ENVIRONMENT AND TECHNOLOGY: USE OF INNOVATION, TECHNOLOGICAL ADVANCES, OPERATIONS RESEARCH AND OPTIMIZATION TO TACKLE CLIMATE CHANGE PROBLEMS

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Nowadays, climate change crisis became a proven fact while only a couple years ago it was only one of scientific theories. As the result, every person, business, organization and government faces a complex problem of planning for the sustainable future. On one side, we are experiencing highly unpredictable climate changes due to human-related activity. On the other side, we live in the world of limited resources and a surplus of carbon dioxide in the atmosphere.

It is widely accepted that we are facing with a massive problem in planning for the sustainable future. The old-fashion primary objective of every business that is maximizing profit (or minimizing costs) is becoming obsolete. Now, we have at least two conflicting objectives in our decision making and those are minimizing environmental impact and maximizing expected profits. Moreover, the problem of minimizing environmental impact is complex by itself as it consists of minimizing use of fossil fuel, maximizing carbon sequestration, optimizing our use of energy, etc. Due to these facts mathematical modeling and operations research techniques are required to tackle these optimization problems.

Currently, businesses are taking the lead in building the environmentally sustainable future and governments are only providing support for those initiatives. It is completely different from the situation in the past decades, when governments were imposing environmental regulations on industries. Transformation of the business environment towards green products and projects is impossible without support of the customers who are willing to pay (and pay higher price in many cases) for green products and technologies to minimize their environmental footprint. The education plays an important role here and sometimes the environmental education takes such unusual channels as TV advertisements and computer games that indirectly teach people to be environmentally responsible. The examples include TV advertisement to change one traditional light bulb to the energy-efficient compact fluorescent light (CFL) bulb or to save the planet by developing renewable energy resources in the free computer game PowerUp created by IBM. The Porchlight project in Canada aims by distributing one free CFL bulb to each household in the country to show people that we can all take action on climate change. If every household in Canada replaced one old light bulb with a CFL, it would be like taking 66,000 cars off the roads; up to now around 1.2 million bulbs were changed that way.

Many companies increase their publicity and environmental awareness by publicizing their environmental initiatives like greenhouse gas emissions reduction resulted from clean technologies or from minimizing processing times and customer waiting times. The competition has increased due to the fact that companies and businesses can make profits by going green. The new term that describes the phenomenon of businesses taking the lead in sustainable development is called “green rush”. The most known “green rush” industrial sectors are the renewable energy and innovative technologies for operating buildings. Renewable energy sources are well-known solar panels and wind mills. Innovative technologies for operating buildings include “green” housing and geothermal heating and cooling. These two directions created the concept of distributed power generation that will replace centralized power generation at the power stations by power generated at the residential buildings and re-distributed among the consumers.

As we already mentioned, mathematical modeling, optimization and simulation techniques are utilized in many areas of engineering and science to analyze and improve performance. In particular, it is important for solving complex economic, business and environmental problems arising in modern fast-changing world. Mathematical models become a necessary tool of cost-benefit analysts due to recent developments in algorithms and software. The main challenge of realistic models – tackling uncertainty – requires considering multiple scenarios and a number of conflicting objectives to optimize. We describe below two case studies performed at McMaster University that demonstrate how operations research combined with simulation and optimization is used to solve these types of problems.

The first case study deals with minimizing border crossing delays for commercial trucks. Recent studies on border crossings have shown that the current infrastructure is incapable of servicing the workload without significant delays. These delays lead to increases in shipping costs and as a net result have a negative impact on the bottom line of businesses on both sides of the border. It is estimated that the cost of transit time and uncertainty of delays at the Canada-USA border is over $5 billion per year. In addition, the environmental impact caused by emissions from the vehicles at the border is very significant. Using historical data on truck arrivals, processing times, staffing patterns, etc., we developed a simulation model of the border, identified the problems and their sources, and proposed a solution to the border congestion problem providing the largest improvement (including environmental benefits) for the least cost.

The second case study describes modeling improved store design to help meeting greener goals at newly planned locations. A fast-food restaurant chain wants to reduce the environmental impact of their business while maintaining the company’s high level of customer service. Resulting designs are ranked based on customer service level and environmental impact (defined as the average quantity of emissions produced by customer vehicles using parking lot and drive-through lane). The simulation model that we developed provides the optimal solution to meet these goals.

In conclusion, innovation, technological advances and modern information technology including operations research and optimization will be the leading forces driving sustainable development and rational use of natural resources.