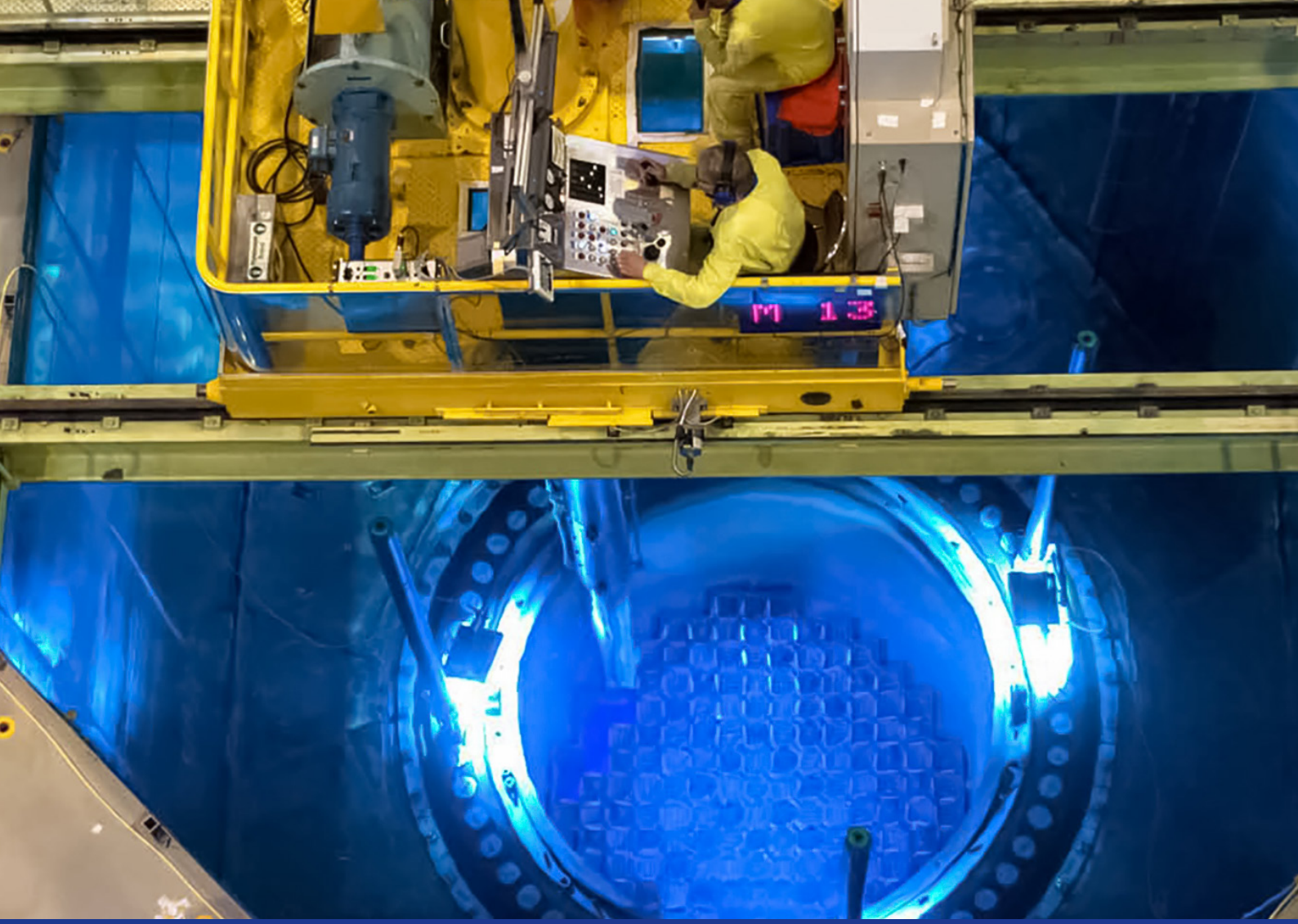

Optimize core reloading using ROSA

Ensuring Nuclear Performance

NRG PALLAS

Nuclear. For Life.

Nuclear power plant operators are under continuous pressure to reduce the operating cost of their assets without compromising on safety and availability of capacity. The main goal of in-core fuel management is to reduce fuel cycle costs within a range of technical or regulatory constraints.

NRG's ROSA fuel management software provides guaranteed fuel savings without compromising on safety or regulatory constraints. Most recently, ROSA realized higher than expected fuel savings at Vattenfall's Ringhals 4 NPP.

The ROSA core loading optimizer

Since more than 20 years, NRG's core loading software, ROSA, is successfully being used by a multitude of NPPs across the globe.

Success rate in realizing optimized core-loading patterns was consistently 100%. ROSA, developed by NRG, is independent from any fuel vendor software, and buildson NRG's extensive expertise in nuclear engineering, research, and reactor operations. ROSA is a sophisticated 3D optimizer which is able to evaluate up to billions of core design options in a day. The software is highly interactive, and the powerful graphical user interface represents the information in an intuitive and user friendly manner, providing comfort to the user and enhancing the core designer's expertise.

ROSA calculates the power distribution of the core in 3D and any combination of more than 60 optimization parameters; users can be certain that any potential constraint can be evaluated in a realistic manner.

The software is seamlessly integrated with all established license codes.

"ROSA outperformed Vattenfall's core reload solutions, and provided us with substantial fuel cost savings."

John Loberg, Principal Engineer Nuclear Fuel and Core Design Vattenfall

Vattenfall core reload optimization

Vattenfall, of Sweden, was highly interested to try ROSA because of (1) the fuel cost savings and (2) the complexity of their core design which was hard to tackle with other core reload solutions. Vattenfall's Ringhals - 4 (3292 MWth, 157 assembly core with 17x17 fuel) uses twelve so-called shielding assemblies for reactor vessel shielding.

These assemblies have little to no uranium and produce almost no power. Because of the high power density of the core, a very balanced loading pattern for the rest of the assemblies is required, with multiple assemblies being close to thermal safety margins. Vattenfall set a goal for ROSA to increase the assembly discharge burnup by 0.25 MWd/kgU. The ROSA solution was demonstrated on five consecutive cycles, in blind competition with Vattenfall's own core design team using other software. Vattenfall provided NRG with data for the reactor model and the fuel history.

After the model was set up, NRG optimized the loading patterns for the five cycles. The performance of the optimized loading patterns, in particular the safety margins and the assembly discharge burnup, were subsequently reproduced with Vattenfall's license code.

During the demonstration a new feature for ROSA was developed in cooperation with Vattenfall, enabling further fine tuning of ROSA's core loading predictions with those of the license code, thus reaching a very high accuracy between the two codes. ROSA's optimized core loading for Ringhals - 4 outperformed Vattenfall's reference case with a higher than required increase of the assembly discharge burnup of 0.6 MWd/kgU per reactor core assembly. This relates to fuel cost savings of about 500,000 Euro per cycle.

As a result of these excellent results Vattenfall decided to purchase ROSA for both Ringhals unit 2 and unit 3 as well.

Vogtle - 1,2,3,4 (US), **Farley** - 1,2 (US), **Watts Bar** - 1,2 (US), **St Lucie** - 1,2 (US), **Point Beach** - 1,2 (US), **Turkey Point** - 3,4 (US), **Seabrook (US), Seqouyah** - 1,2 (US), **V.C. Summer** (US), **Koeberg** - 1,2 (SA), **Grohnde** (DE), **Isar**-2 (DE), **Brokdorf** (DE), **Grafenrheinfeld** (DE - EOL), **Krsko** (SI), **Borssele** (NL), **Ringhals** - 2,3,4 (SE)

ROSA: 20 years of guaranteed fuel savings at more than 25 NPPs across the globe, without compromising on safety margins or regulatory constraints.

The core-loading pattern is decisive for fuel cycle economics, fuel safety parameters and for planning of future cycles. ROSA uses simulated annealing as loading pattern optimization technique, in combination with an extremely fast 3-D neutronics core simulator code for loading pattern calculations. Hundreds of millions to even billions of loading patterns can be evaluated on a workstation or PC in a day.

ROSA's strong points are fuel cost reduction (typically 1% savings but sometimes more), enhanced operational margins, outage time reduction, and engineering time reduction. The code is continuously extended with new optimization parameters and other functionality such as End of Life (EOL) shutdown strategies.

A powerful graphical user interface allows the user to interact with the optimization process by changing optimization targets during the run or perform manual fuel movements, rotations, and/or fresh fuel composition changes.