



Challenges from the HCD session on ECRH and LH heating

New ECRH & LH systems planned to be installed or upgraded on multiple devices

- Significant increase of EC power at ITER + several devices upgrading/installing new EC systems + limited number of suppliers
 - > in-time manufacturing and commissioning of the increased number of gyrotrons, need for 1.5-2MW gyrotrons
 - > extrapolation of technical improvements to other devices is easier due to similar systems
- Support new EC systems through collaboration incl. test facilities, sharing information, transferring best practices
 - EUROfusion-F4E ECRH network – community of practice with online seminars, in-person workshop and joint operator training
- Need to train more EC operators – course + mobility scheme to observe commissioning & operation in person planned in Europe

Impressive technical improvements of ECRH and LH systems and results towards long pulse operation

- Fault detection and gyrotron recovery during discharge + fast gyrotron control to maintain EC power
- Improve protection systems to avoid faults and damage
 - Hardware: reflector tiles against stray radiation, air drying system to reduce humidity in EC transmission lines
 - Software: arc detection, develop (AI) tools to detect trends towards operational limits or potential faults
- Increase reliability, availability and performance -> monitor through reliability and fault database, predictive maintenance
- Feedback control to optimize heating (coupling, power) and its integration with other control schemes (MIMO) -> gas puff feedback to improve LH coupling,

Continue to better understand use cases and their impact -> EC-assisted plasma startup, LHCD to prolong discharge length