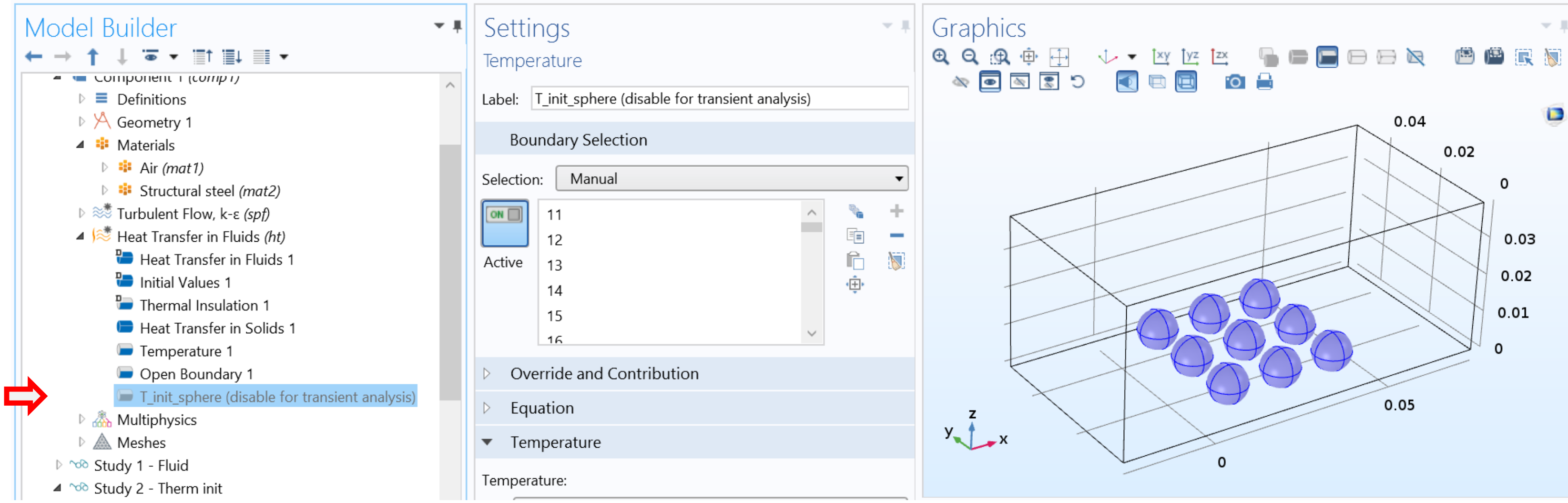
Definition of points/probes (parametric also)



Parametric set-up

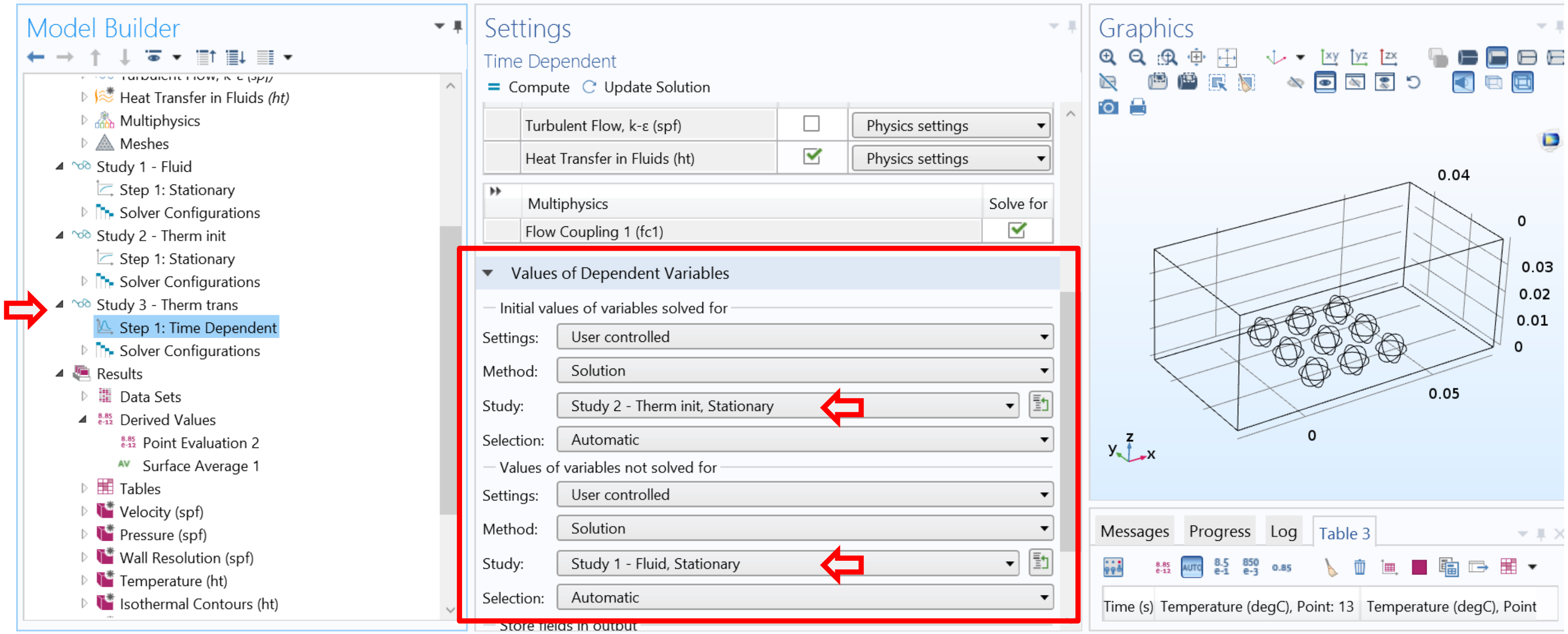
- **Derived values (**time-evolution of the «core» temperature for each sphere, time-evolution of the average temperature of out-flowing air**)**

FROM MODEL TO APP



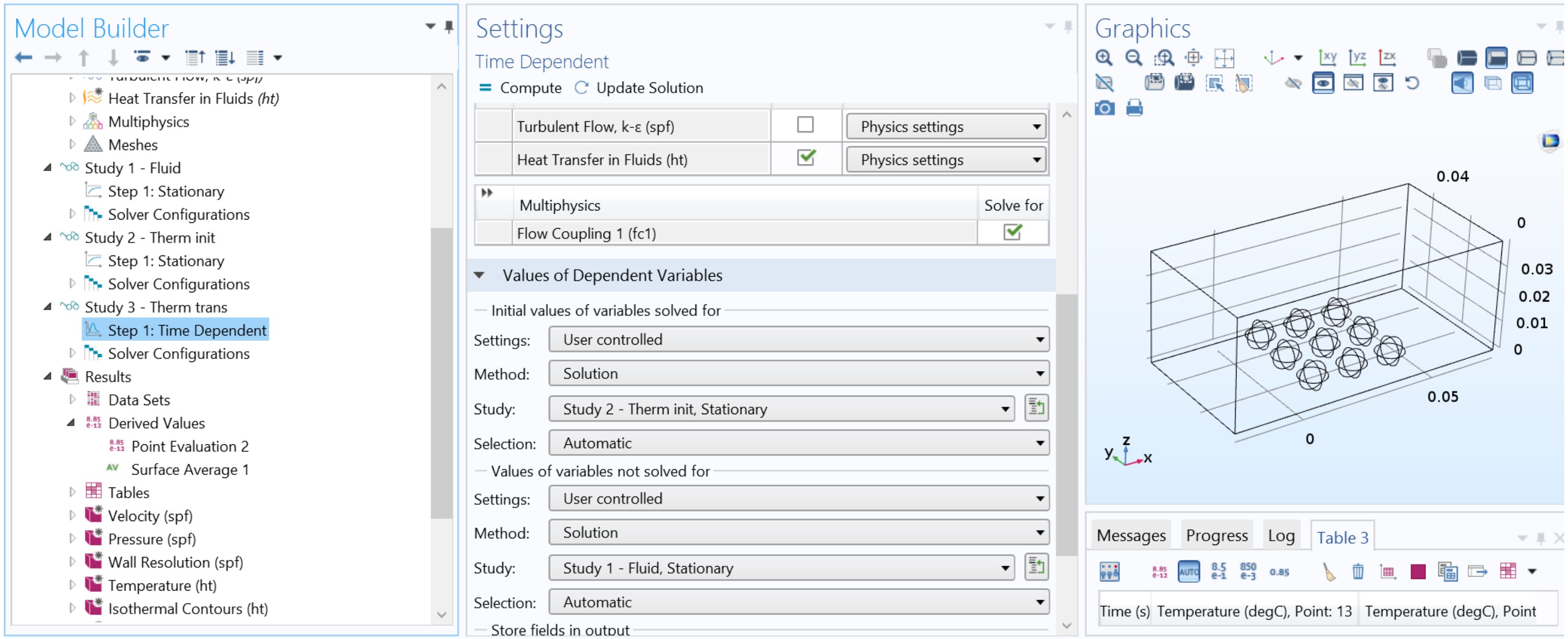
Physics setting

(Initial temperature at solid-fluid interface**)**



Study setting

(A sequence of studies has to be defined by coupling variable values from a study to another)

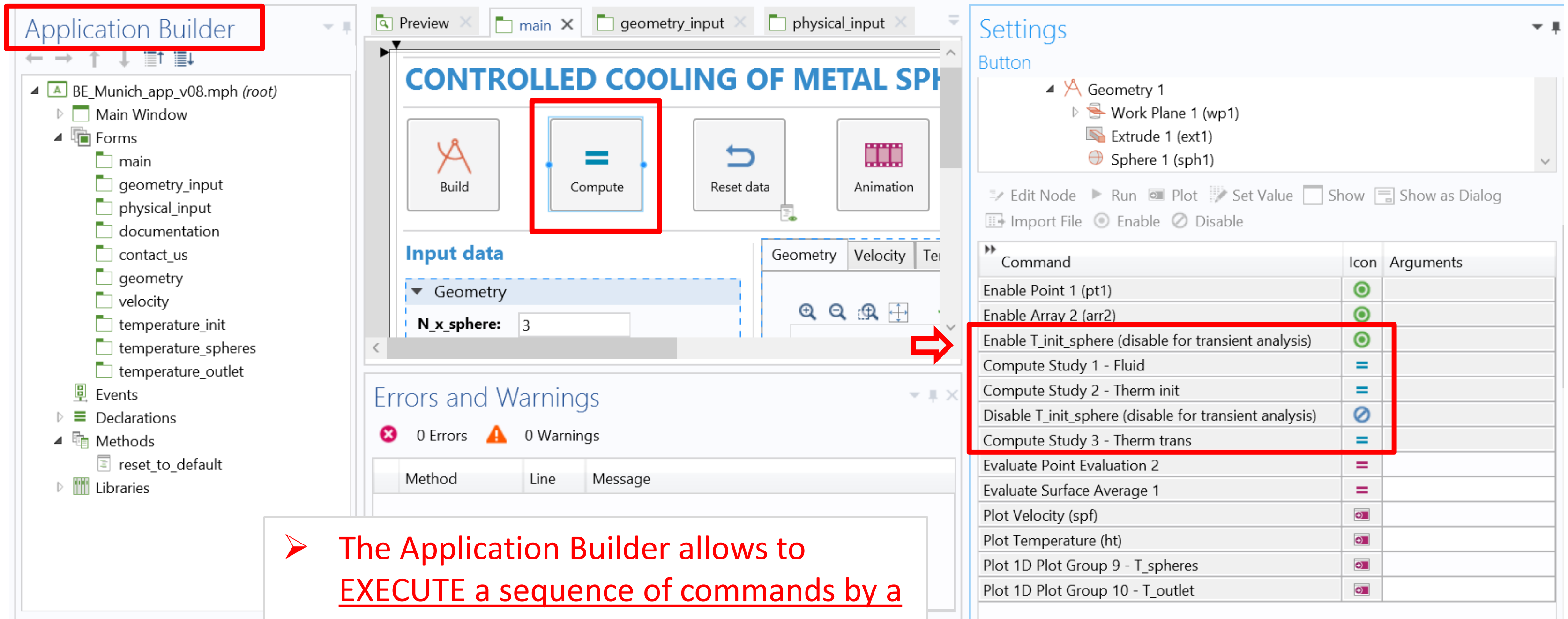


«Manual» work-flow by using the embedded model:

- Run < Study 1 – Fluid > for solving the velocity and pressure fileds
- Set (enable) specific BCs (surface spheres temperature)
- Run < Study 2 – Therm init > to get the specific thermal state at the initial time
- Disable specific BCs (surface spheres temperature)
- Run < Study 3 – Therm trans > to perform the transient analysis

Waiting for solution

Waiting for solution



➢ The Application Builder allows to <u>EXECUTE a sequence of commands by a single «action button» …</u>

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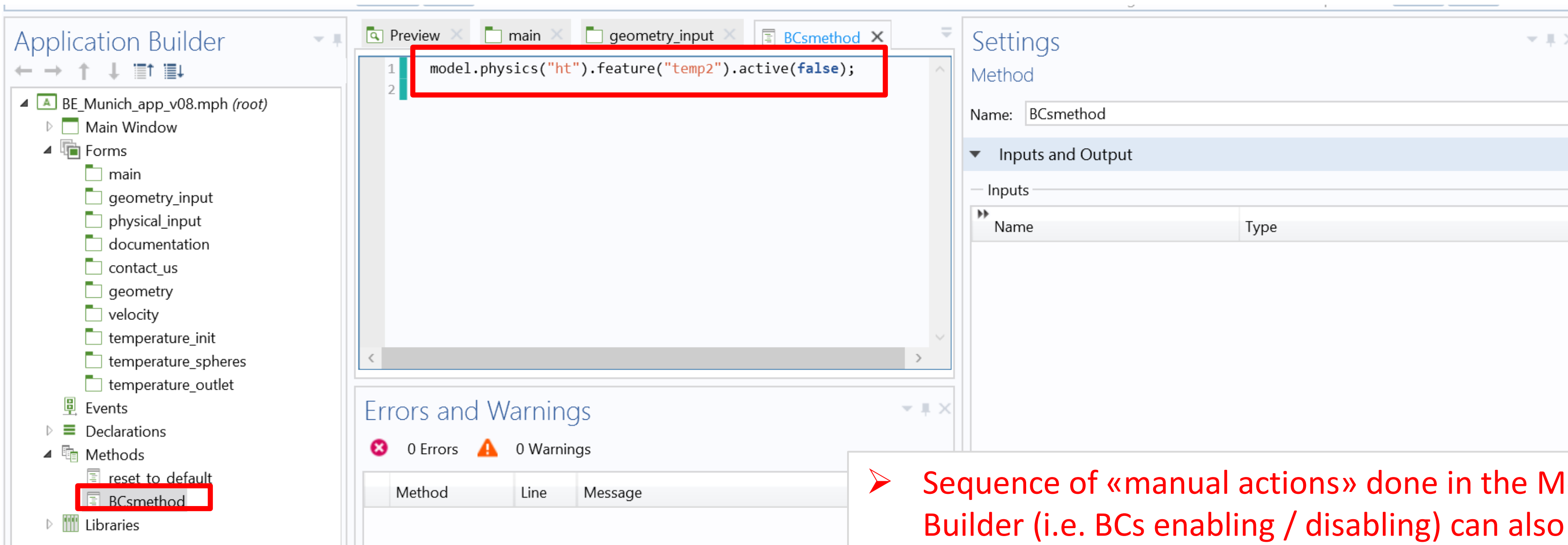

➢ Sequence of «manual actions» done in the Model Builder (i.e. BCs enabling / disabling) can also be recorded: the available code can then be «applied» to an action button, in order to automatically reply the sequence of commands …

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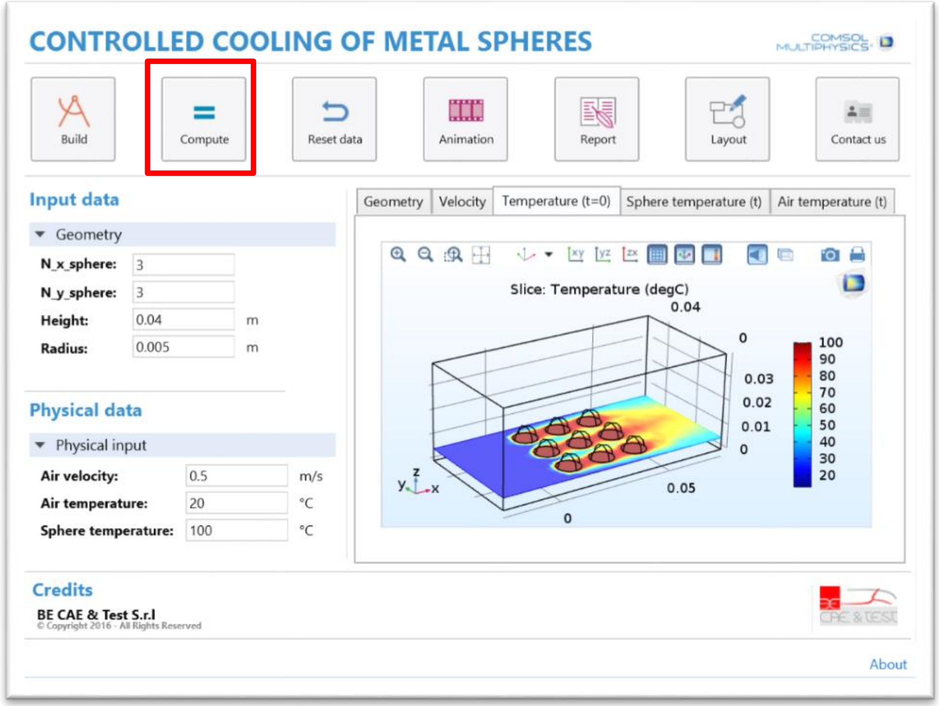
«Manual» work flow by using the App:

- Click the button «Compute» ….



FROM MODEL TO APP

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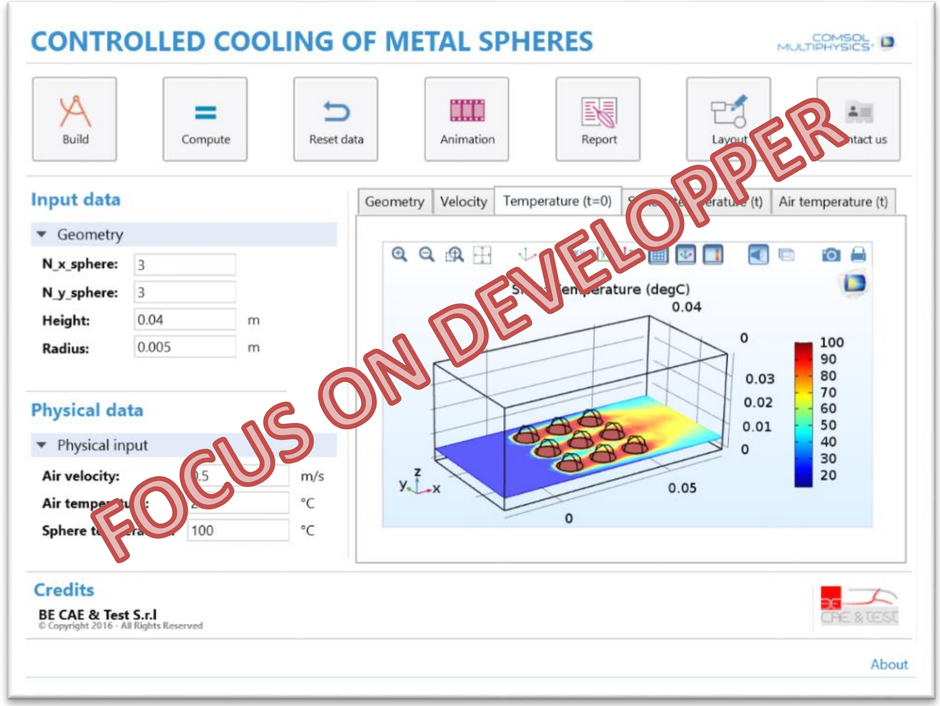

THANK YOU!

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