Coarse woody debris and total ecosystem carbon stocks in a managed sub-Boreal research forest in central British Columbia

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Research questions

• What proportion of total ecosystem carbon (C) is composed of coarse woody debris (CWD)?

• What are the dominant CWD decay classes in managed and unmanaged forests?

• How has current forest management influenced the C balance?

• How would CWD salvage harvesting influence the C balance?
The Aleza Lake Research Forest

- Wet, cool variant of the sub-Boreal spruce zone
  - Mean annual precipitation of 930mm
  - Mean temperature 3°C
  - Fire return interval >200 years
The Aleza Lake Research Forest

- Wet, cool variant of the sub-Boreal spruce zone
  - Mean annual precipitation of 930mm
  - Mean temperature 3°C
  - Fire return interval > 200 years

- Subtle topographic gradient
  - Elevation between 600 and 750m

- Hybrid spruce & sub-alpine fir dominant stands with scattered Douglas-fir veterans
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  - Mean annual precipitation of 930mm
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  - Fire return interval > 200 years

- Subtle topographic gradient
  - Elevation between 600 and 750m

- Hybrid spruce & sub-alpine fir dominant stands with scattered Douglas-fir veterans

- Record of harvesting history since 1919

Adapted National Forest Inventory Ground Sampling Design

Canadian Forest Inventory Committee. 2002.
Field Measurements

Woody Debris Measurements

Micro Plot Measurements

Small and Large Tree and Stump Measurements

Mineral Soil Sampling

CWD Decay Classes

<table>
<thead>
<tr>
<th>Decay Class</th>
<th>Wood Texture</th>
<th>Bark</th>
<th>Branches/Twigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Wood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>intact, hard</td>
<td>intact</td>
<td>both present</td>
</tr>
<tr>
<td>2</td>
<td>intact, hard to partly decaying</td>
<td>intact or partly missing</td>
<td>branches no twigs</td>
</tr>
<tr>
<td>3</td>
<td>hard, large pieces, partly decaying</td>
<td>trace bark</td>
<td>few branches no twigs</td>
</tr>
<tr>
<td>Advanced Decay</td>
<td>small, blocky pieces</td>
<td>no bark</td>
<td>no branches or twigs</td>
</tr>
<tr>
<td>4</td>
<td>many small pieces, soft portions</td>
<td>no bark</td>
<td>no branches or twigs</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results

Total ecosystem C and CWD proportion

![Graph showing total carbon and CWD proportion across different stand ages.](image-url)
Total CWD during stand development

Total CWD by decay class during stand development
Landscape Modelling

- Plot measurements, provincial forest cover data and a 2003 Landsat TM satellite image were used to develop regression models to describe woody debris ($r^2=0.64$) and vegetation ($r^2=0.67$).

- Additional satellite images were acquired from previous years and the models were used to predict total C stocks for those years.

Biomass Model: Predictions over time

1985 – July
1992 – August
1994 – July
1997 – September
1999 – August
1999 – September
2000 – September
2003 – July
Using the model results, the total carbon stocks for 1985 and 2003 were:

<table>
<thead>
<tr>
<th></th>
<th>Biomass</th>
<th>CWD</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>598 ± 14</td>
<td>78.3 ± 4.8</td>
<td>677 ± 15</td>
</tr>
<tr>
<td>2003</td>
<td>589 ± 14</td>
<td>78.9 ± 4.3</td>
<td>668 ± 14</td>
</tr>
<tr>
<td>Net change</td>
<td>9.7 ± 19.7</td>
<td>0.6 ± 6.4</td>
<td>9.0 ± 20.8</td>
</tr>
</tbody>
</table>

*all units in kt

How would total carbon stocks change with CWD salvage harvesting?
Under current harvesting schedules, the amount of CWD that could be salvaged during clearcut operations in the ALRF amounts to ~197 t/year for ~6,000 ha of forest land.
If salvage harvesting had been employed since 1985, total CWD would be 10% lower after 18 years.
Offsetting CWD salvage harvesting

- Clearcutting with CWD salvage harvesting removes more carbon from the stand than clearcutting alone.

- Performing CWD salvage harvesting while maintaining current total carbon stocks in the ALRF would require a ~5% reduction in the annual allowable cut.

Conclusions

- Sound wood that could be salvaged during clearcut operations in the ALRF amounts to 197 tonnes dry weight per year over ~6000 ha of forest land.

- Currently the ALRF maintains a constant carbon stock from year to year.

- Salvage harvesting of woody debris would cause the research forest to become a source of carbon emissions with the current rate of forest harvest.

- If the ALRF operations included CWD salvage harvesting at the time of clearcutting, it’s annual harvest would have to decrease by ~5% in order to maintain a constant carbon stock.
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“Wood Pellets”

Presented by John Swaan
Executive Director- Wood Pellet Association of Canada
Chair – BC BioProducts Association

BioEnergy Option - Wood Pellets

- Wood Pellet Association of Canada
- Wood Pellet Specifications
- Pelletizing Process – Transport – Storage
- Wood Pellet Production and Consumption
  BC – Canada - Europe
- BC BioMass Inventory
- Wood Pellet Research Projects
“Wood Pellet Association of Canada”

- Formerly the BC Pellet Fuel Manufactures Association
- Renamed and reorganized as of January 2006
- Membership of 9 Wood Pellet Producers across Canada
- Association purpose – Serve as an Advocate for the Industry and to conduct Research Projects
- Executive Director - John Swaan

**Wood Pellet Specifications**

- **Moisture** 2.5 – 4.5%
- **Ash** 0.25 – 0.40%
- **Calorific Value** Gross – Dry Basis: 20.4 GJ/Ton, 5.6 MWh/Ton, 8800 Btu/lb.
- **Calorific Value** Net Effective – As Received: 18.5 GJ/Ton, 5.1 MWh/Ton, 8000 Btu/lb.
- **Bulk Density** 40 lb./cu.ft., 600 – 650 kg./m³
Raw Material

Rotary Drum Dryer

Cooler

Raw Material Infeed

Hammermill

Screener

Residue Classifier (Metal Detector)

Pelletizers

Storage

Wood Pellets

“The Most Transportable BioEnergy”
New Pellet Plants currently under construction

Canada’s 23 pellet plants currently produce just over 1,100,000 tons annually

Some 60 plants producing approximately 800,000 tons annually in the US today, exclusively for the residential bagged market.
European Wood Pellet Production

- 240 Pellet plants
- 3.6 MM tons
  2005
“Canadian Wood Pellet Production”
Domestic - US Export - Overseas Export

Currently 16 BC Greenhouse Growers consume 12,000 tons

North American Pellet Technology

FORCED AIR FURNACE
FREE STANDING PELLET STOVE
FIREPLACE INSERTS
BOILER
"WOOD PELLET”
HOT WATER BOILER and STORAGE SYSTEMS

DISTRICT HEATING STATIONS
Denmark – Sweden – Finland – Austria

Complete with Boiler and Pellet Storage
Install 3-4 days
District Heating

Largest growth market for Wood Pellets in Europe
Displacing Coal and/or Oil

CHP Combined Heat and Power Production

BC Pellet Producers will ship 450,000 tons to European Power Plants this year.
How much more pellet production can BC support?

**BC’s Proposed Pellet Production for the Future**

- **Current Production**: 650,000 ton
- **New production 18 – 24 months**: 750,000 ton 1,350,000 ton
- **New production estimate for next five years**: 1,500,000 ton 2.8 – 3,000,000 ton
Pine Beetle Infestation

Estimated Impact:
• 8.5 MM Hectares Infested
• 411 MM M³ Timber Affected
• 85 MM M3 BC’s AAC
• MOF Dec 2005

Clusters – Or CHPPLLus

BioMass Energy Plant

Electricity

Dry Kilns

Wood Pellet Dryer

District Heating Residence & Industry

Ethanol Production

Steam Explosion

Bio Oils
WORLDWIDE WOOD PELLET PRODUCTION Potential Growth

C$ / GJ HHV --
5.00
10.00
15.00
20.00
25.00

Jul-00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05

CAD / GJ Sumas Monthly Index (excl. transp. & GCRA)
CAD / GJ Terasen Schedule 3 (incl. transp.)
CAD / GJ Wood Pellets (incl. transp.)
Wood Pellet Association of Canada  
Research Projects

Wood Pellet Centre – Chair at UBC

**Priority Projects**

- **Off-Gassing**: – MSDS safety code
- **Emissions**:  
  - CO2 utilization for crop fertilization  
  - Chemical and particulate analysis
- **Production**:  
  - Torrifracation  
  - Steam Explosion

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Thank - You
British Columbia’s Mountain Pine Beetle Epidemic
- Wood Residue Potential -

Presented to:
Bio-Energy Conference and Exhibition 2006
Prince George, BC  May 31, 2006

by
Douglas A. Routledge, RPF  -  Vice President Northern Operations

Outline

- The Council of Forest Industries
- Origins of the epidemic, actions to mitigate
- Current magnitude
- Anticipated residues, amount and type
- Business certainties and uncertainties
COFI Corporate Programs (Head Office Vancouver)

- Forest Policy
  - Forestry, First Nations
  - Land Based Environmental
- Markets Access & Trade
- Regulatory Issues:
  - Occupational Health & Safety
  - Manufacturing related Environmental
- Economics – Competitiveness
- Quality Assurance: Structural Lumber Grade Stamp

COFI Regional Programs (Offices: Prince George/Kelowna)

- Community Relations (Connecting with Communities)
- Regional Forest Education (Working with Tomorrow’s Leaders Today)
- Regional Forest Policy (Connecting with Members)
Why an epidemic?
- Resident populations, natural part of pine ecosystems.
- Mild winters, two successive hot dry summers.
- One year life cycle
  - Rapid population response…difficult detection
- Poor access
- Extensive mature and over-mature pine stands, fire suppression.
- Administrative/Economic Constraints
  - New Forest Practices Code admin structure
  - Timber pricing system unresponsive

The Result: “The Perfect Storm”
The Mountain Pine Beetle Epidemic

<table>
<thead>
<tr>
<th>Year</th>
<th>Geographical Area Spread Over</th>
<th>Area Spread Over (ha)</th>
<th>Volume (million m3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>Tweedsmuir/Ootsa</td>
<td>2,500</td>
<td>0.1</td>
</tr>
<tr>
<td>1996</td>
<td>Tweedsmuir/Ootsa</td>
<td>7,500</td>
<td>0.3</td>
</tr>
<tr>
<td>1998</td>
<td>Houston to Entiako</td>
<td>122,500</td>
<td>2.5</td>
</tr>
<tr>
<td>1999</td>
<td>Houston to Quesnel</td>
<td>322,500</td>
<td>6</td>
</tr>
<tr>
<td>2000</td>
<td>Houston BC/Takla Lake to Williams Lake</td>
<td>5.7 million</td>
<td>40</td>
</tr>
<tr>
<td>2001</td>
<td>Smithers/Takla Lake to 100 Mile House</td>
<td>8 million</td>
<td>72</td>
</tr>
<tr>
<td>2002</td>
<td>Smithers/Takla Lake to Cranbrook</td>
<td>9 million</td>
<td>108</td>
</tr>
<tr>
<td>2003</td>
<td>Smithers/Williston Lake to Cranbrook</td>
<td>10 million</td>
<td>174</td>
</tr>
<tr>
<td>2004</td>
<td>Smithers/Williston Lake/Chetwynd to Cranbrook</td>
<td>15 million</td>
<td>283 million</td>
</tr>
<tr>
<td>2005</td>
<td>Smithers/Williston Lake/Chetwynd to Cranbrook</td>
<td>17 million</td>
<td>411 million of 1.2 billion m3</td>
</tr>
</tbody>
</table>

Developing the strategies

- Strategies to deal with the epidemic
  - Strategies & actions aimed at limiting the spread by managing beetle populations;
  - Strategies & actions aimed at recovering value & mitigating timber supply impacts; and,
  - Strategies & actions aimed at implementing community economic diversification options.
Strategies for Mitigating -
1. Impacting Beetle Populations
   - At the Leading Edge -

Actions aimed at impacting beetle populations:

- Maximizing the existing harvest capacity
  - Early detection/information
  - Small patch, multi pass, single tree
  - Administrative streamlining

- Bringing more harvest capacity to bear
  - Removing economic barriers …. reciprocal fibre agreements
  - Single tree, small patch tree removal in Parks & Protected Areas.

Strategies for Mitigating –
2. Timber Supply Impacts
   - At the Trailing Edge -

Actions to minimize the degree and duration of timber supply decline:

- Understand timber supply impacts and options
  - “Shelf life” studies;
  - Inventory updates;
  - Timber supply mitigation analysis;
  - New (non-lumber) manufacturing capacity.

- Review LUP management constraints;
- Use of low timber value stands to accommodate other resource use values;
- Reduce proportion of susceptible stands;
- Rehabilitate stands which lose commercial value;
- “Beetle Proof” future landscapes and stands;
**Community Economic Stability:**

- Diversification related to timber supply
  - Contractor “conversion” (to rehabilitation)
  - Expand traditional markets; Wood quality “unaltered”
  - Establish alt markets; “Denim Pine”, Co-Gen, Pellets, OSB, etc.

- Diversification unrelated to timber supply:
  - Build from existing forestry foundation
  - Oil, Gas, Mining, Transportation, Agriculture
  - Tourism, Recreation, Retirement
  - Small businesses (high speed internet)
  - Shop local

---

**Timber Supply Impacts**

- **Yesterday to today -**

- **2003/04 Timber Supply Impact Report(s):**
  - 12 management units, forecast peak during 2008 flight
  - 80% of pine volume attacked by 2013
  - 800,000 ha may become uneconomic and those areas will experience a 30% reduction in future stand volume
  - May reduce that to 300,000 ha with mitigation measures

- **2006 Timber Supply Impact Report(s):**
  - 18 management units, peak during 2006 flight?
  - 80% of pine volume attacked by 2010
  - 780 million m³ may become uneconomic for lumber and if left unsalvaged will experience a 20% reduction in future stand volume
  - May reduce unsalvaged losses to 120 million m³ with mitigation measures …… If sufficient manufacturing and market capacity??
**Hectare Dynamic**  
**(Timber)**

<table>
<thead>
<tr>
<th>Price of Oil</th>
<th>$60/bbl</th>
<th>$200/bbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sawlog</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Homes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioenergy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pellets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Homes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sawlog</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Cariboo Chilcotin Beetle Action Coalition

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**Uplifts:**

14 million m³ year

**Management units**

<table>
<thead>
<tr>
<th></th>
<th>AAC (m³/yr)</th>
<th>MPB uplifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakes</td>
<td>3,200,000</td>
<td>1,700,000</td>
</tr>
<tr>
<td>Prince George</td>
<td>14,900,000</td>
<td>5,700,000</td>
</tr>
<tr>
<td>Quesnel</td>
<td>5,300,000</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Kamloops</td>
<td>4,350,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Merritt</td>
<td>2,814,171</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Williams Lake (1980’s)</td>
<td>3,768,000</td>
<td>*850,000</td>
</tr>
<tr>
<td>TFL 42 (FSJ)</td>
<td>160,000</td>
<td>40,000</td>
</tr>
<tr>
<td>TFL 5 (near Quesnel)</td>
<td>300,000</td>
<td>177,200</td>
</tr>
<tr>
<td>TFL 53 (near Quesnel)</td>
<td>880,000</td>
<td>557,200</td>
</tr>
</tbody>
</table>
**Uplift Requests:**
> 4.0 million m³ year

<table>
<thead>
<tr>
<th>Management units</th>
<th>MPB uplift requests</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFL 49</td>
<td>~200,000</td>
</tr>
<tr>
<td>Okanagan</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Morice</td>
<td>1,000,000</td>
</tr>
<tr>
<td>100 Mile House</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Williams Lake</td>
<td>?</td>
</tr>
<tr>
<td>Dawson Creek</td>
<td>?</td>
</tr>
<tr>
<td>Mackenzie</td>
<td>?</td>
</tr>
</tbody>
</table>

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**Caution:** Residue forecast subject to TSA assumptions

- Must customize analysis to timber supply unit
  - Species mix (% pine%)
  - Age classes (+60 yrs?)
  - Management unit area - shift the “timber supply area” paradigm?
  - Land use planning assumptions (e.g.: adjacency, recruitment)
  - Economic shelf life ….  
    - Stand/tree shelf life for lumber vs for “other products”
    - Market cycles
Residue Opportunities

➢ Traditional residues – business certainty
  • Known type, volume and duration (once negotiated)
  • Source cost at sawmill
  • This source not likely to substantially increase
    - Shift, not grow the manufacturing capacity ..... Investment return uncertainties
    - Market …& .. Shelf life/AAC fall down uncertainty

➢ Incremental residues – business uncertainty
  • Uncertain type, volume and duration
    - Source costs at stump,
    - Damaged timber crown charges unknown
    - “Shelf life” shifting

Incremental Residue Uncertainty’s

➢ Rough ave delivered costs from the stump:
  • Development $4/m3
  • Logging and Loading $15/m3
  • Admin & Silviculture $10/m3
  • Processing (chipping)
    - Whole log facility “in town” $10/m3
    - Bush chipping $5/m3
  • Transportation $1.80/m3/hour
    - If assume 60km/hr ave speed $0.03/m3/km
  • Crown charges ($0.25/m3 vs ??/m3)
Incremental Residue Uncertainty’s

- Residue type, volume & duration available
  - Biological/physical vs economic shelf life
  - Economic shelf life for lumber use changing
  - Economic shelf life extended with other fibre uses
  - Potential shift in “timber supply area” paradigm
  - Timber supply mitigation impacts will affect available residual timber supply over time
    - TSA-X: Aggressive harvesting results in little to no residual fibre and little fall down; vs,
    - TSA-Y: Aggressive harvesting still results in significant residual fibre and significant fall down

TSR-X (current AAC 1.4 million m³)
- Status quo management:
  - AAC drops: 1.4 million m³ to 1.0 million m³ in year 20
  - Unsalvaged losses at 15 years: 51.2 million m³
- Aggressive harvest of beetle attack:
  - AAC drops less: 4.2 million to 1.3 million m³ in year 20
  - Unsalvaged losses 0.08 million m³
**TSR-Y** (current AAC 3.2 million m³)

- **Status quo management:**
  - AAC drops: 3.2 million m³ to 0.5 million m³ in year 30
  - Unsalvaged losses at 15 years 46.7 million m³

- **Aggressive harvest of beetle attack:**
  - AAC drops more: 4.7 million to 0.1 million m³ in year 20
  - Unsalvaged losses still 23.8 million m³

**Incremental Residue Uncertainty’s**

**How over come uncertainties?**

- **Bush sorting?:**
  - Right fibre to right facility
  - Avoid multiple handling costs

- **Transportation costs:**
  - Haul differentials, road infrastructure improvements?
  - Bush processing?

- **Mitigation benefits:**
  - Capture value, generate jobs
  - Reducing depth and duration of fall down
In Conclusion

- Expanding out of control still
  - 600 million of 1.2 billion m³ by fall 2006?

- Potential timber supply impacts significant
  - Availability and economics of potential incremental residues uncertain

- Measures to reduce uncertainty
  - Benefit, reducing the depth and duration of any fall down

- Web Sites:
  - www.for.gov.bc.ca/PAB/News/Features/beetles
  - www.mpb.cfs.nrcan.gc.ca/
Bioenergy – the Role of Natural Gas

Adrian Partridge
Terasen Gas

Program

- Terasen
- Gas reserves
- Sustainability
- Characteristics
- Co-utilization
- Summary
Terasen Inc. Company Overview

Terasen Gas
- 900,000 customers in BC
- Regulated gas utility

Terasen Energy Services
- Energy systems supplier and district energy

Kinder Morgan

- One of the largest midstream energy companies in the United States
  - Based in Houston, Texas
  - Operates 35,000 miles of natural gas and products pipelines

- The KMI - Terasen merger creates one of the largest integrated pipeline companies in North America.

- Pro forma enterprise value of KMI - TER in combination with KMP is almost $37 billion.
Environmental Awards

- Canada’s Climate Change Voluntary Challenge and Registry (VCR)
  - gold level status for six consecutive years (1998 - 2004)

- VCR Leadership Award (2002, 2004) for efforts to reduce greenhouse gas emissions from our transmission and distribution system

- Industry Advocate award from Natural Resources Canada in 2004
  - marketing campaigns for conversion to high efficiency appliances

- Included in FTSE4Good Index measuring companies that meet global standards for corporate social responsibility.

World Proven Gas Reserves

Global Reserves 6,337 Tcf

Source: BP Statistical Review 2005
North American Gas Supply Regions

GLOBAL
- World natural gas supplies sufficient to meet world demand
- Disconnect between reserves and market locations
- Globalization of natural gas markets

N. AMERICA
- Continental supply projected flat through 2010
- New transmission infrastructure required to move gas to market

Getting Gas to Customers

Terasen Gas purchases gas at market price and passes its cost on without mark up
Terasen Gas’ Sustainability Position

Terasen Gas offers a **safe, reliable, secure, affordable** and **efficient energy choice** to meet the growing needs of businesses and communities while enabling the pursuit of sustainability over the long run.

**Affordable**

**Environmentally Acceptable**

**Pipeline to the Future**

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**Home Heating Efficiency**
**Natural Gas vs. Electricity (new demand)**

![Diagram comparing natural gas and electricity for home heating efficiency]
Characteristics of Gas

- Always available
- Regulated price
- Low particulate emissions
- Reduced environmental impact compared to other fossil fuels
- Can be used in conjunction with other fuels
- ‘Pipeline to the future’ – bridging fuel

Co - Utilization

- Co-firing natural gas and biomass in boilers
- Biomass gasification followed by co-firing of fuel gas and natural gas
- Pyrolysis of biomass followed by co-firing liquid fuels and natural gas
- Greenhouses, mills, general industry – gas as a back up / complementary fuel
Summary

- Natural gas is readily available and in plentiful supply
- Natural gas can have a role as a back up to or in conjunction with biomass
- Terasen Energy Services can help with designing, building, operating and maintaining the energy systems

THANK YOU