

Systems thinking in circular strategies

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Lessons from extending the lifespan of heat pumps

Why don’t circular initiatives always deliver the expected results, even when the scenarios have been carefully thought through? At the HEATReX Living Lab, it became clear that the answer rarely lies in the scenario itself, but in the system behind it.

Systems thinking reveals these underlying dynamics and explains why some circular strategies work and others don’t.



From ReX scenarios to a systems insight in circular strategies

At the HEATReX Living Lab, Sirris is investigating how the material footprint of complex mechatronic products such as heat pumps can be reduced by extending their service life. Possibilities here might include reuse, repair, refurbishment or remanufacturing, collectively referred to as ReX.

Initially, the focus was on identifying and exploring ReX scenarios. These scenarios describe how products, components and value chains are organised to preserve value. They include decisions regarding product strategy, business models, logistics, reverse flows and the division of roles between stakeholders.

For example:

- Repairing appliances using recycled parts
- Upgrading existing installations under service contracts
- Recovering and remanufacturing units for resale

To explore these scenarios, the Living Lab team combined techno-economic analyses with practical experiments and consultations. It spoke to installers and independent remanufacturers. In addition, the scenarios were discussed with various departments, ranging from sales and service to design, operations, compliance and legal. In this way, feasibility was assessed from a range of perspectives.

However, this approach soon came up against a fundamental problem: the reality of circular heat pump systems cannot be captured in individual scenarios. The scenarios themselves were not flawed, but their feasibility depended on an underlying system that was far more complex than it appeared at first glance.

Why scenario planning alone is not enough

Too many scenarios, variants and parameters

To make the scenarios more concrete, they were broken down into ever finer details, including for example:

- Components, product types or models
- R-strategies (such as repairs using new, used, remanufactured or upgraded parts, or the refurbishment of complete heat pumps)
- Revenue models (sales, leasing, heat-as-a-service)
- Return flows (returns from repair, warranty claims, first end-of-life or planned replacements)
- Role division between the actors (who does what)

Every refinement led to an explosion of variants. Minor changes to parameters – such as ownership, service levels, data access or scale – fundamentally altered the outcome.

Close interdependencies are crucial in ReX systems

More importantly, these parameters don’t operate in isolation: they form a single dynamic whole and represent snapshots of a highly interconnected system.

Design choices, operating conditions (e.g. indoors or outdoors) and actual degradation in the field together determine a component’s service life. This in turn affects:

- The functional residual value of a component after its initial phase of use
- The demand for the same component as a spare part within the Rex system

Feasibility depends on your perspective

What “works” varies from actor to actor.

A ReX scenario that is valuable to an end user may be financially or legally unacceptable to an OEM, or operationally unworkable for an installer.

Feasibility is therefore not an objective characteristic of a scenario. It arises from the synergies and tensions between actors, interests and responsibilities.

In practice, discussions always came back to the same underlying questions:

- Who bears which costs and risks?
- Who manages which data?
- How stable is the technology over generations?
- Which regulations reinforce or undermine ReX practices?

In other words: the key is not to compare scenarios, but to understand the systemic conditions that either enable or hinder them.



The shift: from scenarios to system conditions

These insights led to a fundamental reorientation. The central question shifted from: ‘Which ReX scenario is feasible?’ to ‘Under what system conditions do ReX scenarios become feasible or

impossible, for whom, and why?’

This is where systems thinking comes into play for circular strategies. It does not replace scenario analysis, but puts it into the right context. First, the system and its dynamics are mapped out; only then do the scenarios take on meaning.

The benefits of systems thinking for circular strategies

When the ReX system is made explicit, for example using a causal loop diagram, dependencies, tensions, lock-ins and levers become apparent.

Design choices, business models, regulations, data flows and stakeholder behaviour turn out to either reinforce or hinder one another. Systems thinking helps to identify which limited set of parameters has a major impact on the whole: the so-called leverage points.

Not every detail is equally important. Some system variables determine whether entire families of scenarios are useful or not.

Two examples from the HEATReX Living Lab, in which these system dynamics are analysed in detail, illustrate this.

Case 1: Heat-as-a-service and the operational costs of electrification

Heat-as-a-service is often presented as a way of circumventing the high initial investment costs associated with heat pumps.

However, from a systems thinking perspective, the feasibility of such models depends heavily on the operational costs of electrification. As long as electricity remains consistently more expensive than gas, heat-as-a-service primarily shifts the upfront financing and the risk between different parties. The underlying cost problem remains.

The real leverage therefore lies in systemic interventions that reduce operating expenses (OPEX), such as a different pricing structure for electricity compared to gas, rather than in the business model itself.

Case 2: Technological stability and extended service life

Changes in refrigerants have a significant impact on the design of a heat pump: from components and interfaces to safety and control systems. Without technological stability, ReX becomes particularly difficult across product generations.

In such a context, large-scale refurbishment or remanufacturing across generations is not particularly robust. Service life extensions within a single generation – such as repairs, maintenance and limited upgrades – remain one of the few truly viable ReX pathways.

Here too, systems thinking helps to clarify priorities: some scenarios become temporarily less relevant, while others become more of a priority.

When do circular scenarios actually work?

Scenario analysis remains essential for comparing specific options, facilitating discussion of choices and providing a basis for decision-making. However, its full value only becomes apparent once the underlying system conditions are clear. Only then do scenarios no longer stem from assumptions, but from a shared understanding of the system in which they operate.

Want to get started with circular strategies yourself?

Would you like to accelerate ReX within your business or value chain, with a clear understanding of where action really makes a difference? Bring your ReX challenge and stakeholders together around a single system narrative, identify the levers that make scenarios possible and take targeted steps towards scalable and robust ReX solutions.

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