Life Cycle Performance of ec-H2O NanoClean™ Technology

Evaluation of ec-H2O NanoClean vs Traditional Cleaners in Floor Cleaning Applications

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Prepared for:

Analysis By:

This analysis and report was prepared for Tennant Company by Ecoform, an environmental consulting firm specializing in the design, evaluation, and adoption of clean products and materials through technical and policy research.

Results and conclusions of this report are based on data provided to Ecoform for ec-H2O NanoClean™ technology by Tennant and its suppliers. This analysis would not have been possible without the cooperation of individual Tennant suppliers who voluntarily provided data and confidential business information in support of this effort. Ecoform staff would like to thank the companies and their representatives for their cooperation and assistance in this analysis. Please direct any questions or enquiries about this report to the following:

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OVERVIEW OF LCA STUDY

Tennant Company is a leading developer of innovative cleaning systems. A manufacturer of premium value-added machines, Tennant equipment caters to clients who value quality, durable equipment. With the rapidly growing emphasis on green building and human health, there is a demand in the market for environmentally focused cleaning systems that reduce or eliminate exposures to chemicals and indoor emissions.

In 2008, Tennant developed an innovative breakthrough technology called "ec-H2O™", capable of significantly minimizing chemical exposures and indoor emissions resulting from cleaning, while reducing impacts across the life-cycle[1]. Now Tennant has developed the next generation ec-H2O NanoClean™ technology, optimizing performance of the technology across a variety of user conditions.

To accurately assess the environmental and human health benefits of the next generation ec-H2O NanoClean technology, Tennant has contracted Ecoform to evaluate the Life-cycle performance of the next generation ec-H2O NanoClean technology as compared to that of traditional chemical-based floor cleaning systems used in specific applications. This study evaluates the relative life-cycle benefits associated with the use of ec-H2O NanoClean as compared to a conventional chemical-based floor cleaning system.

ec-H2O NanoClean DESCRIPTION

ec-H2O NanoClean technology is comprised of several components that are designed into the chassis of select floor scrubbers produced by Tennant Company. ec-H2O NanoClean technology uses electrolysis to electrically covert water into an innovative cleaning solution. This converted water is created by an on-board e-cell that generates billions of microscopic nanobubbles that promote cleaning efficacy. When combined with the mechanical scrubbing action of the brushes or pads, the converted solution has been shown to clean a wide variety of soils including typical daily soils, as well as more stubborn soils like food greases, road salt, and more. This next generation technology offers the same benefits of the first generation ec-H2O, with improved cleaning performance over a wider variety of applications.

Figure 1. T300 Scrubber with ec-H2O NanoClean

The ec-H2O NanoClean technology required to outfit a T300 scrubber is evaluated in this analysis. An ec-H2O NanoClean equipped T300 has a liquid flow rate of 0.12 gallons per minute, a scrub deck 20 inches wide, and an average operating time of 2.5 hours per charge. Although ec-H2O NanoClean™ requires energy to activate the water, the differences in energy consumption between the outfitted T300 scrubber

[1] Ecoform. "Cleaner Technology Assessment of ec-H20 Technology". 2010

and a standard T300 are not significant. See Appendix A for a more detailed description of the components evaluated in this LCA of the ec-H2O NanoClean technology.

LIFE-CYCLE ASSESSMENT SCOPE

Life-Cycle Approach

Life-cycle impacts in a variety of human health and environmental categories resulting from the cleaning of select building types were evaluated in a comparative life-cycle assessment. Two separate cleaning scenarios were evaluated, each based on data from actual building maintenance operations associated with each building type. For each scenario, the impacts associated with the production, transportation and disposal of the cleaning solutions and their associated packaging were calculated to assess the environmental and human health performance of the Tennant ec-H2O NanoClean equipped scrubber as compared to the use of conventional, chemical based cleaning systems. Because the ec-H2O NanoClean technology is a modification to traditional scrubber platforms offered by Tennant, the analysis focuses on the material differences between a T300 Tennant conventional scrubber designed for chemical cleaning, and that of an ec-H2O NanoClean equipped T300. As such, all scrubber parts identical to each machine were scoped out of the study, the effect of which is considered to be minimal. The scope of the study is depicted in Figure 2.

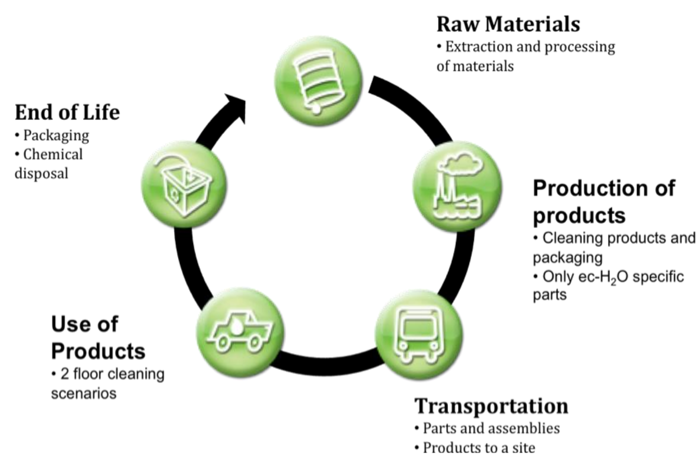

Figure 2: Scope of LCA Analysis

The life-cycle analysis was performed using version 6 of the GaBi Life-Cycle Software. Secondary data from GaBi and Ecoinvent datasets, supplemented by proprietary Ecoform data sets, comprised the entirety of the life-cycle inventory data. Specific environmental and human health impact categories evaluated are described in Appendix B.

Overall, data quality is considered medium for this analysis, taking into account the lack of primary manufacturing data for either alternative and the average quality of a few of the secondary data sets. Overall, 96% of the total mass of the ec-H2O NanoClean was characterized in this assessment.   Sensitivity analyses were conducted around these potential data gaps, with minimal affect on the overall disparity of the impacts. As such, the overall confidence in the study is evaluated to be good.

Life-Cycle Scenarios

This analysis compares the environmental performance of the next generation ec-H2O NanoClean™ technology to that of a conventional, chemical-based floor scrubbing system. Traditional resilient floor cleaning is performed using chemical-based cleaning agents applied using a floor scrubbing machine that mechanically agitates the surface with brushes. A variety of cleaning chemicals suitable for institutional and commercial cleaning are available on the market, each typically sold as a concentrate in one gallon bottles. Product is typically purchased in cartons of 2 or 4 bottles. This assessment evaluated a "typical" floor cleaner formulation developed from multiple floor cleaners and does not represent a particular floor cleaner on the market. Other product parameters include:

- Concentrated cleaner with a dilution rate of 1 oz per gallon
- Cleaning product in 1-gallon bottle with HDPE weight of 0.14 kg
- Product packaged 4 bottles per carton with corrugate weight of 0.65 kg

Figure 3. Typical Floor Cleaning Concentrates

Individual life-cycle scenarios were constructed to describe floor cleaning in an educational setting as well as for cleaning in the retail/health care environment. Scenarios characterize the critical parameters associated with floor cleaning and are used to define a functional unit for the study.

Specific parameters defined by the scenarios are presented below.

Table 1. Key Scenario Parameters – Floor Cleaning

Parameter	Scenario Value
Chemical dilution rate – oz/gal	1
Liquid flow rate – gal/min	0.4 Chemical-based 0.12 ec-H2O NanoClean
Floor scrub rate – sq ft/hr	9,274[a]
Floor Area Cleaned – sq ft/day	25,000
Frequency of Cleaning - Cycles/yr	365 Retail/Health Care (daily) 200 Education (5 days/wk, 40 wks/year)

[a] The Official ISSA 612 Cleaning Times Book, 2014.

The **functional unit** for the LCA for each scenario is defined as the cleaning of 25,000 square feet of resilient floor over a period of five years at a frequency consistent with the parameters described in the table above. The five-year evaluation period represents an average useful life for an ec-H2O NanoClean equipped scrubber in the considered market applications. The functional unit establishes a fair basis of comparison between ec-H2O NanoClean and the chemical-based cleaning operations based on the performance of a like amount of cleaning performed. Bills of materials (BOM) for both the ec-H2O NanoClean and for the chemical-based cleaning operations are resented in Appendix C.

Life-Cycle Inventory Scope

The Life Cycle Inventory Analysis covers the life-cycle stages as shown in Figure 4.

Materials
Includes raw materials and extraction processes for all chemicals and materials identified in BOMs.

Production
Production of individual Tennant ec-H2O components as well as all chemical products and packaging was evaluated. No assembly processes were included.

Transport
Transport from suppliers to final use was modeled. Average transport profile for U.S. is assumed

Use
Includes use of Tennant ec-H2O technology and chemical products during floor cleaning scenario

End of Life
Based on current market practices, all equipment and packaging is considered in this analysis to be sent to a landfill.

Figure 4: Inventory Scope by Life Cycle Stage

LIFE-CYCLE IMPACT ASSESSMENT

Impacts to a variety of key environmental and resource categories for the two floor cleaning systems are presented for both the education and retail/health care scenarios. Results reflect impacts associated with the life-cycle product chain consistent with the scope of the inventory data. Detailed descriptions of individual impact categories are described in the Appendix B.

Life-Cycle Impacts - Education Scenario

Life-cycle impacts assessed for both the ec-H2O NanoClean™ and chemical-based floor cleaning alternatives are presented in Table 2. Results are based on the education scenario and functional unit, which specifies the performance of 1,000 floor cleaning cycles over a five year period. Results have been normalized, and the percent differences have been presented in Table 2 and visually depicted in Figure 5.

Table 2. Life Cycle Impacts – Education

LCA Categories		Chemical-based	ec-H2O	Benefit (%)
Energy	(MJ)	28,008	1,841	**93**
CO_2 Emissions	(kg CO_2)	988	81.2	**92**
Ozone	(g CFCs)	0.0000583	0.00000658	**89**

Smog	(kg NOx)	0.000134	0.00000489	**96**
Acid	(kg SO_2)	3.06	0.396	**87**
Eutrophication	(kg PO4)	0.036	0.0212	**41**
Particulate	(kg PM2.5)	0.701	0.0807	**88**

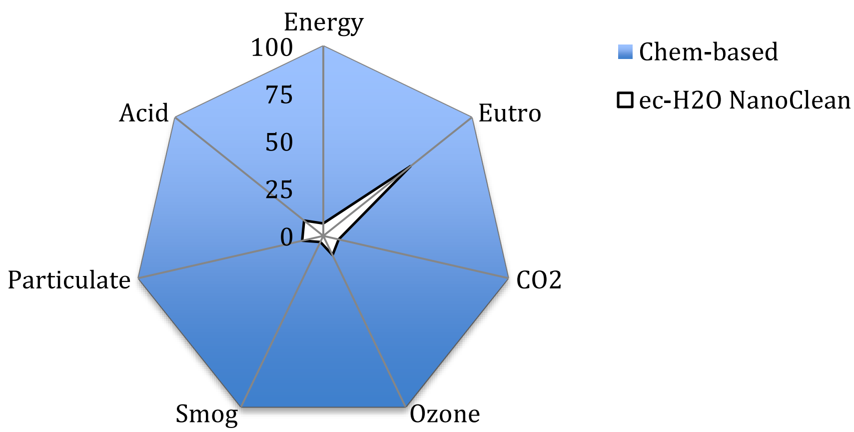

Figure 5. Chart of Relative Life Cycle Impacts – Education

Life-Cycle Equivalents - Education

Calculation of a series of equivalent offsets (e.g. car emissions offset) for specific categories such as CO_2 emissions provide additional context for the relative results of the life-cycle comparison. Offsets are calculated by comparing the net improvement in a particular category (e.g. energy consumption) to established factors such as the energy content of coal, or emissions from an airplane. The accumulated benefits of the ec-H2O NanoClean expressed in common equivalent offsets are presented in the Table 3.

Table 3. Equivalent Offsets per ec-H2O NanoClean – Education

Category	Savings 1 Year	Savings 5 year	Equivalent Offsets (per unit)
Energy (MJ)	5,233	26,170	Barrels of Oil Offset (5 yr) – 4.23 barrels Months of Household Energy Offset (5 yr) – 7.7 mos Number of Households Offset (5 yr) – 0.66 households Gallons of Gasoline Offset (5 yr) – 200 gallons
CO_2 Emissions (kgCO2)	181	907	Months of Passenger Car Travel (5 yr) – 2.4 mos Number of Cars Offset (5 yr) – 0.2 cars per ec-H_2O unit

ecoform

Education buildings are the fifth most prevalent commercial building type in the U.S., with approximately 309,000 buildings which include preschools, elementary schools, middle or junior high schools, high schools, vocational schools, and college or university classrooms. They are, on average, the largest commercial buildings, with 25,100 square feet per building, and they account for 11 percent of all commercial floor space.[2] Were 10 percent of the school buildings in the U.S. to use an ec-H2O NanoClean equipped T300 scrubber to perform floor cleaning, collectively they would save enough energy annually to power more than 3,960 homes a year and offset the CO_2 emissions of more than 1,213 cars annually.

Life-Cycle Impacts - Retail/Health Care

Life-cycle impacts assessed for both the ec-H2O and chemical-based floor cleaning alternatives are presented in Table 4. Results are based on the retail/health care scenario and functional unit, which specifies the performance of 1,850 floor cleaning cycles over the five year analysis period. Benefits (%) associated with use of ec-H2O NanoClean™ are presented for each impact category. Results have been normalized, and the percent differences have been presented in Table 4 and visually depicted in Figure 6.

Table 4. Life Cycle Impacts – Retail/Health Care

LCA Categories		Chemical-based	ec-H2O NanoClean	Benefit (%)
Energy	(MJ)	51,114	1,926	**96**
CO_2 Emissions	(kg CO_2)	1,803	128	**93**
Ozone	(g CFCs)	0.000109	0.00000641	**94**
Smog	(kg NOx)	0.000263	0.00000738	**97**
Acid	(kg SO_2)	5.589	0.522	**91**
Eutrophication	(kg PO4)	0.071	0.0297	**58**
Particulate	(kg PM2.5)	1.362	0.134	**90**

[2] http://www.apep.uci.edu/der/buildingintegration/2/BuildingTemplates/School.aspx

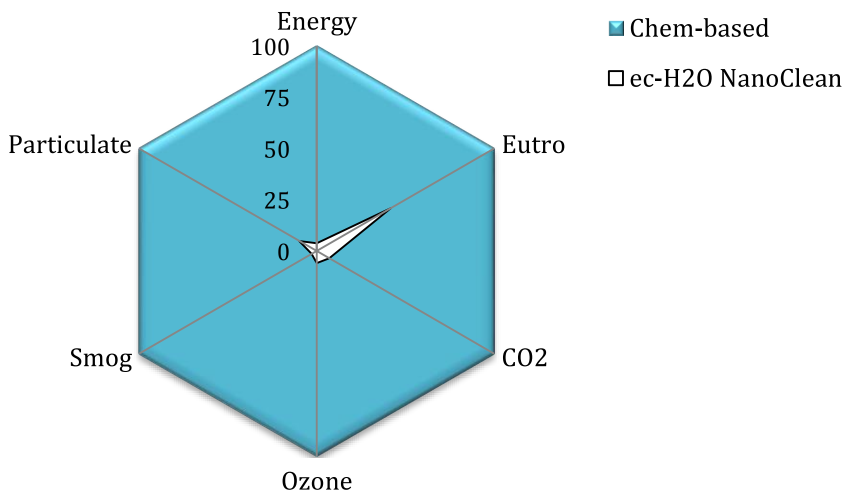

Figure 6. Chart of Relative Life Cycle Impacts – Retail/Health Care

Life-Cycle Equivalents - Retail/Health Care

Calculation of a series of equivalent offsets (e.g. car emissions offset) for specific categories such as CO_2 emissions provide additional context for the relative results of the life-cycle comparison. Offsets are calculated by comparing the net improvement in a particular category (e.g. energy consumption) to established factors such as the energy content of coal, or emissions from an airplane. The accumulated benefits of ec-H2O NanoClean™ under the education scenario are presented below.

Table 5. Equivalent Offsets per ec-H2O NanoClean – Retail/Health Care

Category	Savings 1 Year	Savings 5 year	Equivalent Offsets (per unit)
Energy (MJ)	9,840	49,200	Barrels of Oil Offset (5 yr) – 8 barrels Months of Household Energy Offset (5 yr) – 14.5 mos Number of Households Offset (5 yr) – 1.2 households Gallons of Gasoline Offset (5 yr) – 375 gallons
CO_2 Emissions ($kgCO_2$)	335	1,675	Months of Passenger Car Travel (5 yr) – 4.4 mos Number of Cars Offset (5 yr) – 0.36 cars per ec-H_2O

There are approximately 16,400 hospitals or other primary health care facilities in the U.S. averaging nearly 74,600 square feet in total floor space. In total, they account for 3% of the overall U.S. commercial floor space[3]. Unlike some commercial buildings, hospitals typically clean their floors daily to maintain a

[3] http://www.apep.uci.edu/der/buildingintegration/2/BuildingTemplates/School.aspx

clean and healthy indoor environment for patients and employees. If only 10 percent of the U.S. hospitals were to use a pair of ec-H2O NanoClean equipped T300 scrubbers to perform floor cleaning, collectively they would save enough energy annually to power more than 790 homes a year and offset the CO_2 emissions of more than 240 cars annually.

Analysis of LCA Results

Results of the life-cycle impact assessment demonstrate clearly the significant environmental benefits associated with the use of ec-H2O NanoClean™. In every category evaluated, ec-H2O NanoClean resulted in only a small fraction of the overall environmental impacts associated with the chemical-based floor cleaning. Net benefits ranged from 41-97 percent depending on the category, and on the scenario evaluated.

To fully understand the disparity, a critical analysis of the life-cycle material and resource consumption of the two alternatives is useful. Key consumption data for each alternative are presented in Table 6.

Table 6. Key Consumption Parameters for ec-H2O NanoClean Scenarios

Parameter	Education Scenario		Health/Retail Scenario	
	Chemical-Based	ec-H2O	Chemical-Based	ec-H2O
Manufacturing				
Total Mass – Year 1	392 kg	4.68 kg	697 kg	4.68 kg
Total Mass – Years 2-5	392/yr	0.24 kg	697 kg/yr	0.24 kg
Product Use				
Water use - year	12,840 gal/yr	3,880 gal/yr	23,430 gal/yr	7,084 gal/yr

Data for the education scenario demonstrate the large initial disparity in the materials required to manufacture the two cleaning alternatives. The 4.68 kilogram adjusted net mass of ec-H2O NanoClean™ (see Table C4) is significantly less than the 392 kilogram mass of the floor cleaning chemicals and packaging associated with the chemical-based system leaving a margin of more than 387 kilograms in only the first year. The disparity grows to nearly 1,960 kilograms in following years, as ec-H2O NanoClean operates a minimum of five years, while chemical-based cleaners are consumables requiring continuous replacement as they are depleted. The accumulated life-cycle impacts associated with the production of this additional mass of chemicals clearly dominates this analysis, and becomes even greater in the health/retail scenario.

During the use stage, both systems require the use of a scrubber to effectively clean the surface of resilient floors. Though a Tennant T300 scrubber was used for each alternative, the ec-H2O NanoClean outfitted scrubber cleans a comparable surface area of floor using a much lower liquid flow rate (see Table 1). The resulting savings in water during cleaning operations totals 8,960 gallons over the five year analysis period in the education scenario, and even greater for health/retail. The benefits of the reduced water consumption contribute to the overall disparity in life-cycle results for the two systems, in either scenario. Other parameters such as energy consumed during operation are nearly identical between the standard and ec-H2O NanoClean outfitted machine.

Upon review of this data, it is clear that the results are supported by the underlying data and align with expectations. It is also unlikely that the system would be sensitive to small changes in many of the key parameters that were assumed for this study given the disparity in the overall material consumption profiles. For example, even if the volume of chemicals consumed yearly was halved, the total mass of consumables use in traditional cleaning would still be 980 kg, or more than 200 times greater than that of ec-H2O NanoClean.

Overall, the results indicate that there are significant benefits to the environment associated with the use of ec-H2O NanoClean in every category as compared with traditional chemical-based floor cleaning.

ADDITIONAL ENVIRONMENTAL INFORMATION

Toxic Hazards

Chemical-based floor cleaners may be comprised of any number of chemical compounds, some of which may pose a potential threat to human health or the environment. Floor cleaning chemicals applied to the floor during the cleaning process are suctioned into the scrubber tank and subsequently disposed by drain into the local water works where they may pose a hazard to aquatic ecosystems. In addition, chemical cleaners may leave a film of chemical residue on the surface of the floor leading to potential exposures for children or other vulnerable populations.

The ec-H2O NanoClean™ technology is a detergent-free system that cleans effectively using water from the tap. As a result, use of the ec-H2O NanoClean technology significantly reduces potential exposures for workers and building inhabitants to chemicals used in traditional floor cleaners.

The next generation technology utilizes food-grade polyphosphate to optimize the performance of ec-H2O NanoClean equipped machines over a variety of water conditions. When present in wastewater in large amounts, polyphosphate has the potential to contribute to the eutrophication of local waterways. However, the quantities of food-grade polyphosphate utilized by the ec-H2O NanoClean system are minute, ranging from 2-4 parts per million, similar to the amount used by many municipal water treatment facilities. As such, polyphosphate emissions are unlikely to promote meaningful eutrophication effects.

The overall effect of the added polyphosphate was evaluated in this LCA. Despite the added polyphosphate, floor cleaning with the next generation ec-H2O NanoClean resulted in a 41-58 percent improvement in eutrophication impacts over those with the use of a conventional chemical-based scrubber, depending on the scenario.

Water Consumption

Both the ec-H2O NanoClean technology and chemical-based floor cleaning systems rely on the use of a scrubber machine to physically scrub the surface to clean effectively. To control for variation, both systems were evaluated using the Tennant T300 scrubber. However, the ec-H2O NanoClean equipped machine operates with a liquid flow rate of 0.12 gal/min, much less than the 0.4 gal/min liquid flow rate of a conventional T300 machine. Under the education scenario, use of the ec-H2O NanoClean technology results in a savings of 44,800 gallons of water over the 5-year evaluation period, and over 81,800 gallons of water under the scenario for retail/health care. These savings result in not only a natural resource benefit, but also reduce impacts resulting from the production and distribution of fresh water as well as from the treatment and disposal of the wastewater.

Other Non-Renewable Resource Consumption

Chemical-based cleaners are made largely from petroleum-based chemicals and plastic packaging which ultimately are unrecovered at the end of their useful lives. After application, chemicals that do not volatilize are removed from the surface are disposed down a drain and into the local sewage system, while packaging is routinely disposed to a landfill. Over a 5-year period, a total of 313kg of non-renewable, petroleum-based resources are consumed by chemical-based floor cleaning operations in the education scenario (see BOM), with even greater consumption totaling 572 kg in the retail/health care setting.

The ec-H2O NanoClean technology represents a significant improvement over the use of chemical cleaners. While much of the BOM for ec-H2O NanoClean is also comprised of non-renewable resources, together they account for only 4.7 kg in total mass. In addition, because of the high value the machines retain at the end of 5-years, they often are kept in use well beyond the warranty period and are typically repaired or rebuilt to extend the life of the product, further exaggerating the non-renewable resource benefits of the ec-H2O NanoClean technology.

REFERENCES

Baird C, Cann M. 2005. *Environmental Chemistry*. 3rd ed. W.H. Freemand and Company: New York.

California Air Resources Board (CARB). California Environmental Protection Agency. http://www.arb.ca.gov/homepage.htm

Milhelcic J. 1999. *Fundamentals of Environmental Engineering*. John Wiley and Sons, Inc: New York.

Office of Air and Radiation. U.S. Environmental Protection Agency. http://www.epa.gov/air/.

Tennant Company. *Ec-H2O NanoClean Brochure*. Tennant Company website accessed March 6, 2015. http://assets.tennantco.com/globalassets/webassets/innovations/ec-h20%20nanoclean_comm%20brochure_nobles_5.001.008.am.en.pdf

Tennant Company. Tennant Speed Scrub *T300 Brochure*. Tennant Company website accessed March 6, 2015. http://assets.tennantco.com/globalassets/webassets/scrubber%20walk-behinds/speedscrub%20300_1.624.001.am.en.pdf

University of California-Irvine. Building Integration Tutorial, Advanced Power and Energy Program. Accessed on November 11, 2009. http://www.apep.uci.edu/der/buildingintegration/2/BuildingTemplates/Hospital.aspx

APPENDIX A – Boundaries of Study

This LCA compares the impacts resulting from the use of two T300 scrubbers manufactured by Tennant: a T300 scrubber, and a T300 scrubber equipped with the ec-H2O NanoClean™ technology. The primary difference in the two models is the inclusion of the module required to implement the ec-H2O NanoClean technology, depicted in Figure A1, below. A Bill of Materials for the module is given in Appendix Table C4.

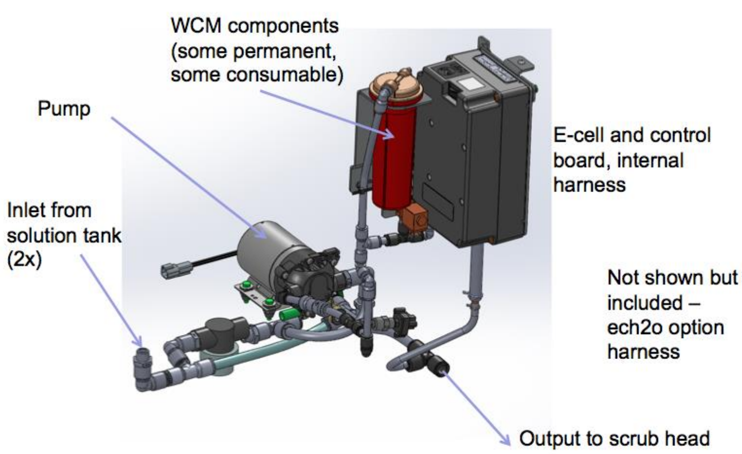

Figure A1- Components of ec-H2O NanoClean module assessed in LCA

Figure A2 depicts the portions of the T300 scrubber that are replaced by the ec-H2O NanoClean technology and thus are no longer needed by the new scrubber. These materials are treated as a credit, offsetting any impacts resulting from the materials that comprise the ec-H2O NanoClean technology.

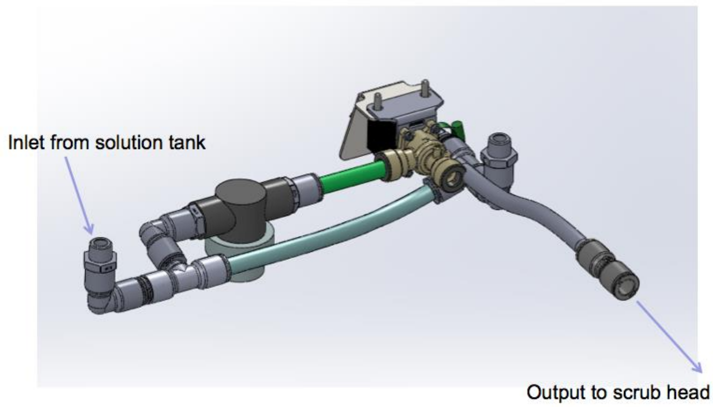

Figure A2 – Components of T300 replaced by ec-H2O NanoClean technology

APPENDIX B – IMPACT CATEGORY

Acidification, (AP): Acidification originates from the emissions of sulfur dioxide and oxides of nitrogen. These oxides react with water vapor in the atmosphere to form acids that subsequently fall to earth in the form of precipitation, and present a hazard to fish and forests by lowering the pH of water and soil. The most significant man-made sources of acidification are combustion processes in electricity and heating production, and transport. Acidification potentials are typically presented in g SO_2 equivalents

CO_2 Emissions, (CO2): Global warming of the atmosphere occurs when carbon dioxide, methane, or other gasses contributing to global warming absorb infrared radiation from sunlight, trapping it within the atmosphere. Some of the biggest human contributors to global warming are the combustion of fossil fuels like oil, coal and natural gas. This impact category includes the contributions of all such gases, even though it is expressed as CO_2 Emissions. Global warming potential are typically presented in g CO_2 equivalents.

Eutrophication, (EP): Nutrients from discharged wastewater and fertilized farmland act to accelerate the growth of algae and other vegetation in the water. Oxygen deficiency then results from the degradation of organic material in the water, posing a threat to fish and other life in the aquatic ecosystem. Oxides of nitrogen from combustion processes are of significance. Eutrophication potentials are typically presented in g NO_3 equivalents.

Ozone Depletion Potential, (ODP): Stratospheric ozone is broken down as a consequence of man-made emissions of halocarbons (CFC's, HCFC's, haloes, chlorine, bromine etc.). The ozone content of the stratosphere is therefore decreasing, resulting in a thinning of ozone layer, often referred to as the ozone hole. The consequences are increased frequency of skin cancer in humans and damage to plants. Ozone depletion potentials are typically presented in g CFC equivalents.

Particulates, (P): Particulates are released as a consequence of both mobile and point source operations, usually involving combustion of materials. When inhaled, particulates directly affect humans often resulting in respiratory irritation and even prolonged chronic respiratory illness. Smaller diameter particulates, such as those smaller than 2.5 microns (PM 2.5) pose the greatest threat. Particulates are typically presented in g PM 2.5 released.

Photochemical Smog, (POCP): Photochemical smog (also referred to as ground level ozone) is formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of heat and sunlight. Smog forms readily in the atmosphere, usually during hot summer weather, and contributes to respiratory illness in humans such as chronic bronchitis and emphysema. Photochemical smog formation potentials are typically presented in g ethane equivalents.

APPENDIX C – Bill of Materials

Life-cycle analysis was conducted on the alternatives for cleaning resilient flooring in two separate scenarios. The model for each scenario was based on a bill of materials (BOM) calculated from data collected from actual cleaning operations for identical buildings, key operating parameters, or both. A BOM is a listing of the total materials and resources that make up that alternative. This appendix presents the BOMs and other key parameters for the Tennant ec-H2O NanoClean™ technology as well as for the system using a conventional, chemical-based cleaning system.

Chemical-Based Floor Cleaning

A traditional chemical-based floor cleaning system is comprised of the materials listed below. See Table 1 for specific parameters of each scenario. Table C1 presents a breakdown of the chemical content used in each scenario evaluated. The content is based on the formulation of a generic floor cleaner concentrate, developed using MSDS data from multiple leading brand chemical cleaners and is diluted to 1 oz of cleaner per gallon of water.

Table C1. Breakdown of Chemical Content- By Scenario (5 Yr)

Chemical/Material	Life-Cycle Evaluation Scenarios		
	Wt %	Health Care/ Retail	Education
CHEMICALS (gal conc)			
Water (in concentrate)	87.25	805	441
Alcohol ethoxylate	9.5	88	48
Sodium Xylene Sulfonate	2.5	23	13
Versene 100, EDTA	0.75	7	4

A complete BOM for the chemical-based system is shown in Table C2. The data reflect the quantity of chemicals and packaging required for the 5-year period defined by the functional unit under each scenario.

Table C2. Bill of Material of Conventional Cleaning Systems (kg)

Chemical/Material	Life-Cycle Evaluation Scenarios	
	Health Care/ Retail	Education
Chemicals	3,484	1,909
Packaging	128	70
Corrugate	150	82
Total Materials– Non-H20	**3,763**	**2,062**
Water (dilution)	426,000	233,424
Total Materials (kg)	**429,763**	**235,486**

__**Tennant ec-H2O NanoClean**__

The ec-H2O NanoClean™ technology is comprised of a number of materials, each listed in Table C3. Components of the technology total 5.19 kilograms in mass. However, the presence of the ec-H2O NanoClean technology displaces a portion of the T300 machine, making those parts extraneous to the ec-H2O NanoClean equipped machine. The net balance of each material, given in the table below is used as an input to the LCA model. The BOM characterizes the portions of the scrubber associated with ec-H2O NanoClean technology. See Appendix A for a more detailed description of the portions of the scrubber analyzed.

Table C3. Breakdown of Material Content – ec-H2O NanoClean

Chemical/Material	Life-Cycle Evaluation Scenarios		
	Ec-H2O NanoClean	T300 (extraneous)	Net Quantity
Materials (kg)			
Carbon Steel	1.235	-	1.235
Stainless Steel	1.18	0.499	0.681

Aluminum	0.29	-	0.29
Copper	0.38	0.120	0.26
Brass	0.021	-	0.021
Titanium	0.1	-	0.1
Other metals	-	-	-
ABS	0.489	-	0.489
Nylon	0.006	-	0.006
Polycarbonate	0.27	-	0.27
Polypropylene	0.081	-	0.081
Polystyrene	0.078	-	0.078
PVC	0.165	-	0.165
HDPE	0.059	0.073	- 0.014
EPDM	0.014	0.006	0.008
Polyamide	0.186	0.118	0.068
Vinyl	0.003	-	0.003
Polyester	0.002	-	0.002
Printed Wiring Board	0.2	-	0.2
Sodium Phosphate	0.333	-	0.333
Sodium Triphosphate	0.037	-	0.037
Other Materials	-	-	-

A complete BOM for the ec-H2O NanoClean system is presented in Table C4. It characterizes all of the materials and resources, excluding energy, required to perform the required floor cleaning operations for each building type over the five-year period of this analysis. Because both alternatives are based on a T300 scrubber, and since the energy consumption of a ec-H2O NanoClean™ equipped machine is nearly identical to that of a T300, energy consumption is likely to be identical between the alternatives and was scoped out of the study.

Table C2. Bill of Material of ec-H2O NanoClean (kg)

Chemical/Material	Life-Cycle Evaluation Scenarios	
	Health Care/ Retail	Education
Materials		
Ec-H2O NanoClean	5.19	5.19
Displaced T300 Content	0.51	0.51
Total Materials– ec-H2O NanoClean	**4.68**	**4.68**
Water use	128,806	70,579
Total Materials (kg)	**128,810**	**70,580**