WELCOME!
Electricity Conservation in your Faith Building
“Lunch n Learn” Webinar
November 20, 2019 11:00 am to 12:00 pm
Our Presenter: Dr. Don Dewees

AGENDA
• 11:00 -11:05 Welcome and Land Acknowledgement - Lucy Cummings, FCG
• 11:05 - 11:40 Runnymede United Case Study - Electricity Conservation & Paybacks - Don Dewees, Professor Emeritus, U of T, BSEE, LLB, PHD Economics
• 11:40 - 12:00 Question & Answer - Donna Lang, FCG

Thanks to Ontario Trillium Foundation for supporting this webinar!
Runnymede United
Electricity Conservation Case Study

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Greening Sacred Spaces Webinar
20 November 2019
Introduction

• I am an engineer and economist.
• I chair Property Committee, do repairs, projects
  • Talking plain English today
• This talk is about \textbf{electricity} conservation
  • Not heating; heating was 8 May. No A/C.
• Two and one-half topics today
  • How to evaluate projects, choose which to do.
  • Examples of results from actual projects.
    • Rules of thumb for easy guidance.
Evaluating, Choosing Conservation Projects

• We want sustainability.
• We have limited funds, can’t do everything.
• How do you choose among projects?

Choose projects that give the biggest bang for the buck, considering:
  • How much does the project cost?
  • How much does it save in electricity costs?
  • How much does it reduce GHG?
Choosing Conservation Projects (2)

• Shortcut decision variable - **payback period**

• How many years of savings to recover the initial cost? 3 ways:
  • Cash flow analysis – look at $ the building owner spends and saves.
  • **Social** cash flow analysis – look at **total project cost** (including subsidies, grants) and what the owner saves.
  • Social cash flow + **ENV** (environmental) analysis:
    • include GHG reduction in annual saving, valued at $50/tonne of CO2.

• Result: payback period (years) for each measure
  • = initial (capital) cost/annual net savings = years to pay back

• Less than 10 years is a good investment; more is not.
Choosing Conservation Projects (3)

• Why $50/tonne for GHG?
  • To compare projects that reduce GHG, you need a value for GHG reduction.
  • Governments are adopting (and fighting over) carbon pricing:
    • Carbon tax
    • Cap and trade
  • Analysis based on a carbon price will help you get maximum carbon reduction per $ spent.
    • Suppose you have $1000 to spend.
      • Projects costing $200/tonne – you reduce 5 tonnes.
      • Projects costing $50/tonne – you reduce 20 tonnes.
  • $50 is the upper limit of recent actual policies for GHG control.
  • If you prefer $100/tonne, re-do my analysis using $100. etc.
Assessing Electricity Conservation: Example

• To assess projects, need to estimate savings.
• For lighting, use bulb and fixture specifications and ‘on-time’.
• **Example**: Replace 150W incandescent bulb with 17W LED bulb
  • (The LED produces more light than the 150W.)
  • Savings = 150-17 = 133 Watts.
  • On-time = 15 hours/week x 50 weeks = 750 hours/year.
    • Annual savings = 133W x 750hrs = 99,750 Watt-hours/year.
    • Divide by 1000 to get kWh: 99.75 kWh/year – call it 100 kWh.
  • Cash flow savings depend on electricity price
    • **Assume** electricity price = $0.10/kWh
    • Cash flow savings = $10/year per bulb. (100kWh x $0.10)
Assessing Electricity Conservation: Example (2)

• Cost of LED bulb = $35.
  • These large LED are much more expensive than 60W, 100W equivalent.

• Cash flow payback
  • Initial cost/annual savings
  • $35/$10 = 3.5 years
  • Payback period much less than 10 years. Passes the test easily.
  • **Great project**, recover your money quickly, keep saving for decades.
  • If we had a grant, our cost would be lower, cash flow payback period shorter.
    • But someone pays the grant cost, so **SOCIAL** cost payback period is 3.5 years.

• Better (shorter) payback with longer on-time (more hours), or higher electricity price.
Estimating GHG Reduction: Example

• How much less GHG when we conserve electricity?

• Depends on Ontario generation mix.
  • 100% coal generation: save about 1 tonne CO2 per 1000 kWh saved.
  • 100% hydroelectric generation: save NO CO2 per 1000 kWh saved.
  • 2019 in Ontario, no coal; gas generates <10% of electricity, sets the price maybe 30% of the time. Assume 30% gas.
  • Saving 1000 kWh saves 0.16 tonnes CO2

• Our 17W (150W equivalent) LED bulb saves 100 kWh/year = 0.016 tonnes CO2.
Assessing Social + ENV Payback Period

• Our LED bulb saved 0.016 tonnes of GHG/year
• 0.016 t/yr x $50/t = $0.80/year value of GHG saving at $50/tonne.
• Social + ENV payback period = Cost/(cash flow + ENV)
  = $35/($10+$0.80) = 3.24 years.
  • GHG value <8% of the cash flow savings.
  • Counting GHG reduces the payback time, but less than 8%.

• Great project, but:
  • Ontario has fairly clean electricity, so electricity conservation does not reduce GHG much.
  • Including GHG reduction does not improve payback period much.
RUC Case Study Projects: Background

• Analyze projects from RUC experience.
  • RUC: 28,000 square feet, built 1926 and 1951, stone and brick.
  • Sanctuary seats 750: incandescent bulbs switched to LED recently.
  • Mostly fluorescent lights elsewhere: 4-foot 2-tube ceiling fixtures.
  • Some halogen floods, outdoor floods, specialty lights.

• No air conditioning conservation projects analyzed here.
  • We just added A/C to some rooms: 2016, 2019.
    • Increased our summer electricity consumption.
Runnymede Sanctuary Lights (and candles)
Project #1, Ceiling Fluorescent Light Upgrade

• We had 110+ 4-foot 2-tube fluorescent fixtures. 2012 upgrade.
  • Usage varies from 5,000 hours/year (100 hours/week) to < 1000 hrs/yr
  • Fat bulbs (‘T12’, 1 ½ inch diameter) with magnetic ballasts: >82 Watts/fixture
  • Upgrade to thin fluorescent bulbs (‘T8’, 1-inch) + electronic ballasts: 42 W/fix
    • Cash flow payback period: 4 years with grant, 5.4 years without grant, 4.6 years with GHG.
    • Great investment, but very hard to verify electricity use before or after!
• Today you would upgrade to thin (T8) LED bulbs, no ballast, 28 W/fixture
  • Save 24 Watts over T8 fluorescent.
    • Payback period = 10 years with no grant, no GHG if they are on more than 3,500 hours/year.
  • Save 54 Watts over T12 fluorescent.
    • Payback period < 5 years, no grant. Break even (10 years) at less than 1,700 hours/year.
2-tube fluorescent fixtures converted to LED

Installing T8 LED bulbs
LED bulbs installed

LED in use
Ceiling Fluorescent Light Upgrade (2)

- **Rules of thumb for 4-foot fluorescent upgrade:**
  - If you have **fat T12 bulbs with magnetic ballast**, replace with no-ballast LED bulbs in any fixture used more than 30 hours/wk = 1,500 hours/year.
    - Payback period 10 years or less. Good investment.
    - 40 hours/week = 2,000 hours/year. Great investment.
    - More hours/week gives faster payback, better investment.
  - If you have **thin T8 bulbs with electronic ballast**, the savings from converting to T8 LED are small.
    - Only worthwhile (payback less than 10 years) if lights are on more than 3,500 hours/year.
    - Do it in intensively-used areas.
    - Poor investment (17-year payback) in areas used only 40 hours/week (2,000 hrs/yr).
      - Wait for ballasts to start failing.
Project #2: Washroom Motion Sensors

• Problem: lights left on after users leave. Sometimes overnight.

• Need to estimate weekly **excess on-time**.
  • No data, just guessing.
  • Assumed 10 hours/week/washroom (one overnight)

• Washroom wattage: lights + fan = 130 Watts.

• Savings = 10 hrs x 52 weeks x 130 W = 67.6 kWh/year, 0.01 t GHG.
  • Cash flow savings = $11.14 (price > 10 cents/kWh)
  • Sensor cost $35 (free volunteer installation)
  • Cash flow payback = 3.14 yrs. With GHG = 3.0 years. **Great investment.**

• Attractive project, but very small savings.

• Professional electrician or poor sensor choice wipes out savings.
Washroom Motions Sensors: Poor and Good

User can move slider: Off, Auto, On. Some users move from Auto to Off or On, defeating purpose.

Adjustments are behind the cover plate, not seen by users. No tampering. 15-minute on-time, user can tap off and switch reverts to automatic.
Project #3: Incandescent Bulb to LED Upgrade

• LED bulbs use only 20% as much electricity as incandescent.

• Popular bulbs (60, 100W equivalent) cost little more than incandescent, last > 10 times as long.
  • Payback period is < 1 year for LED replacement used 1,000 hours/year.
  • Rule of thumb: replace all these bulbs with LED except rarely used.

• Larger bulbs (150W equivalent and up) cost much more.
  • In some areas lighting quality is very important.
  • Dimmer compatibility is a challenge.
  • Usage requires careful estimation.
150 W Incandescent, LED Replacements

- Left, 27 Watt, 3500 lumen
- Sansi LED

- Middle, 150 Watt, 2100 lumen incandescent.

- Right, 17 Watt, 2500 lumen
- Sansi LED
Incandescent Bulb to LED Upgrade (2)

- We replaced 62 sanctuary 150-250 W incandescent & halogen bulbs with LED:
  - Cost = $3,144 (+ 60 hours volunteer labour, scaffold work)
  - Hours/year = 750 (worship, choir, rehearsals, cleaning, rental, etc.)
  - Savings = 7,755 kWh/yr
    - $1,200/yr cash flow saving. No grant.
    - Cash flow payback = 3 years. Great investment
    - 1.21 tonnes/yr GHG reduction
    - Social + GHG payback= 2.9 years. Great investment but minor GHG reduction

- Rule of Thumb:
  - Replace incandescent bulbs used > 10 hours/week with expensive LED when suitable quality LED light is available.
Project #4: Outdoor Floodlight LED Upgrade

- Outdoor floods could be halogen, metal halide, high pressure sodium.
- MH and HPS are pretty efficient.
  - Not large energy savings available unless reduce light level.
  - But less light may be enough.
- Lights at night on 4,000 hours/year or more.
- We replaced five MH and HPS fixtures using 180-210 Watts each with LED fixtures using 50 Watts.
  - Half the light (5,000 lumens replacing 10,000 lumens), 1/3 to ¼ the Watts
  - Aimed the lights more horizontal to get better ground-level lighting.
    - Reduced light spillage to the sky. Less waste.
Outdoor Floods, Old and New.

Old floodlight, 150 Watt HPS, ballast.

New floodlight, 50 Watt LED.
Outdoor Floodlight LED Upgrade (2)

• Project cost = $1,300 with professional electrician.
• Saving 756 Watts x 4,000 hours = >3,000 kWh/year
• Mostly night-time use, so relatively low electricity price.
  • Cash flow savings = $292/year, payback period 4.4 years.
  • Great project.
  • GHG reduction = 0.47 tonnes/year. Not much gas at night.
    • Cash flow + GHG payback period = 4.1 years.
    • Even greater project.
• Rule of Thumb: Outdoor floodlight conversion to LED achieves great savings if you can reduce lighting levels. Do it.
What about Non-Lighting Conservation?

• Fridges and freezers are significant energy-users, but hard to measure consumption, likely savings from upgrading.
  • User groups (employees, tenants, etc) hate to give up their own fridge.
  • We got rid of some, replacements appeared . . .
• Air conditioning can use lots of electricity. Tips to conserve:
  • Set temperature as high as users will tolerate.
  • Only cool heavily used rooms if there is a choice.
  • With heavy masonry construction, may save money to run A/C at night (low price), turn off during peak price hours.
Conclusions

• Calculating payback periods helps decide what projects to do.
  • Maximize conservation from limited project funds.
• Usage matters: hours/week the lights are on.
• T12 fluorescents, more than 5 hours/week, go LED.
• Incandescent or halogen bulbs, more than 5 hours/week, go LED.
• All-night outdoor floods – if less light OK, go LED.
• WC motion sensors – yes if there is significant electricity: >100W and significant on-time.
• Reducing electricity use in Ontario does not reduce GHG much.
Appendices

• Project results summary table
• Sanctuary photo showing chandeliers
Summary of Electricity Conservation Project Data and Results

<table>
<thead>
<tr>
<th>Project</th>
<th>Cost</th>
<th>Energy Saved</th>
<th>GHG Saved</th>
<th>Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>($)</td>
<td>(kWh/yr)</td>
<td>(tonnes/year)</td>
<td>(years)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cash Flow</td>
<td>Social + Cash Flow</td>
</tr>
<tr>
<td>#1 Lighting, T12→T8</td>
<td>7,900**</td>
<td>10,340</td>
<td>4.66</td>
<td>4.0</td>
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<tr>
<td>T8→LED (utility)</td>
<td>2,380**</td>
<td>11,486</td>
<td>1.78</td>
<td>0.04**</td>
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<tr>
<td>#1 T8→LED (self est)</td>
<td>2,380**</td>
<td>2,908</td>
<td>0.45</td>
<td>0.14**</td>
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<tr>
<td>#2 WC motion sensor</td>
<td>35*</td>
<td>67.6</td>
<td>0.01</td>
<td>3.1</td>
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<tr>
<td>WC motion sensor</td>
<td>110†</td>
<td>67.6</td>
<td>0.01</td>
<td>9.9</td>
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<td>#3 Incandescent→LED</td>
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<td>7,775</td>
<td>1.21</td>
<td>2.65</td>
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<td>#4 Outdoor flood→LED</td>
<td>1,300</td>
<td>3,024</td>
<td>0.47</td>
<td>4.4</td>
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</tbody>
</table>

*Not including value of substantial volunteer labour.

** A grant offset a significant part of this cost and thus the cash flow payback.

† Professional labour in place of volunteers

Decision rule: Priority projects have payback period less than 10 years.