Case Study: Dutch Rail Yard Site, Village of Bilthoven, Province of Utrecht, Netherlands	
Site Overview	The site is strategically located in the center of Bilthoven. It has had a long history of industrial uses dating back to 1863 when the Dutch railway company purchased it. Over the years various operations have taken place and have included: warehousing, wood, petroleum and coal distribution centers, paint company and rail yard. During World War II (I944), allied forces bombed the site resulting in its complete destruction. In 1947, the petroleum company rebuilt their business and stayed in operation until 1984. From 1984 to 2008, a paint company occupied the property until it abandoned its business. Since 2008, this site has sat vacant with only building demolition (2011), site investigation and remediation work being completed on it. The site's soil and groundwater is contaminated with mineral oils starting from half a meter down to nine meters below ground surface (bgs). In 2011, contaminants located in the vadose zone (.5 meters to 2 meters bgs) were excavated and removed. The remaining contaminants located in the saturated zone (2 to 9 meters bgs) are currently being treated with Sustainable In-Situ Soil Remediation (SISSR) technology.

GSR Project Outcome

At the Bilthoven site, renewable energy technologies (wind and solar) are being employed in order to eliminate the reliance on nonrenewable energy sources. SISSR avoids the high cost and risk associated with biological, chemical and thermal remediation treatments by exploiting what is naturally present in the subsurface to immobilize and cleanup contamination. It accomplishes this by increasing temperatures and injecting air into the soil to accelerate biostimulation. Results so far are better then expected with a reduction in mineral oils from 8,000 µg/l to 590 µg/l in only 50 weeks. This remediation project has been classified as net zero since all energy consumed comes from renewable energy sources. Each renewable energy source has two primary functions:

Wind Power
1.To produce compressed air which is than injected into the soil to support the biodegradation process
2.To extract soil vapors generated from the biodegradation process.

Solar Power
1.To generate electricity to run all the small pumps and electrical components
2.To produce warm water using a solar thermal collector system which is then circulated into the soil to increase subsurface temperatures by 7^{o} to 12^{o} C

Once remediation activities cease (in 2014 to 2016) the intention is to integrate the wind and solar power into the new redevelopment plans since this infrastructure still has a life expectancy between 15 to 25 years. Implementing the green technology into new community uses will result in long-term community sustainability.

With SISSR at the Bilthoven site, it has reduced adverse ecological impacts such as truck movement, vehicle emissions, soil disturbance, dust and noise since the offsite movement of soil contaminated in the saturated zone is being treated in-situ. Further environmental impacts that have been reduced with SISSR technology are the elimination of contaminated filters and injection of chemicals into the subsurface. Results have shown that SISSR is not only a sustainable remediation solution, but that it is cheaper (€95.00 developmental cost) to implemented then conventional in-situ remediation projects (€154.00).

Background & Drivers	• The owner (SBNS – Stichting Bodemsanering NS a non-profit soil remediation foundation of the Dutch Railways) wanted to implement sustainable/green elements into their remediation activities • Initial decision was to remove contamination through excavation, but due to safety concerns (stability issues) regarding the proximity of the rail lines to the contamination and excavation cost, an alternative solution was needed • Completed risk assessment studies on various remediation options and determined the SISSR idea could be cheaper then other conventional in-situ approaches • Renewable equipment used during remediation could be reused and integrated into the new redevelopment plans of the site • Potential owner interested in redeveloping the vacant site, if the contaminants are removed/below regulatory limits • Wanted to demonstrate social responsibility to the local community by cleaning up the contamination in a sustainable manner since the village intends to be a green community and therefore suits their philosophy
Regulatory Program	Voluntary – the intention is to have the site redeveloped in the future
Site End Use	Once remediation actions are completed, a potential buyer has shown interest in purchasing the property for redevelopment purposes. The proposed redevelopment will include office buildings, a tunnel system to allow for ease access across the rail lines and potentially some residential dwellings.
Contaminants of Concern and Impacted Media	Primary chemical of concern is located in both the soil and groundwater: • Mineral oils
Key Stakeholders in Project	• Concept team: SBNS, HMVT and Tauw European Consultants and Engineers • Cleanup team: SBNS and ProRail (remediation contractor) • City council members • Community members in the Village of Bilthoven

Cleanup Objectives	Risk-based Objectives: • Protect public against exposure to unsafe soil and groundwater contamination levels • Cleanup site to a level that will allow for residential and commercial redevelopment in the future
Remediation Strategy	• Reduce soil and groundwater contamination in the saturated zone through construction of subsurface heating and air injection wells • Monitor soil and groundwater levels to determine effectiveness of treatment and if added nutrients and/or air needs to be injected into the zone in order to enhance the biodegradation process • Decrease remediation treatment time and cost • Implement land-use controls and/or restrictions, if needed
GSR Strategy/Best Management Practices (BMPs)	• Solar collectors to heat 100% of the water heating needs • 4 solar cells to produce 100% of the electricity needed to run all small pumps and electrical components • Energy efficient pumps and motors • Solar inverter used to covert sunlight into usable energy • 1 - 2.5 kW wind turbine to generate compressed air and extract subsurface vapors generated during the remediation process • Venting system for soil vapor extraction • Optimize treatment time by controlling the amount of air/heat/nutrients injected into the soil • Completing risk assessments studies on various types of in-situ remediation technologies in order to determine cost and environmental impacts of each • This technology has drawn the attention of large groups including Dutch Royal Army, Shell, Philips, Solvay, German and French Rail and has been presented at various meetings/conference including: Canadian Brownfields Network (CBN), Network for Industrial Contaminated Land in Europe (NICOLE), and Sustainable Remediation Form (SURF)
GSR Metrics and/or Footprinting Tool(s)	

Lessons Learned [Optional]	• This project demonstrated that renewable energy sources significantly reduced operating costs. • Having city council support and knowing what the village philosophy (green image) is and tailoring the remediation goals with this in mind created positive public acceptance of the project • Treating the contamination in-situ greatly reduces the environmental impacts in comparison to other ex-situ remediation options • Increasing soil temperature by 10^{o} C or more greatly increase the remediation process since it enhances desorption • An energy storage facility is not required because temporary interruptions (wind deficiencies and/or solar restrictions) allow for preferential pathways in the subsurface to be redistributed with new bacteria making it easier for bacteria to consume the contaminants once the system starts up again
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Relevant Links [Optional]	HazMat Article: http://issuu.com/glaciermedia/docs/hmmspr201301/14?e=1087626/1729114 Website: http://www.johanvanleeuwen.org/photos.html
References [Optional]	van Leeuwen, J. (2013). Green remediation: “Zero emissions” in-situ soil remediation. *HazMat Management*, Spring, 14-18. http://issuu.com/glaciermedia/docs/hmmspr201301/14?e=1087626/1729114