Project Charter

Enhancing Sustainability Performance in Aquatic Centres: A Lifecycle Approach

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1. Project Background

Swimming is one of the most popular exercise activities in Canada, with around 2700 public pools, including >35% being indoor swimming pool facilities (ISPs). The large quantities of energy required to maintain heating and proper air and water circulation within ISPs results in increases to their energy consumption. The requirements for maintaining healthy air quality within these facilities is also higher. The complex relationship between energy use, water temperature, and optimal ventilation is exacerbated by the related risks to the human health of swimmers and staff that deteriorating water and air quality can cause. Additionally, disinfectants are applied to treat pathogens in pool water, readily producing disinfection by-products (DBPs) by reacting with common organic matter in the water. The DBPs are linked to many critical health effects, with over 600 DBPs identified in chlorinated water. Maintenance of water quality in terms of DBPs requires certain operational conditions and pool design, which may impact energy consumption and greenhouse gas emissions. Therefore, considering all these complex and interrelated factors governing energy consumption, water quality, and risks to human health in ISPs, the concept of Water-Health-Energy-Nexus (WHEN) is needed to optimize these systems operations and ensure long-term environmental and economic benefits for ISPs.

The concept of a water-energy-nexus (WEN) has been successfully applied in urban water systems. Adding a component of health would allow decision-makers to evaluate the effects of DBPs in this application. This focus on health further allows the study to be among the first to comprehensively consider water, health, and energy to manage these ISPs better. Our research team from UBCO has analyzed the water and air quality of some ISPs but based on limited samples, allowing the life-cycle environmental impacts of design changes to these facilities to be assessed. Therefore, expanding the scope of this research to include the health element with water and energy will allow a more holistic performance assessment of ISPs parameters and formulation of new operational guidelines to manage both energy consumption and health risks better. The impetus to develop new, generalisable guidelines is driven by two key challenges: the need for clear guidelines on maximum levels of disinfectants to minimise DBP formation ensuring human health, and optimizing energy consumption during operation to meet national carbon emissions targets.

2. Project Objectives

This project aims to identify the optimal operational strategies and best management practices for ISPs to minimize human health risks, environmental impacts, and operational costs using the Water-Health-Energy-Nexus (WHEN). The project will be mobilized in three themes, i.e., monitoring and management of pool water quality, energy use, and evaluating other occupant parameters (Themes A & B) and developing optimal operational strategies using "WHEN" to identify the suitable ISP settings (Theme C).

The project is divided into three themes as described above which encompass the primary analytical goals and deliverables, with detailed descriptions provided in Section 4 below. The themes are as follows:

- *Theme A: Monitoring Pool Status*
- *Theme B: Monitoring Building Energy Use and Occupant Experience*
- *Theme C: Developing Optimal Operation Strategies and Information Dashboard using "*WHEN.*"*

This project will be mobilized using one aquatic centre in the City of Burnaby (CoB), one in the City of Richmond (CoR), and two in the City of Kelowna (CoK1 and CoK2). The research and development through

this project will assist in optimising energy consumption, chemical use, and pool design of ISPs, giving participating stakeholders a competitive advantage in an increasingly energy-conscious market. Additionally, the development of an *ePool* interface that will allow pool operators to continuously monitor and optimize water quality, energy consumption, and indoor environment will also be a key objective. The health agencies will ensure that the relevant knowledge base developed in this project will assist in future ISP guidelines. Results will be shared with all partners and published in academic platforms to ensure they are available to ISPs throughout Canada.

3. Stakeholder Summary

	UBC
Dr. Michael De Coste	Project Manager/PDF
Dr. Haroon R. Mian	Project Coordinator/PDF-Water
Dr. Anber Rana	Project Coordinator/PDF-Energy
Intern (TBD)	MASc Student (MSc 1)
Intern (TBD)	PhD Student (PhD 1)
Intern (TBD)	PhD Student (PhD 2)
Intern (TBD)	PhD Student (PhD 3)
Field Assistant (TBD)	Undergraduate Field Assistant
Rehan Sadiq	Principal investigator, Professor and Provost, UBC Okanagan
Kasun Hewage	Co-investigator, Professor, School of Engineering UBC Okanagan
Andrea MacNeil	Collaborator, Clinical Associate Professor
	Others
City of Kelowna	City/Partner
City of Richmond	City/Partner
City of Burnaby	City/Partner
DB Perks & Associates Ltd.	Company/Partner
AME consulting group	Company/Partner
HCMA	Company/Partner
Myrtha Pools	Company/Partner
Interior Health	Collaborator
Fraser Health	Collaborator
Vancouver Coastal Health	Collaborator

PDF: Post Doctoral Research Fellow

4. Project Scope

Theme A

Task A-1: Measurement of parameters and DBPs in water and air

- Literature review to identify key parameters, corresponding health guidelines, and measurement methods.
- Develop sampling schedule and conduct sampling campaigns in winter and summer season at each of the five ISPs.
- Installation of real-time sensors in applicable ISPs to continuous monitor water quality indicators, as needed.

Task A-2: Development of predictive models

- Computational Fluid Dynamics (CFD)-based predictive models to track DBPs formation and occurrence.
- Integrate developed models with other indoor characteristics to develop relationships between DBPs (air and water).
- Validation of predictive models with the real time data collected from sensors.

Theme B

Task B-1: Building energy and air quality performance assessment

- Development of Building Energy Models (BEMs) for considered ISPs utilizing architectural and operational data.
- Existing operational guidelines will be used along with real time energy use data for calibration and validation of models.

Task B-2: Occupant surveys

- Surveys of users will be conducted to gather data on perceptions of thermal comfort, odor, humidity level, frequency and duration of pool use, etc.
- Coupled results with Indoor Environmental Quality (IEQ) data to analyze demographic responses and relationships to provide information on acceptable indoor conditions for Task C-1.

Theme C

Task C-1: Human health risk, environmental, and economic assessments

- Information generated in Themes A and B will be used to conduct and evaluate human health risk assessments associated with water quality and DBPs.
- Conduct lifecycle analysis of ISPs to assess the long-term environmental and economic performance/impacts.

Task C-2: Dynamic simulation testbed of facility energy system

- Dynamic simulation of the ISP facility energy systems will be developed using data from literature, performance modelling, and simulations from previous objectives to provide information on indoor air and pool water conditions.
- Real time data recorded from CoK location will be used to calibrate the model, which will then be used as an ‘actual’ system to test proposed operational strategies.

Task C-3: Development of optimal operational strategies and dashboard

- Develop a comprehensive WHEN-based performance model using energy use, thermal comfort, and health risk data from results of Task C-1.
- Baseline energy performance assessment using existing operational guidelines.
- Optimization of conditions based in environmental performance, economic aspects, and health risks to evaluate the feasibility of net-zero energy and emissions status.

- Developing an "*ePool*" dashboard for the monitoring of real time paramerers of ISP facilities and projected emissions using the sensors installed in the CoK facility as a demonstration.

5. Deliverables and Success Criteria

1. Measurement of water quality i.e., DBPs for considered ISPs
2. Develop and validation of DBP's predictive models to evaluate water quality
3. Building energy performance of ISPs using direct measurements, utility data, and simulations
4. Human health risk assessments and life cycle assessment of ISPs facilities
5. Formulate optimal operational scenarios and develop guidelines on energy performance employing WHEN models for ISPs
6. Development and testing of *ePool* dashboard for monitoring operational status of ISPs

6. Communication Plan

Action	Deliverable	Dates	Accountable
Progress reports	Bullet point notes circulated by email	Quarterly	Michael De Coste
Progress review meeting	Progress updates	Bi-weekly	Michael De Coste and UBCO Research Team (Internal)
Technical meetings	Zoom, telephonic, and email communication with the partner participating utilities	As needed	UBCO Research Team and Partners
Data collection	Conduction of sampling campaigns, conduction of surveys, installation of monitoring equipment	As needed	UBCO Research Team and Partners
Deliverable Reports	Yearly progress and other deliverables-based reports	Several reports throughout project term, as per needs	UBCO Research Team
Final Project Report & *ePool* development	Development of models, optimization, proposal and testing of operational guidelines	End of term	UBCO Research Team

7. Resources

Required resources	Accountable
Access and logistics for field samplings, visits, and interviews	CoK, CoR, CoB
Water utility data	CoK, CoR, CoB
Community data	CoK, CoR, CoB

Regulatory Data	Interior Health, Fraser Health, Vancouver Coastal Health
Support, review, and advising on Architecutral, Construction, Operational, Design Data, Monitoring, and Sampling	Myrtha Pools Canada, AME Consulting Group LTD, DB Perks and Associates LTD, HCMA

8. Milestones

Milestone	Deliverable	Target date	Accountable
Measurement of water quality and DBPs in CoK ISP (A-1)	Report on DBP Status (D1)	Apr, 2024	PhD 1, MSc 1
Development of BEM using relevant data from CoK2 (B-1)	Report on ISP building energy performance (D2)	Apr, 2024	PhD 3
Development of predictive DBP model framework using CFD and Fugacity-approach (A-2)	Report on framework and results from CoK1(D3)	Oct, 2024	PhD 2, PDF
Measurement of Water Quality and DBPs in CoR1 and CoR2 (A-1)	Report on DBP Status of CoR (D4)	Apr, 2025	PhD 1, MSc 1
Human health risk assessment of DBPs in ISPs using gathered data (C-1)	Report on human health risks from DBPs (D5)	Apr, 2025	PhD 2, 3, PDF
Completion of BEM and development of modelling guidelines for BEM in ISP (B-1)	Report on remaining ISP building energy performances and developed guidelines (D6)	Oct, 2025	PhD 3
Measurement of Water Quality and DBPs in CoB and CoK2 and installation of CoK2 monitors (A-1)	Report on DBP Status and monitoring (D7)	Jan, 2026	PhD 1, MSc 1
Extension of predictive CFD-Fugacity framework for DBP prediction to other ISPs, validate with CoK2 realtime data (A-2)	Report on results and validation of CFD-Fugacity approach for four ISPs (D8)	Apr, 2026	PhD 2, PDF
Occupant surveys of ISPs and analysis of optimal comfort levels (B-2)	Report on the optimal operational scenarios of ISPs (D9)	Apr, 2026	PhD 2, 3, PDF
Developments of guidelines on energy performance of ISPs based on lifecycle assessments (C-1)	Report on proposed lifecycle guidelines for ISPs (D10)	Apr, 2026	PhD 2, 3, PDF
Completion of human health risk assessment from remaining ISPs (C-1)	Report on human health risks from DBPs (D11)	July, 2026	PhD 2, 3, PDF
Development of optimized WHEN model and optimal operation strategies (C-2)	Report on WHEN performance (optimization) model (D12)	Oct, 2026	PhD 3, PDF
Development of *ePool* dashboard (C-3)	Report on *ePool* dashboard performance (D13)	Apr, 2027	PhD 3, PDF
Compilation of project results	Final Report	Apr, 2027	PDF

*Target dates are tentative and subject to change

9. Resource & Budget Summary

One (1) post-doctoral research fellow (PDF) will be hired full time on this project for its lifetime. Three PhD students will work on this project for the duration of its lifetime. One MASc student will work full-time on this project for two years. The funds available will be used for the following purposes:

Year	**Salaries ($)**	**Equipment/Software ($)**	**Materials/Supplies ($)**	**Travel ($)**	**Total cost ($)**	**Budget (%)**
1	137,560	10,000	14,060	4,880	166,500	25.69
2	140,120	5,000	28,120	14,260	187,500	28.94
3	120,120	4,500	28,120	11,260	164,000	25.31
4	115,000	9,000	0	6,000	130,000	20.06
Total	**512,800**	**28,500**	**70,300**	**36,400**	**648,000**	100
Budget %	79.14	4.40	10.85	5.62	100	

Appendix A: Project Timeline

Themes and Tasks	PIs and HQP	2023			2024				2025				2026				2027
		May-July	Aug-Oct	Nov-Jan	Feb-April	May-July	Aug-Oct	Nov-Jan	Feb-April	May-July	Aug-Oct	Nov-Jan	Feb-April	May-July	Aug-Oct	Nov-Jan	Feb-April
Theme A: Monitoring Pool Water Status																	
Task A-1: Measurement of water and air quality	Sadiq, PhD1, MASc1				**D1**				**D4**			**D7**					
Task A-2: Development of predictive models integrating CFD & fugacity	Sadiq, PhD2, RA						**D3**						**D8**				
Theme B: Assessment of Building Energy and Indoor Environment																	
Task B-1: Building energy and air quality performance assessment	Hewage, PhD3				**D2**						**D6**						
Task B-2: Formulation of operational scenarios for controlling DBPs and others	Sadiq, Hewage, PhD2, PhD3, RA												**D9**				
Theme C: Development of Optimal Operational Strategies and ePool Dashboard																	
Task C-1: Human health risk and life cycle assessment for defined scenarios	Sadiq, MacNeill, PhD2, PhD3, RA								**D5**				**D10**	**D11**			
Task C-2: Identification of optimal operational strategies	MacNeill, PhD3, RA																
Task C-3: Development of optimal operational strategies and dashboard	Sadiq, PhD3, RA														**D12**		**D13**

Appendix B: Contact Information for Stakeholders

UBC			
Michael De Coste	Project Manager	mdecos01@mail.ubc.ca	403-394-5754
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Communities			
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Eric Bientjes	City of Burnaby	Eric.Bientjes@burnaby.ca	604-294-7598
Kirsten Close	City of Richmond	kclose@richmond.ca	604-238-8041
Partners			
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Dan Thompson	Myrtha Pools Canada Inc.	Dan.thompson@myrthapools.com	416-568-3157
Collaborators			
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PDF: Post Doctoral Research Fellow