Subject: Re: EPRI__Fusion_Report 1025636 10-2012
Date: Thu, 21 May 2020 17:07:59 -0400
From: Martin Greenwald
To: Steven B. Krivit

Steven,

Agreed on your numbers for power output.

So the key number in the net power is the estimate of 300 MWe input. I can't be sure of the answer, because I'm not sure where that number came from and what assumptions went into it.

For example is it the maximum power pulled off the grid during a pulse or is it the average power? One also has to distinguish between reactive power and dissipated power. When powering a superconducting magnet, the electrical energy is converted to magnetic energy at high efficiency. Most of that can be converted back to electrical energy when the magnet is turned off.

Typically the most important energy loss mechanism is in the heating systems. That is, how many MW of electrical power does it take to put 1 MW of heating power into the plasma? (This pushes reactor designs to higher values of Q - with values of 20-30 often targeted.) As an experiment, the ITER team prioritized heating systems for their flexibility rather than efficiency.

Sorry this is all muddy, but since the calculation of net power subtracts two large numbers in this case, you could probably get a positive or negative difference depending on details...

- Martin

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Subject: Re: EPRI__Fusion_Report 1025636 10-2012
Date: Thu, 21 May 2020 15:06:08 -0700
From: Steven B. Krivit
To: Martin Greenwald

Hi Martin,

Thank you for your e-mail.

I have four or five sources for the 300 MWe number.

1. Daniel Jassby, retired, PPPL was my first source. In a series of discussions with me, this is what I learned from him:

Jassby explained that ITER will have three primary sets of power-consuming systems. The first will be the steady-state power, drawing about 100 MW of electricity. This occurs always, during the startup phase, the fusion phase, and even when the reactor is not operating. The power is necessary for a variety of essential reactor systems such as liquid-helium refrigerators, water pumps, vacuum pumps, temperature controls for the reactor buildings and tritium processing systems.

“The second set of power-consuming systems will consume about 300 MW of electricity,” Jassby said. “This will be required before the start of the fusion phase. It will be used primarily for the various magnetic and electrical systems to start up the discharge and reach operating conditions. This 300 MW of electricity will not be used during the fusion phase. The total power consumption before the fusion phase will therefore be about 400 MW of electricity.”

“Third,” Jassby said, “during the fusion phase, the electric power consumption for the reactor’s plasma heating systems, current drive, and magnetic controls will be about 200 MW of electricity. The total power consumption during the fusion phase therefore will be about 300 MW of electricity.”

2. Hartmut Zohm, the head of the Tokamak Scenario Development Division at the Max-Planck-Institute of Plasma Physics was my second source. He contacted people within the ITER organization and provided me with this information:

“From my discussions with some of the ITER team members,” Zohm wrote, “I learned the following: At the peak operation point, ITER will produce 500 MW of fusion power which is 10 times the external power needed to heat the plasma. The magnet system will require about 80 MW of electrical power and the heating systems about 150 MW. Add to this an overall consumption of the site of around 100 MW (for all subsystems needed to run the whole plant), we would have about 330 MW of electrical power needed to run the machine in this state.”

3. Steven Cowley, the current director of PPPL, was my third source. I contacted him by email in the summer of 2017 while he was still working in the U.K.

Cowley wrote that, in ITER, for a 50 MW thermal input, “with the efficiency of the beams etc., the electrical power in would be over 300 MW.” Cowley concurred that the primary goal of ITER is a 500 MW thermal output for a 50 MW thermal input, but he also said that, according to computer simulations, the reactor might get hot enough for ignition, where no external heating would be required. This is contradicted by an article in Nature, in which Cowley is quoted as a source, that says that ITER is not designed for ignition.

4. My fourth source comes from PDF page 31 of a document I found called "Hearing on Nuclear Fusion before the Bundestag Committee for Education, Research and Technology Assessment, Berlin, 28 March, 2001." Source URL: https://fire.pppl.gov/eu_bundestag_english.pdf

The German government asked their national labs "What will be the energy demand of ITER during operation for heating and magnets?" Two of the labs responded. FZJ (Jülich Research Centre) said the total input power would be 260 - 350 MW of electricity.

5. IPP (Max Planck Institute for Plasma Physics) said the total input power would be about 350 MW of electricity. IPP is where Zohm is based, so this may be a redundant source.

So do you think the 300 MWe input power number for the steady-state burn is solid?

Steven