Subject: Oceanhamnen, Helsingborg (SE) – Vacuum Drainage-Based Wastewater Management with Resource Recovery - Extended submission

1 Technical Innovation Introduced

The Oceanhamnen development in Helsingborg (Sweden) represents a new concept in urban wastewater management, where vacuum technology assists in achieving a fully circular, resource-efficient system.

The Oceanhamnen project is built around a district vacuum drainage network, serving 320 apartments and commercial buildings with total combined daily population of circa 1500. The wastewater system serving the above district in Helsingborg is based on a complete source separation of blackwater (BW), greywater (GW), and food waste (FW) at individual building/apartment level - for high-efficiency resource recovery.

The use of vacuum toilets and vacuum type drainage system delivers two critical technical advantages:

- Ultra-low water consumption, producing highly concentrated blackwater discharge
- Controlled, closed-pipe transport, independent of gravity, enabling flexible urban design and reduced excavation

The wastewater concentration effect is fundamental and improves the general system efficiency for energy and nutrient recovery. The Oceanhamnen development integrates a suite of innovative and advanced treatment technologies:

- Anaerobic digestion (UASB reactors) fed with concentrated blackwater and food waste, maximising biogas production
- Biogas upgrading (enabling direct substitution of fossil fuels e.g. in city buses)
- Nutrient recovery processes, including: Struvite (phosphorus recovery), Ammonium stripping (nitrogen recovery) and production of high-quality biofertilizers
- Improvement efficiency made viable by a district-wide vacuum drainage system

The vacuum system is not just a transport solution as it plays a role of the key system integrator, enabling efficient downstream processes by:

- Reducing dilution of wastewater
- Stabilising flow conditions
- Allowing precise separation of waste streams

The project also introduces multi-stream infrastructure within buildings, requiring close coordination between building services design, architecture, and urban planning. Vacuum technology enables this integration by reduced pipe sizes (smaller that equivalent gravity drainage) and allowing routing flexibility, not possible with gravity systems.

From a systems perspective, Oceanhamnen extends beyond wastewater treatment into a cross-sector resource platform transforming “waste” from buildings to energy systems (biogas utilisation) and agriculture (fertiliser reuse).

This is reinforced by a full Life Cycle Assessment (LCA) approach, capturing benefits across the entire value chain .

Crucially, the project demonstrates collaboration between manufacturers, utilities, designers, and researchers.

In summary, Oceanhamnen’s innovation lies in repositioning vacuum drainage from a niche solution to a core urban infrastructure technology, enabling:

- Source separation at scale
- High-efficiency resource recovery
- Integrated circular systems in the built environment

2. Improvements in Performance, Safety, or Regulatory Compliance

The implementation of vacuum drainage technology in Oceanhamnen delivers measurable, system-wide improvements in environmental performance, operational safety, and regulatory alignment, as evidenced by LCA results.

The vacuum system fundamentally improves performance by concentrating blackwater and eliminating wastewater dilution, which directly enhances downstream treatment efficiency resulting in approx.. 80% reduction in climate change impact from the source separation system compared to a conventional system.

These improvements are linked also to vacuum-enabled processes because of the following:

- Higher organic concentration improves the efficiency of biogas yield,
- Efficient nutrient generation reduces reliance on synthetic fertilisers
- Lower water demand is directly associated with WC water use of 0.7 litre per flush which impacts not only on the upstream energy use associated with water supply side, but also on energy use for wastewater transportation and treatment

This is particularly relevant for future water-stressed urban environments.

Operational Safety and Hygiene

The vacuum drainage system enhances safety of the end-user as the system do not rely on water-seal odour trap at appliances, but a vacuum appliance-specific seal. The vacuum specific appliances must undergo a laboratory-test reliability of 250 000 mean cycles between failures (EN 12109 requirement). This represents an enhancement compared to gravity drainage systems relying on water seal (see the 2003 SARS outbreak in Hong Kong which was linked to faulty plumbing - failed water seal traps in showers, leading to transmission of pathogens via air circulation in the drainage system).

3. **Application Value for the Building Services Sector**

Oceanhamnen demonstrates that vacuum drainage is a transformative technology for modern building services engineering, with wide potential across sectors and project types.

Traditionally, drainage systems are designed to remove waste efficiently. Oceanhamnen shows that, when based on vacuum drainage technology can in addition:

- Improve resource recovery efficiency
- Reduce water and energy consumption
- Contribute directly to net-zero strategies
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The project proves that vacuum systems can be successfully deployed at a district scale, supporting residential, mixed-use type or urban regeneration projects. Being independent from gravity, the design can utilise more flexible layouts (for budlings or apartment positioning), reduce structural constraints or felicitate integration into complex urban environments, due to design and coordination benefits

For building services engineers, vacuum systems offer:

- Smaller pipe diameters
- Reduced gradients and excavation
- Simplified coordination in congested service zones

Reduced water consumption with lower operating costs, biogas production contributing to renewable energy generation, or nutrient recovery with potential revenue from fertilisers, all contribute to ESG objectives and Future-Proofing of Buildings

This could play an important part in areas with scares water resources or where Wastewater infrastructure capacity is limited.

Oceanhamnen demonstrates that vacuum drainage can move from niche applications into mainstream building services.

In conclusion, the project establishes vacuum technology as a key enabler of next-generation building services, delivering measurable environmental, operational, and economic benefits while supporting the transition to sustainable cities.

For further details, click this link: Oceanhamnen, Helsingborg (SE) – H2020 project Run4Life.