**Supplementary Material**

***Summary Graphs of Topic Coverage for Mandatory Undergraduate Courses***

**Figure 7** - Topic coverage in the theme of “Built Environment Context” for mandatory undergraduate courses.

**Figure 8** - Topic coverage in the theme of “Common Threads” for mandatory undergraduate courses.

**Figure 9** - Topic coverage in the theme of “Circular Economy” for mandatory undergraduate courses.

**Figure 10 -** Topic coverage in the theme of “Energy and Carbon” for mandatory undergraduate courses.

**Figure 11 -** Topic coverage in the theme of “Water” for mandatory undergraduate courses.

**Figure 12** - Topic coverage in the theme of “Ecology and Biodiversity” for mandatory undergraduate courses.

**Figure 13 -** Topic coverage in the theme of “Connectivity and Transport” for mandatory undergraduate courses.

***Climate Framework Topics Excluded from Survey:***

* Global Context and Fundamentals
  + Climate Fundamentals: Climate Change
    - Psychological & Physical Health Impacts and Social Awareness
* Built Environment Context
  + Environmental Impacts and Drivers of the Built Environment
    - Cross-cutting Themes
* Construction and Real Estate Industry
  + Activities, Briefing, Decision-Making and Communication
  + Stakeholders and Values
  + Governance
  + Construction Processes and Supply Chains
  + Financing Models
* Common Threads
  + Designing for Performance, Feedback and Closing the Performance Gap
    - Outcome-based Design
    - Integrated Systems, Technologies and Controls
    - User Engagement and Training
    - Commissioning, Monitoring and Post Occupancy Evaluation
    - Roles and Responsibilities
  + Process, Investment and Procurement
    - Funding and Investment (for the Asset and the Team)
    - Alternative Development Models
    - Value Approach to Procurement (Value Toolkit)
    - Team Formulation and Delivery/Validation Process
    - Sustainable Outcomes Value and Life Cycle Costing
  + Stakeholder Engagement
    - Co- and Participatory Design
    - Stakeholders Representation
    - Roles and Responsibilities
    - Business Case and Brief
    - Engagement and Communication Strategy
  + Research, Innovation and Partnerships
    - Research-based Design and Implementation in Practice
    - “Interprofessionalism”: Transdisciplinary and Interdisciplinary Approach
    - Future Scenarios: Benchmarking and Analysis through Digital Innovation
    - Governance and Funding
    - International/Regional/Local Agency, Institutions and Partnerships

*Note: Only the topics listed were excluded, the themes and subthemes are just listed to provide context for the topics’ location in the Climate Framework.*

***Engineers Canada Accreditation Criteria: Mentions of Sustainability [[1]](#footnote-1)***

The engineering profession expects of its members competence in engineering as well as an understanding of the effects of engineering on society. Thus, accredited engineering programs must contain not only adequate mathematics, science, and engineering curriculum content but must also develop communication skills, an understanding of the environmental, cultural, economic, and social impacts of engineering on society, the concepts of sustainable development, and the capacity for life‐long learning.

*One of the graduate attributes is:*

Impact of engineering on society and the environment: An ability to analyze societal and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions, and the concepts of sustainable design and development and environmental stewardship.

*Under curriculum content and quality criteria:*

3.4.4.2: A minimum of 225 AU in engineering science is required. Engineering science subjects involve the application of mathematics and natural science to practical problems. They may involve the development of mathematical or numerical techniques, modeling, simulation, and experimental procedures. Such subjects include, among others, the applied aspects of strength of materials, fluid mechanics, thermodynamics, electrical and electronic circuits, soil mechanics, automatic control, aerodynamics, transport phenomena, and elements of materials science, geoscience, computer science, and environmental science.

3.4.4.5 A minimum of 225 AU in engineering design is required. Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.

3.4.5.1: While considerable latitude is provided in the choice of suitable content for the complementary studies component of the curriculum, some areas of study are essential in the education of an engineer. Accordingly, the curriculum must include studies in the following:

a. Subject matter that deals with the humanities and social sciences;

b. Oral and written communications;

c. Professionalism, ethics, equity and law;

d. The impact of technology and/or engineering on society;

e. Health and safety;

f. Sustainable development and environmental stewardship;

g. Engineering economics and project management.

**Table 1**: Topic coverage for undergraduate mandatory environmental engineering courses

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Climate Change | Key Indicators and Monitoring (5/6) |
| Projected Physical Impacts (on Land, Nature, etc.) and Regional Priorities (4/6) |
| Scientific Evidence (3/6) |
| Climate Fundamentals: Resource Use | Current Trends and Future Prospects of Natural Resources (4/6) |
| Sustainable Resource Use and Management (4/6) |
| Socio-economic Implications of Irresponsible Resource Use (3/6) |
| Climate Fundamentals: Systems Thinking | Measurable Changes in Earth’s Systems and Processes (4/6) |
| Socioeconomic Drivers and Economic Consequences (3/6) |
| Causes and Effects of Global Changes (3/6) |
| International Legislations, Agreements, Frameworks, Roadmaps and Plans for Action | United Nations Agenda 2030: Sustainable Development Goals, Global Indicator Framework for SDGs and Targets of the 2030 Agenda, The New Urban Agenda and Race to Zero & Race to Resilience Campaigns (5/6) |
| United Nations Framework Convention on Climate Change, The Kyoto Protocol and the Doha Amendment (4/6) |
| The Paris Agreement and Regional (EU) Directives (3/6) |
| Risks and Opportunities in a Net-Zero Economy | Physical Risks (Stranded Assets), Monitoring / Measurement, Opportunities and Actions (2/6) |
| Built Environment Context | Environmental Impacts and Drivers of the Built Environment | **Impacts on the External Environment (Land Use, Air, Soil, Water Pollution, Other Greenhouse Gases) (6/6)** |
| Impacts on the Internal Environment (Energy and Water Use, Waste, Thermal Efficiency, Health) (3/6) |
| Building Whole Life and Product Life Cycles (3/6) |
| Ethics and Value of Sustainability | Rights of Current and Future Generations (3/6) |
| Health, Wellbeing, Safety and Resilient Communities (2/6) |
| Ethics in Practice (2/6) |
| Sustainable Urbanism, Architecture and Engineering | Regenerative Urban Development, Buildings, Infrastructure and Growth (4/6) |
| Built Environment Policy, Legislation, Regulations, Commitments, Benchmarks and Construction Industry Guidance | Policies, Legislation, Regulations, Carbon Budgets and Implementation (3/6) |
| Other Mechanisms for Change (Certifications such as BREEAM, LEED, WELL, NABERS, DGNB, HQE, Green Star, CASBEE, BEAM Plus, GORD, One Planet Living, Living Building Challenge (The Red List Materials), Passivhaus and Declarations,) (2/6) |
| Common Threads | Retrofit (Adaptation and Reuse) | Energy Efficiency Action Plan (for Buildings), EnerPHit and Net-Zero (3/6) |
| Transitions: Incentives, Policy and Engagement (3/6) |
| Hierarchy of Interventions: Passive Design, Retro-First, Fabric and Fuel (2/6) |
| Whole Building Approaches: Rethinking Retrofit Delivery and Cost (2/6) |
| Building Safety | Toxic Materials and Long-term Health (2/6) |
| Planning for (Climate) Extremes, Disaster Risk, Resilience/Robustness, Redundancy and Adaptation | Climate Change Impacts (from Increased Temperatures (Heatwaves and Urban Heat Island Effect), Winds, Wildfires, Sea Level Rises, Increased Precipitation, Storms, Floods, Droughts, Earthquakes) (4/6) |
| Vulnerability (Exposure and Sensitivity) and Adaptive Capacity (2/6) |
| Climate Justice, Equitable and Inclusive Design | Access to Affordable, Green Energy, Resources and Opportunities (2/6) |
| Circular Economy | Resource Efficiency and Geographic Implications | The R’s of Circular Economy: Reduce, Reuse, Repair, Repurpose, Recycle (5/6) |
| Waste Sources and Reduction (3/6) |
| Designing for Change (Flexibility and Adaptability) and Regeneration | Designing for Adaptability (for a Change of Use and Climate), Durability and Resilience (2/6) |
| Waste as a Resource | Waste Sources from the Built Environment: Materials, Energy, Water, Organic Matter (4/6) |
| Waste-to-Energy (Heat and Electricity) (2/6) |
| Environmental and Health Impacts of Materials and Waste | **Pollution on Air, Water and Land (6/6)** |
| Chemical Impact (Toxicity) (4/6) |
| Waste Impact (Hazards) (4/6) |
| Carbon Impact (Recycle Content, Recyclability, Bio-based and Biogenic Materials) (2/6) |
| Energy and Carbon | Passive Design | Building Orientation, Form, Form Factor and Layout (3/6) |
| Thermal Mass (2/6) |
| Passive Heating and Cooling (2/6) |
| Active Design: Environmental Systems and Technologies | Low Carbon and Renewable Energy Supply (3/6) |
| Building Systems (2/6) |
| Energy Demand, Supply Sources and Balance (Heat Gains and Losses) (2/6) |
| Energy Storage, Load Sharing and District Networks (2/6) |
| Whole Life Carbon Impacts (for Retrofit and New Build | Upfront Impacts (Stage A): Product and Construction (2/6) |
| In-Use (Embodied and User) Impacts (Stage B) and Capital Carbon (2/6) |
| End-of-life (Embodied) Impacts (Stage C) (2/6) |
| Carbon Offsetting | Renewable Energy Procurement (2/6) |
| Operational Energy Modelling, Embodied Carbon Assessment and Iterative Design Process | Life Cycle Assessment: Embodied Carbon and other Environmental Indicators (4/6) |
| Water | Water Cycles, Sources, Stresses, Quality and Management | Water Quality and Sanitation (4/6) |
| Water Distribution and Management (4/6) |
| Water Availability and Stresses (4/6) |
| Water Sources and Uses (3/6) |
| Water Cycles (2/6) |
| Water Recycling and Reuse | Benefits and Challenges (4/6) |
| Wastewater Treatment and Reuse (4/6) |
| Wastewater Resources (3/6) |
| Health, Environment and Socioeconomic Outcome (2/6) |
| Rainwater Harvesting, Stormwater Management and Sustainable Urban Drainage | Sustainable Urban Drainage Systems (4/6) |
| Water Runoff, Quantity and Quality (4/6) |
| Benefits and Challenges (4/6) |
| Catchment and Storage (2/6) |
| Rainwater Uses (2/6) |
| Water Pollution on Land and in Aquatic Habitats | Water Pollution Sources (5/6) |
| Causes and Effects (4/6) |
| Water Pollution Prevention (4/6) |
| Water Pollution Control (4/6) |
| Water Pollution Monitoring and Management (2/6) |
| Impacts of Climate Change (Water-related Hazards and Disasters) | Designing for Intense Rainfall, Storms and Wind Damage (3/6) |
| Impacts on People & Nature and Cascading Events (3/6) |
| Designing for Water Scarcity and Droughts (2/6) |
| Ecology and Biodiversity | Biodiversity and Net Gain | Biodiversity Value and Habitat Evaluation: Factors, Impacts, Risks, Pre- and Post-Development Conditions (2/6) |
| Nature-based Solutions | Benefits (2/6) |
| Barrier and Trade-offs (2/6) |
| Land Use and Building Density | Land Use Changes (2/6) |
| Pressures: Environmental, Socioeconomic, Cultural (2/6) |
| Connectivity and Transport | Site Selection, Location and Urban Ecosystems | Greenfield, Brownfield and Reclaimed Sites (3/6) |
| Economies of Scale: Environment, Economic and Social Implications (2/6) |
| Compact Development and Walkability | Complete Streets and Curbside Management (2/6) |
| Regional and Local Infrastructure and Planning | Sustainable Transportation Indicators (2/6) |
| Sustainable Land Use Planning (2/6) |
| Low Carbon Transport and Multimodal Transportation Networks | Flows and Capacity (2/6) |
| Active Travel (Walking, Cycling, etc.) (2/6) |
| Planning for Future of Transportation | Demand and Sustainability of Alternative Fuels (3/6) |

**Table 2** - Teaching resources for mandatory undergraduate environmental engineering courses

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Concordia University: Sustainable development and Environmental Stewardship | York University: Civil Engineering for Sustainable Future | University of Ottawa: Environmental Impact Assessment and Field Investigation | University of Waterloo: Engineering and Sustainable Development | Dalhousie University: Sustainability concepts for civil and environmental engineers |
| **Textbooks** | Introduction to Engineering and the environment by Edwards S. Rubin | Sustainable Engineering Concepts, Design, and Case Studies; D.T. Allen and D.R. Shonnard; Prentice Hall, 2012  Sustainable Infrastructure: The Guide to Green Engineering and Design; S. Bry Sarte; John Wiley and Sons, 2010  A Handbook of Sustainable Building Design and Engineering; D. Mumovic and M. Santamouris; Earthscan, 2009  Urban Engineering for Sustainability; S. Derrible; The MIT Press, 2019 |  | Introduction to Engineering and the Environment by Edwards S. Rubin  Introduction to Environmental Engineering and Science, 3rd Edition, Gilbert Masters and Ela Wendell, 2008 | Latawiec & Agol, Sustainability Indicators in Practice  Hauschild et al.  Life Cycle Assessment: Theory and Practice |
| **Readings** | EPA  Environment Canada  Environment Quebec |  | Impact Assessment Agency Website and documents |  | IPCC reports and summaries for policy makers  PIEVC climate change risk assessment documentation  LEED documentation  Provincial Energy Profiles[[2]](#footnote-2) |
| **Software** |  | BEES Online (Building for Environmental and Economic Sustainability) [[3]](#footnote-3)  AATHENA Building Impact Estimators [[4]](#footnote-4) |  |  |  |
| **Case Studies** |  |  | EIA for two real projects |  | Case studies in "Sustainability Indicators in Practice"  PIEVC case studies[[5]](#footnote-5)  LCA case study for an assignment:  Gilmore, 2016. teaching life cycle assessment in environmental engineering: a disinfection case study for students. |
| **Projects** | Life Cycle Analysis Project | Students work in groups for building rehabilitation projects. Each team is assigned a building to assess the existing conditions and propose improvements in different categories (water, energy, materials, sustainable sites, etc.) Software is used to perform comparative analysis between the existing and proposed improvements. |  |  |  |

**Table 3 -** Climate change topic coverage for mandatory transportation engineering courses

|  |  |  |
| --- | --- | --- |
| ***Theme*** | ***Subtheme*** | ***Topic*** |
| Global Context + Fundamentals | Climate Fundamentals: Resource Use | Shifts in Global, Regional & Local Land Use, Migration, Displacement and Conflict (2/3) |
| Connectivity and Transport | Site Selection, Location and Urban Ecosystems | Urban Accessibility (2/3) |
| Compact Development and Walkability | Change in Behaviours and Health Benefits (2/3) |
| The 15-minute Neighbourhood and City (2/3) |
| Safe, Walkable, Liveable Streets, Car-free Centres and Mobility Hubs (3/3) |
| Complete Streets and Curbside Management (2/3) |
| Regional and Local Infrastructure and Planning | Sustainable Land Use Planning (2/3) |
| Shifts in Infrastructure Modes (2/3) |
| Low Carbon Transport and Multimodal Transportation Networks | Flows and Capacity (3/3) |
| Active Travel (Walking, Cycling, etc.) (3/3) |
| Electric Vehicles and Charging Infrastructure (2/3) |
| Autonomous Vehicles (2/3) |
| Planning for Future of Transportation | Sustainability and Livability Planning Trends (2/3) |

**Table 4** - Teaching Resources for mandatory transportation engineering courses

|  |  |  |
| --- | --- | --- |
|  | **University of Manitoba: Transportation Engineering Design** | **UBC Okanagan: Introduction to Transportation Engineering** |
| **Software** | Streetmix.net | ArcGIS  Envision  Railway Systems Engineering  SIDRA  Nacto.org website for complete streets |
| **Literature** | Smart Growth America’s Complete Streets Literature  https://smartgrowthamerica.org/resources/ |  |
| **Projects** | A complete streets redesign and site design project | A traffic calming/sustainable transportation engineering analysis project based on where the student lives, works, plays, and learns. It involves trip diaries, transport economics, transport safety planning, and sustainable transport. Students look at the problem from their perspective to consider what is relevant to quality of life, health, safety, and environment and propose solutions. |

**Table 5** - Coverage of climate change topics in mandatory structural engineering courses

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Resource Use | Sustainable Resource Use and Management (2/4) |
| Built Environment Context | Environmental Impacts and Drivers of the Built Environment | Sustainable Consumption and Production, Scale, Balance, and Monitoring (2/4) |
| Building Whole Life and Product Life Cycles (2/4) |
| Common Threads | Building Safety | Fire & Life Safety and Sustainability in the Built Environment (2/4) |
| Circular Economy | Resource Efficiency and Geographic Implications | Choice of Construction Methods (2/4) |
| Designing for Change (Flexibility and Adaptability) and Regeneration | Designing for Adaptability (for a Change of Use and Climate), Durability and Resilience (2/4) |
| Environmental and Health Impacts of Materials and Waste | Carbon Impact (Recycle Content, Recyclability, Bio-based and Biogenic Materials) (2/4) |
| Energy and Carbon | Active Design: Environmental Systems and Technologies | Low Carbon and Renewable Energy Supply (2/4) |

**Table 6** - Teaching Resources for mandatory engineering economics courses

|  |  |  |
| --- | --- | --- |
|  | University of Toronto: Engineering Economics and Decision Making | UBC Okanagan: Engineering Economics |
| Projects | Although an economics project at its core, students are asked to compare a wind farm to a natural gas plant. Climate change is integrated into the project by requiring students to consider CO2 emissions. | Weekly debates. Topics include:   * Canada should opt out of COP21. * Site C dam should NOT be built. * Net-zero and passive building designs should be an engineering design code requirement. * An Okanagan Valley all-electric semi-highspeed regional passenger railway, running between Oroville and Kamloops, makes sense. |

**Table 7** - Climate change topic coverage in other mandatory courses

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Resource Use | Socio-economic Implications of Irresponsible Resource Use (2/2) |
| Climate Fundamentals: Systems Thinking | Causes and Effects of Global Changes (2/2) |
| Socioeconomic Drivers and Economic Consequences (2/2) |
| Risks and Opportunities in a Net-Zero Economy | Circular Economy Implementation and Climate Positive Economy (2/2) |
| Built Environment Context | Environmental Impacts and Drivers of the Built Environment | Sustainable Consumption and Production, Scale, Balance and Monitoring (2/2) |
| Impacts on the External Environment (Land Use, Air, Soil, Water Pollution, Other Greenhouse Gases) (2/2) |
| Ethics and Value of Sustainability | Health, Wellbeing, Safety and Resilient Communities (2/2) |
| Common Threads | Retrofit (Adaptation and Reuse) | Retrofit Primer: Scale, Urgency, Challenges and Opportunities (2/2) |
| Circular Economy | Resource Efficiency and Geographic Implications | The R’s of Circular Economy: Reduce, Reuse, Repair, Repurpose, Recycle (2/2) |
| Ecology and Biodiversity | Land Use and Building Density | Land Use Changes (2/2) |
| Connectivity and Transport | Low Carbon Transport and Multimodal Transportation Networks | Active Travel (Walking, Cycling, etc.) (2/2) |
| Electric Vehicles and Charging Infrastructure (2/2) |
| Car Sharing (2/2) |

**Table 8** - Teaching Resources for other mandatory courses

|  |  |  |
| --- | --- | --- |
|  | University of Toronto: Technology in Society and the Biosphere | University of British Columbia: Impacts in Civil Engineering |
| Textbooks | Solved: How the world’s great cities are fixing the climate crisis by David Miller. |  |
| Readings | Roy, “Understanding the Delhi Urban Waterscape Through the Actor Network Theory”  Davis and Chouinard, “Theorizing Affordances”  Postman, “Five Things We Need to Know About Technological Change”  Beever and Brightman, “Reflexive Principlism as an Effective Approach for Developing Ethical Reasoning in Engineering”  Whyte and Cuomo, “Ethics of Caring in Environmental Ethics: Indigenous and Feminist Philosophies”  Cech, “The (Mis)framing of Social Justice”  Leydens et al., “What is Design for Social Justice?”  Engler, “Canada’s Mining Industry Is Spreading Havoc Around the World”  Tost et al., “The state of environmental sustainability considerations in mining”  Carter, “PetroCapitalism and the Tar Sands”  Todd, “Fish, Kin and Hope: Tending to Water Violations in amiskwaciwâskahikan and Treaty Six Territory”  Jacobson and Delucchi, “A Path to Sustainable Energy”  Sconfienza, “The Post-Sustainability Trilemma”  Stahel, Walter, “Circular Economy” Nature, 2016.  Pereira and Karner, “Transportation Equity”  Suárez-Eiroa et al., “Operational principles of circular economy for sustainable development”  Stubbs, “Technocapitalism, the Intangible Economy, and Economic Centralization"  Kitchin, “Ethics of Smart Cities”  Russell and Vinsel, “Hail the Maintainers” | Peuportier, B., Leurent, F., Roger-Estrade, J. (2016) Eco-design of Buildings and Infrastructure. CRC Press, London.  Pearce, A., Ahn, Y.H. (2012) Sustainable Buildings and Infrastructure: Paths to the Future, Taylor and Francis, ProQuest Ebook Central,  Green, E., Hope, T., Yates, A. (2015) Sustainable Infrastructure: Sustainable Buildings. ICE.  Sarte, S. B., (2010) Sustainable Infrastructure: The Guide to Green Engineering and Design. Wiley.  Andrew, C., and Graham, K.A. (2014) Canada in Cities: The Politics and Policy of Federal-Local Governance. McGill-Queen's University Press, Montreal & Kingston.  Boone, C.G. (2012) Social Dynamics and Sustainable Urban Design, Chpt 3 in Resilience in Ecology and Urban Design: Linking Theory and Practice for Sustainable Cities (eds. Pickett, Cadenasso & McGrath), Springer Neatherlands, 47-61.  Evans, L. (2007) Moving Towards Sustainability: City-Regions and Their Infrastructure. Canadian Policy Research Networks, Ottawa.  Ingram, G.K., Brandt, K.L. (2013) Infrastructure and Land Policies. Lincoln Institute of Land Policy, Cambridge Mass.  Infrastructure Design and Operations Van Bueren, E.M., et al., eds. (2011) Sustainable urban environments: an ecosystem approach. Springer Science & Business Media.  Geller, G., Glucklich, D. (2012) Sustainable Rural and Urban Ecosystems: Design, Implementation, and Operation. Springer Science & Business Media.  Austin, G. (2014) Green Infrastructure for Landscape Planning: Integrating Human and Natural Systems. Taylor and Francis.  Muller, N., Werner, P., Kelcey, J.G. (2010) Urban Biodiversity and Design. John Wiley & Sons.  Lenz, V., Ronsch, C., Schaubach, K, Bohnet, S., Thran, D. (2018) Transitioning the Heat Supply System - Challenges with Special Focus on Bioenergy in the Context of Urban Areas, Chpt 10 in Urban Transformations: Sustainable Urban Development Through Resource Efficiency, Quality of Life and Resilience (eds. Kabisch, Koch, Gawel, Haase, Knapp, Krellenberg, Nivala, & Shensdorf), Springer International Publishing, 173-196.  Visa, I., (2014) Sustainable Energy in the Built Environment - Steps Toward nZEB. Proceedings of the Conference on Sustainable Energy. CSCE.  Grigg, Neil S. (2012) Water, Wastewater, and Stormwater Infrastructure Management, 2nd Edition. CRC Press. ProQuest Ebook Central,  Sarma, A.K., Singh, V.P., Bhattacharjya, R.K., Kartha, S.A. (eds.) (2018) Urban Ecology, Water Quality and Climate Change. Springer International Publishing.  Taherzadeh, M.J., Tobias, R. (eds.) (2015) Resource Recovery to Approach Zero Municipal Waste. CRC Press, Boca Raton.  Zabalza Bribian, I., Valero Capilla, A., Aranda Uson, A. (2011) Life Cycle Assessment of Building Materials, Building and Environment, 46 (5), 1133-1140.  NACTO (2017) Urban Street Stormwater Guide, Island Press/Center for Resource Economics  Van der Ree, R., Smith, D.J., Grilo, C. (2015) Handbook of Road Ecology, First Edition. John Wiley and Sons Inc.  Clark, W.W., Cooke, G. (2016) Smart Green Cities: Toward a Carbon Neutral World. Routledge, London.  Beatley, T. (2014) Green Cities of Europe: Global Lessons on Green Urbanism. Birkhauser,  Boston. |
| Case Studies | Coastal Gas Links Pipeline in BC  Nova Scotia power generation  Ontario Ring of Fire development  Ontario mid-Peninsula highway  Ontario wind-power installation  Delhi India water generation  Deep Water Cooling in Toronto |  |

**Table 9** - Climate change topic coverage for design courses

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Climate Change | Key Indicators and Monitoring (2/4) |
| Key Contributors, Individual & Collective Responsibilities, Carbon Budget and Debt (2/4) |
| Climate Fundamentals: Resource Use | Sustainable Resource Use and Management (4/4) |
| Planetary Boundaries, Resources and Climate Change (2/4) |
| Climate Fundamentals: Systems Thinking | Risk & Resilience, the Role of Data/Feedback (2/4) |
| Risks and Opportunities in a Net-Zero Economy | Physical Risks (Stranded Assets), Monitoring / Measurement, Opportunities and Actions (2/7) |
| Built Environment Context | Environmental Impacts and Drivers of the Built Environment | Sustainable Consumption and Production, Scale, Balance and Monitoring (2/4) |
| Impacts on the External Environment (Land Use, Air, Soil, Water Pollution, Other Greenhouse Gases) (2/4) |
| Impacts on the Internal Environment (Energy and Water Use, Waste, Thermal Efficiency, Health) (2/4) |
| Building Whole Life and Product Life Cycles (2/4) |
| Common Threads | Planning for (Climate) Extremes, Disaster Risk, Resilience/Robustness, Redundancy and Adaptation | Climate Change Impacts (from Increased Temperatures (Heatwaves and Urban Heat Island Effect), Winds, Wildfires, Sea Level Rises, Increased Precipitation, Storms, Floods, Droughts, Earthquakes) (4/4) |
| Vulnerability (Exposure and Sensitivity) and Adaptive Capacity (2/4) |
| Proactive Adaptation and Managed Retreat (2/4) |
| Circular Economy | Resource Efficiency and Geographic Implications | Choice of Construction Methods (3/4) |
| Designing for Change (Flexibility and Adaptability) and Regeneration | Designing for Adaptability (for a Change of Use and Climate), Durability and Resilience (3/4) |
| Designing for Disassembly, Deconstruction and Reassembly (Prefabrication, Standardisation, Panellisation) (2/4) |
| Designing for Flexibility (for Change of Space within the Same Use) (2/4) |
| Waste as a Resource | Waste Sources from the Built Environment: Materials, Energy, Water, Organic Matter (2/4) |
| Waste-to-Material/Product (Upcycling and Downcycling) (2/4) |
| Energy and Carbon | Active Design: Environmental Systems and Technologies | Building Systems (2/4) |
| Energy Demand, Supply Sources and Balance (Heat Gains and Losses) (2/4) |
| Smart Systems, Technologies, Monitoring and Maintenance (2/4) |
| Whole Life Carbon Impacts (for Retrofit and New Build) | Upfront Impacts (Stage A): Product and Construction (2/4) |
| Water | Water Cycles, Sources, Stresses, Quality and Management | Water Sources and Uses (2/4) |
| Water Cycles (2/4) |
| Water Recycling and Reuse | Wastewater Treatment and Reuse (2/4) |
| Rainwater Harvesting, Stormwater Management and Sustainable Urban Drainage | Sustainable Urban Drainage Systems (3/4) |
| Catchment and Storage (3/4) |
| Benefits and Challenges (2/4) |
| Water Runoff, Quantity and Quality (2/4) |
| Rainwater Uses (2/4) |
| Impacts of Climate Change (Water-related Hazards and Disasters) | Designing for Intense Rainfall, Storms and Wind Damage (2/4) |
| Designing for Sea Level Rise and Flood Risk (2/4) |
| Adaptation Opportunities and Challenges [to reducing Vulnerabilities] (2/4) |

**Table 10** - Teaching resources for design courses

|  |  |  |  |
| --- | --- | --- | --- |
|  | University of New Brunswick: Civil Engineering Design II | University of New Brunswick: Senior Team Design | Queens University: Engineering Design and Practice |
| Software | Athena Impact Estimator |  |  |
| Readings |  | United Nations reports |  |
| Projects |  |  | Each student is involved in the design of a system resilient to climate change or addressing a current climate challenge, and related content is delivered in one or two lectures preceding the group activity. Students do two to three projects, and the project topics change every year but examples include:   * Design and construct a 30cm^3 'house' that is thermally stable using only recycled materials * Keep a seedling alive for a month using only 1L of water under changing external conditions * Create a system that can desalinate as much water as possible over the course of 1 week without consuming electricity * Keep a block of ice from melting for as long as possible under changing external conditions * Construct a dyke/earth berm that is resistant to wave action   Each of these projects involves the construction of a prototype which is tested, groups then present their findings in the context of observing the other groups. |

**Table 11** - Coverage of climate change topics in water resource engineering courses

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Climate Change | Scientific Evidence (5/7) |
| Projected Physical Impacts (on Land, Nature, etc.) and Regional Priorities (5/7) |
| Key Indicators and Monitoring (2/7) |
| Climate Fundamentals: Resource Use | Current Trends and Future Prospects of Natural Resources (2/7) |
| Sustainable Resource Use and Management (2/7) |
| Climate Fundamentals: Systems Thinking | Risk & Resilience, the Role of Data/Feedback (3/7) |
| Causes and Effects of Global Changes (2/7) |
| Risks and Opportunities in a Net-Zero Economy | Physical Risks (Stranded Assets), Monitoring / Measurement, Opportunities and Actions (2/7) |
| Built Environment Context | Environmental Impacts and Drivers of the Built Environment | Impacts on the External Environment (Land Use, Air, Soil, Water Pollution, Other Greenhouse Gases) (7/7) |
| Ethics and Value of Sustainability | Health, Wellbeing, Safety and Resilient Communities (2/7) |
| Common Threads | Planning for (Climate) Extremes, Disaster Risk, Resilience/Robustness, Redundancy and Adaptation | Climate Change Impacts (from Increased Temperatures (Heatwaves and Urban Heat Island Effect), Winds, Wildfires, Sea Level Rises, Increased Precipitation, Storms, Floods, Droughts, Earthquakes) (6/7) |
| Circular Economy | Designing for Change (Flexibility and Adaptability) and Regeneration | Designing for Adaptability (for a Change of Use and Climate), Durability and Resilience (2/7) |
| Waste as a Resource | Waste Sources from the Built Environment: Materials, Energy, Water, Organic Matter (2/7) |
| Environmental and Health Impacts of Materials and Waste | Pollution on Air, Water and Land (2/7) |
| Water | Water Cycles, Sources, Stresses, Quality and Management | Water Sources and Uses (5/7) |
| Water Cycles (4/7) |
| Water Availability and Stresses (4/7) |
| Water Quality and Sanitation (4/7) |
| Water Distribution and Management (4/7) |
| Rainwater Harvesting, Stormwater Management and Sustainable Urban Drainage | Water Runoff, Quantity and Quality (4/7) |
| Catchment and Storage (3/7) |
| Benefits and Challenges (2/7) |
| Sustainable Urban Drainage Systems (2/7) |
| Impacts of Climate Change (Water-related Hazards and Disasters) | Designing for Intense Rainfall, Storms and Wind Damage (3/7) |
| Impacts on People & Nature and Cascading Events (2/7) |
| Designing for Water Scarcity and Droughts (2/7) |
| Adaptation Opportunities and Challenges [to reducing Vulnerabilities] (2/7) |
| Ecology and Biodiversity | Nature-based Solutions | Benefits (2/7) |
| Balanced solutions at scale (2/7) |

**Table 12** - Teaching Resources for water resource engineering courses

|  |  |  |  |
| --- | --- | --- | --- |
|  | **McGill University: Water resources and hydraulic engineering** | **Queen’s University: Water Treatment** | **Queen’s University: Lake, Reservoir and Coastal Engineering** |
| Textbooks/readings | <https://www.epa.gov/water-research/storm-water-management-model-swmm>  Water resources Systems Planning and Management: An Introduction to Methods, Models and Applications, by Loucks, D., van Beek, E., Stedinger, J.R., Dikman, J.P.M. and Villars, M.T. 2017 (http://hdl.handle.net/1813/48159) |  | Introduction to Coastal Engineering and Management (J.W. Kamphuis) |
| Case Studies | Aral Sea  Mexico City surface water drainage system | Emerging contaminants under climate change conditions |  |
| Projects | Green stormwater design project to increase infiltration as compared to traditional design |  |  |
| Other resources | Students watch the movie “An Inconvenient Truth” to be introduced to climate change |  |  |

**Table 13** - Climate change topic coverage for environmental engineering technical electives

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Climate Change | Key Indicators and Monitoring (2/4) |
| Projected Physical Impacts (on Land, Nature, etc.) and Regional Priorities (2/4) |
| Scientific Evidence (2/4) |
| Climate Fundamentals: Resource Use | Current Trends and Future Prospects of Natural Resources (3/4) |
| Sustainable Resource Use and Management (2/4) |
| Planetary Boundaries, Resources and Climate Change (2/4) |
| Climate Fundamentals: Systems Thinking | Risk & Resilience, the Role of Data / Feedback (3/4) |
| Causes and Effects of Global Changes (2/4) |
| International Legislations, Agreements, Frameworks, Roadmaps and Plans for Action | United Nations Framework Convention on Climate Change, The Kyoto Protocol and the Doha Amendment (2/4) |
| The Paris Agreement and Regional (EU) Directives (2/4) |
| Risks and Opportunities in a Net-Zero Economy | Transition Risks (Renewable Energy Technology Developments) and Environmental & Social Value (2/4) |
| Built Environment Context | Environmental Impacts and Drivers of the Built Environment | **Impacts on the External Environment (Land Use, Air, Soil, Water Pollution, Other Greenhouse Gases) (4/4)** |
| Impacts on the Internal Environment (Energy and Water Use, Waste, Thermal Efficiency, Health) (2/4) |
| Sustainable Consumption and Production, Scale, Balance and Monitoring (2/4) |
| Built Environment Policy, Legislation, Regulations, Commitments, Benchmarks and Construction Industry Guidance | Policies, Legislation, Regulations, Carbon Budgets and Implementation (2/4) |
| Common Threads | Retrofit (Adaptation and Reuse) | Retrofit Primer: Scale, Urgency, Challenges and Opportunities (2/4) |
| Planning for (Climate) Extremes, Disaster Risk, Resilience/Robustness, Redundancy and Adaptation | Climate Change Impacts (from Increased Temperatures (Heatwaves and Urban Heat Island Effect), Winds, Wildfires, Sea Level Rises, Increased Precipitation, Storms, Floods, Droughts, Earthquakes) (2/4) |
| Vulnerability (Exposure and Sensitivity) and Adaptive Capacity (2/4) |
| Circular Economy | Resource Efficiency and Geographic Implications | The R’s of Circular Economy: Reduce, Reuse, Repair, Repurpose, Recycle (2/4) |
| Waste Sources and Reduction (2/4) |
| Designing for Change (Flexibility and Adaptability) and Regeneration | Designing for Adaptability (for a Change of Use and Climate), Durability and Resilience (2/4) |
| Waste as a Resource | Waste Sources from the Built Environment: Materials, Energy, Water, Organic Matter (2/4) |
| Waste-to-Material/Product (Upcycling and Downcycling) (2/4) |
| Waste-to-’Food’ (Composting) (2/4) |
| Waste-to-Nature (Decomposition) (2/4) |
| Environmental and Health Impacts of Materials and Waste | Pollution on Air, Water and Land (3/4) |
| Chemical Impact (Toxicity) (2/4) |
| Carbon Impact (Recycle Content, Recyclability, Bio-based and Biogenic Materials) (2/4) |
| Energy and Carbon | Operational Energy Modelling, Embodied Carbon Assessment and Iterative Design Process | Life Cycle Assessment: Embodied Carbon and other Environmental Indicators (2/4) |
| Water | Water Recycling and Reuse | Wastewater Resources (2/4) |
| Water Pollution on Land and in Aquatic Habitats | Water Pollution Prevention (2/4) |
| Impacts of Climate Change (Water-related Hazards and Disasters) | Impacts on People & Nature and Cascading Events (2/4) |
| Designing for Water Scarcity and Droughts (2/4) |
| Designing for Intense Rainfall, Storms and Wind Damage (2/4) |
| Designing for Sea Level Rise and Flood Risk (2/4) |
| Adaptation Opportunities and Challenges [to reducing Vulnerabilities] (2/4) |

**Table 14** -Topic Coverage for transportation engineering technical electives

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Climate Change | Projected Physical Impacts (on Land, Nature, etc.) and Regional Priorities (4/5) |
| Key Indicators and Monitoring (3/5) |
| Scientific Evidence (3/5) |
| Key Contributors, Individual & Collective Responsibilities, Carbon Budget and Debt (2/5) |
| Climate Fundamentals: Resource Use | Socio-economic Implications of Irresponsible Resource Use (3/5) |
| Planetary Boundaries, Resources and Climate Change (2/5) |
| Shifts in Global, Regional & Local Land Use, Migration, Displacement and Conflict (2/5) |
| Climate Fundamentals: Systems Thinking | Risk & Resilience, the Role of Data / Feedback (3/5) |
| Socioeconomic Drivers and Economic Consequences (3/5) |
| International Legislations, Agreements, Frameworks, Roadmaps and Plans for Action | United Nations Agenda 2030: Sustainable Development Goals, Global Indicator Framework for SDGs and Targets of the 2030 Agenda, The New Urban Agenda and Race to Zero & Race to Resilience Campaigns (3/5) |
| Risks and Opportunities in a Net-Zero Economy | Physical Risks (Stranded Assets), Monitoring / Measurement, Opportunities and Actions (4/5) |
| Transition Risks (Renewable Energy Technology Developments) and Environmental & Social Value (2/5) |
| Built Environment Context | Environmental Impacts and Drivers of the Built Environment | Impacts on the External Environment (Land Use, Air, Soil, Water Pollution, Other Greenhouse Gases) (2/5) |
| Impacts on the Internal Environment (Energy and Water Use, Waste, Thermal Efficiency, Health) (2/5) |
| Ethics and Value of Sustainability | Supply and Value Chains (3/5) |
| Health, Wellbeing, Safety and Resilient Communities (3/5) |
| Ethics in Practice (3/5) |
| Rights of Current and Future Generations (2/5) |
| Sustainable Urbanism, Architecture and Engineering | Regenerative Urban Development, Buildings, Infrastructure and Growth (4/5) |
| 19th Century Industrial Revolution: Building in a Time of Industry (2/5) |
| 20th Century International Style: Building in a Time of Globalisation (2/5) |
| 21st Century Imperative: Building in a Time of Emergency (2/5) |
| Built Environment Policy, Legislation, Regulations, Commitments, Benchmarks and Construction Industry Guidance | Policies, Legislation, Regulations, Carbon Budgets and Implementation (2/5) |
| Common Threads | Retrofit (Adaptation and Reuse) | Retrofit Primer: Scale, Urgency, Challenges and Opportunities (4/5) |
| Transitions: Incentives, Policy and Engagement (2/5) |
| Planning for (Climate) Extremes, Disaster Risk, Resilience/Robustness, Redundancy and Adaptation | Climate Change Impacts (from Increased Temperatures (Heatwaves and Urban Heat Island Effect), Winds, Wildfires, Sea Level Rises, Increased Precipitation, Storms, Floods, Droughts, Earthquakes) (3/5) |
| Vulnerability (Exposure and Sensitivity) and Adaptive Capacity (2/5) |
| Proactive Adaptation and Managed Retreat (2/5) |
| Climate Justice, Equitable and Inclusive Design | Access to Affordable, Green Energy, Resources and Opportunities (2/5) |
| Designing for Equitable, Healthy and Universal Communities (2/5) |
| Access to Sustainable Housing, Work, Leisure and Green Spaces (2/5) |
| Accountability, Responsibility and Distribution of Economic Investment (2/5) |
| Circular Economy | Resource Efficiency and Geographic Implications | Urban Systems and Circularity (3/5) |
| Environmental and Health Impacts of Materials and Waste | Carbon Impact (Recycle Content, Recyclability, Bio-based and Biogenic Materials) (3/5) |
| Pollution on Air, Water and Land (2/5) |
| Water | Impacts of Climate Change (Water-related Hazards and Disasters) | Designing for Intense Rainfall, Storms and Wind Damage (2/5) |
| Ecology and Biodiversity | Land Use and Building Density | Land Use Activities and Models (2/5) |
| Land Use Changes (2/5) |
| Pressures: Environmental, Socioeconomic, Cultural (2/5) |
| Demand and Supply: Human Needs and Natural Capital (2/5) |
| Land Use Planning, Zoning and the Built Environment (2/5) |
| Connectivity and Transport | Site Selection, Location and Urban Ecosystems | Economies of Scale: Environment, Economic and Social Implications (4/5) |
| Urban Accessibility (3/5) |
| Greenfield, Brownfield and Reclaimed Sites (2/5) |
| Landlocked and Transit-bridging Sites (2/5) |
| Rural Accessibility (2/5) |
| Compact Development and Walkability | Complete Streets and Curbside Management (3/5) |
| Change in Behaviours and Health Benefits (3/5) |
| Safe, Walkable, Liveable Streets, Car-free Centres and Mobility Hubs (3/5) |
| The 15-minute Neighbourhood and City (2/5) |
| Regional and Local Infrastructure and Planning | **Sustainable Transportation Indicators (5/5)** |
| Shifts in Infrastructural Modes (4/5) |
| Polycentric, Unicentric and Regenerative Communities (2/5) |
| Sustainable Land Use Planning (2/5) |
| Low Carbon Transport and Multimodal Transportation Networks | Active Travel (Walking, Cycling, etc.) (3/5) |
| Flows and Capacity (2/5) |
| Electric Vehicles and Charging Infrastructure (2/5) |
| Car Sharing (2/5) |
| Autonomous Vehicles (2/5) |
| Planning for Future of Transportation | Demand and Sustainability of Alternative Fuels (4/5) |
| Investment and Risks (3/5) |
| Sustainability and Livability Planning Trends (3/5) |
| Net-Zero Carbon Regeneration and Renewal (2/5) |

**Table 15** - Teaching resources for transportation engineering technical electives

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | UBC Okanagan: Go Global Course International Sustainable Engineering and Planning | UBC Okanagan: Railway Systems Engineering | UBC Okanagan: Transportation Systems Engineering | University of Manitoba: Transportation Systems | University of Waterloo: Pavement Structural Design |
| Readings | Dutch Centre for Research and Contract Standardization in Civil Engineering (CROW, 1998) – Recommendation for traffic provisions in built-up areas, Publication (Record) 15, ISBN: 906628 265 7, Ede, NL. (Sustainably Safe Systems Design)  CROW (2007) Design Manual for Bicycle Traffic, Publication (Record) 25, ISBN: 978 90 6628494 4, Ede, NL. (Networks, links, nodes – safe system design)  DHV Royal Haskoning (2009) Roundabouts - Application and design: A practical manual,  prepared for the Dutch Ministry of Transport, Public Works and Water management, Partners  for Roads, June 2009, 104 pages. (roundabouts and turbo-roundabouts)  CROW (2006) Urban design and traffic – a selection from Bach, Publication (Record) 221, ISBN: 978 90 6628 473 9, NL.  Infrastructure by Design, by Marc Verheijen, nai010 publishers, 2015,  ISBN: 978-94-6208-240-3, available in full English translation, 224 pages. |  | NACTO.org (2013) Urban Streets Design Guide– available on-line at nacto.org/usdg  CROW Publication 25: Bicycle Design Manual, 2007 – available from instructor  SMARTer Growth (Fused Grid) Neighborhoods, 2015  **Recommended:**  The Dutch Town of Houten is a Case Study in Bike Friendly Suburban Planning[[6]](#footnote-6)  NACTO / CITE / TAC / IBPI / Dutch / Danish Bikeway & Pedestrian Design Guidelines  National Association of City Transportation Officials (NACTO, 2012) Urban Bikeway Design Guide, 2nd Edition, New York, NY, USA. www.nacto.org,  Lovegrove, G. (2007) Road Safety Planning, Mueller, German[[7]](#footnote-7)  Grammenos & Lovegrove (2015) Remaking the City Street Grid: A Model for Urban and Suburban Development, McFarland & Co., Jefferson, NC, USA – all about Fused Grid design. |  |  |
| Websites |  |  | YouTube: How the Dutch got their bicycle paths[[8]](#footnote-8)  YouTube: “Houten Easy Town” [[9]](#footnote-9)  YouTube: Railway Engineering: An Integral Approach [[10]](#footnote-10)  **Recommended:**  Fastest Train in the World Ever Made – Full Documentary [[11]](#footnote-11)  Dutch urban planning / built-form guide, Publ 221  Dutch road design guidelines in built up areas, Publ 15: | Government-published reports and data |  |
| Software |  |  | Vissum  SPSS  SIDRA  ArcGIS |  | OpenLCA  Athene Impact Estimator |
| Case Studies |  |  | CROW Case study  SMART-er growth case study  SIDRA roundabout case study  AutoCAD roundabout design case study    CROW Turbo-roundabout design case study  Complete Streets case study from NACTO.org  CROW / ITE  Traffic Calming case study  Kelowna / SMARTer Growth 1-way couplet & crossings case study |  | Climate change implications for roadways and airfield pavements.  Impact of materials on the climate change and environmental impacts that can be improved through using innovative paving materials. |
| Projects |  | Term Projects:  Students must familiarize themselves with HYDRAIL, the emerging zero-emission, hydrogen/battery-powered  rail engine technology, and related topics (see reading list below, especially the OVER PR business case, and  the hydrail video on YouTube[[12]](#footnote-12)  The design project will consist of  technical review, duty cycle construction, service schedule, station location, and cost estimate for the West  Kelowna to Lake Country portion of the Okanagan Valley Electric Regional Passenger Rail (OVER PR)  tram-train. |  | Students do a fuel consumption comparative analysis |  |

**Table 16** - Climate change topic coverage for building science engineering technical electives

|  |  |  |
| --- | --- | --- |
| **Theme** | **Subtheme** | **Topic** |
| Global Context and Fundamentals | Climate Fundamentals: Climate Change | Scientific Evidence (2/2) |
| Projected Physical Impacts (on Land, Nature, etc.) and Regional Priorities (2/2) |
| Built Environment Context | Sustainable Urbanism, Architecture and Engineering | Regenerative Urban Development, Buildings, Infrastructure and Growth (2/2) |
| Built Environment Policy, Legislation, Regulations, Commitments, Benchmarks and Construction Industry Guidance | Overview of (Key) Existing Guidance, Targets and Standards (ISO, CEN, EPD, HPD, RIBA, AIA, LETI, UKGBC, CIBSE, RICS, BBP, IStructE, etc.) (2/2) |
| Common Threads | Retrofit (Adaptation and Reuse) | Retrofit Primer: Scale, Urgency, Challenges and Opportunities (2/2) |
| Whole Building Approaches: Rethinking Retrofit Delivery and Cost (2/2) |
| Energy Efficiency Action Plan (for Buildings), EnerPHit and Net-Zero (2/2) |
| Building Safety | Fire & Life Safety and Sustainability in the Built Environment (2/2) |
| Planning for (Climate) Extremes, Disaster Risk, Resilience/Robustness, Redundancy and Adaptation | Climate Change Impacts (from Increased Temperatures (Heatwaves and Urban Heat Island Effect), Winds, Wildfires, Sea Level Rises, Increased Precipitation, Storms, Floods, Droughts, Earthquakes) (2/2) |
| Circular Economy | Resource Efficiency and Geographic Implications | Choice of Construction Methods (2/2) |
| Designing for Change (Flexibility and Adaptability) and Regeneration | Designing for Adaptability (for a Change of Use and Climate), Durability and Resilience (2/2) |
| Energy and Carbon | Passive Design | Climate and Microclimate (2/2) |
| Fabric First Approach, Thermal Comfort and Overheating (2/2) |
| Whole Life Carbon Impacts (for Retrofit and New Build) | Upfront Impacts (Stage A): Product and Construction (2/2) |

1. https://engineerscanada.ca/sites/default/files/accreditation/2021-2022-cycle/accreditation-criteria-procedures-2020.pdf [↑](#footnote-ref-1)
2. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-canada.html [↑](#footnote-ref-2)
3. https://ws680.nist.gov/bees/(A(fMXkPxCq2QEkAAAAY2YxMjBhNjEtYmMxNy00OGFmLTg4ODQtNDZmMTQ0NmY4MDEyEVTBGBv1VkqqcR4D8-6Keb0asO41))/default.aspx [↑](#footnote-ref-3)
4. https://calculatelca.com/software/impact-estimator/ [↑](#footnote-ref-4)
5. https://pievc.ca/assessments/ [↑](#footnote-ref-5)
6. <https://www.bloomberg.com/news/articles/2015-06-17/the-dutch-town-of-houten-is-a-case-study-in-bike-friendly-suburban-planning> [↑](#footnote-ref-6)
7. https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/gordon\_lovegrove\_road\_safety\_overview.pdf [↑](#footnote-ref-7)
8. <https://www.youtube.com/watch?v=XuBdf9jYj7o> [↑](#footnote-ref-8)
9. https://www.youtube.com/watch?v=SyF8dH9lMV4 [↑](#footnote-ref-9)
10. https://www.youtube.com/watch?v=qXW4eXT4ydA [↑](#footnote-ref-10)
11. <https://www.youtube.com/watch?v=fW0zzVTbfrU> [↑](#footnote-ref-11)
12. <https://www.youtube.com/watch?v=8K5s0or33f8&feature=youtu.be> [↑](#footnote-ref-12)