Natural Resources Canada | Ressources naturelles Canada

Canadian Forest Service

CANADIAN WOOD FIBRE CENTRE

Fibre Facts nº 20

Biomass Storage and Safety

Biomass storage is an essential part of the bioenergy supply chain. Without it, there would not be a way to maintain a continuous supply of feedstock for bioenergy systems. During storage, however, natural biological, chemical and physical processes occur, resulting in:

Dry-matter loss

Degradation of feedstock where bacteria and fungi break down woody biomass over time, inevitably leading to a loss of overall material and therefore energy available for bioenergy production.

Off-gassing

Biproducts of woody biomass degradation include the release of carbon dioxide, methane and some carbon monoxide. These gases can threaten worker safety when biomass is stored in confined spaces and also contribute to green house gas emissions.

Self-heating

Bacteria and fungi produce heat as they degrade the woody biomass. This phenomenon can escalate to the point where spontaneous combustion fires may ignite, leading to dangerous fires on site and loss of entire feedstock stores.

Canada

CWFC and collaborators focused on finding solutions to mitigate these problems and optimize biomass storage. Based on four recent scientific publications, here are some important **findings** and **considerations** for pile management of forestry residues:

1

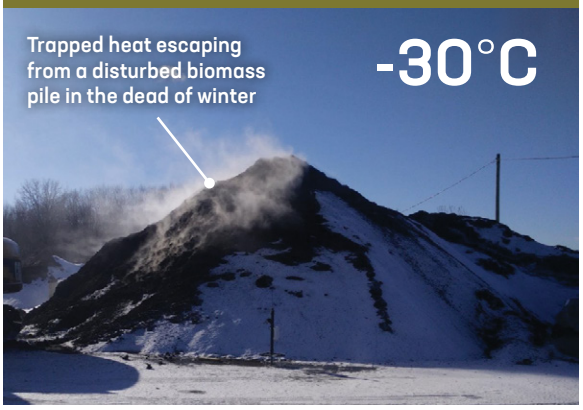
Biomass Storage Safety

Self-heating fires, dust explosions and off-gassing during biomass storage are serious hazards that can have devastating consequences, including worker fatality, health impacts, bioenergy plant destruction and complete loss of production.

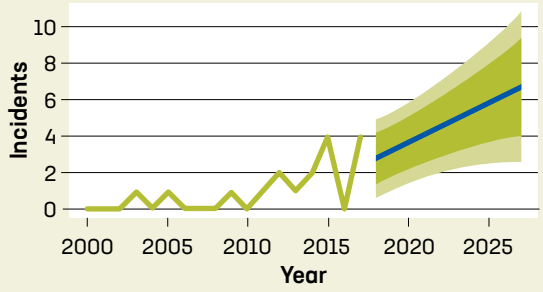
- A compilation of incident reports from 2000–2018 revealed that these potential hazards continue to be a major concern.
- There has been a decreasing trend of dust explosions and off-gassing incident reports.
- There has been an increasing trend of reports related to self-heating fires and fires of uncertain cause.

Real-time pile temperature monitoring may offer a solution for reducing fire incidents.

Significance of self-heating even at outside winter temperatures of -30°C.



Self-heating incident trends (2000-February 2018) Displaying 2018-2028 forecast (blue line)



2

Bark vs. Woodchip Storage

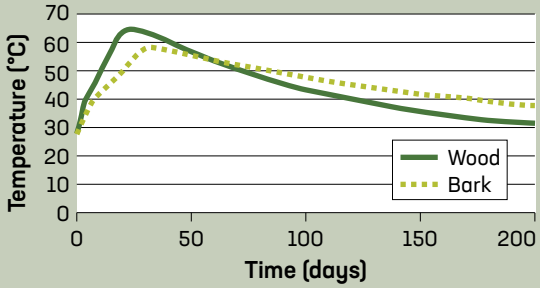
Though bark and woodchips can both be utilized as feedstock, their physical and chemical properties differ significantly.

- Bark self-heating model simulation comparisons revealed that woodchip parameters are insufficient for modelling bark pile dynamics accurately; specific bark parameters are necessary.
- Woodchip piles appear to experience a higher temperature peak faster whereas bark piles heat up more gradually while retaining more heat over time.
- Factors associated with microbial activity had some of the greatest influence on self-heating.

Alternative pile management strategies are likely required for bark piles to optimize feedstock quality and to diminish self-heating risks.

These feedstock differences affect pile storage dynamics

A comparison of woodchip and bark predicted pile temperatures



Wood T_{max} = 64.9 °C on Day 23
Bark T_{max} = 58.4 °C on Day 33

3

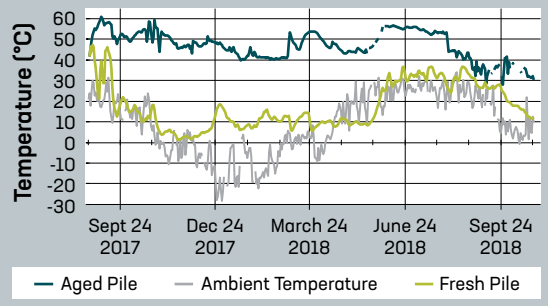
Fresh vs. Older Woodchip Storage Piles

Older woody biomasses previously labelled as wood waste may be an attractive supplementary feedstock for bioenergy generation, however their storage dynamics have remained understudied.

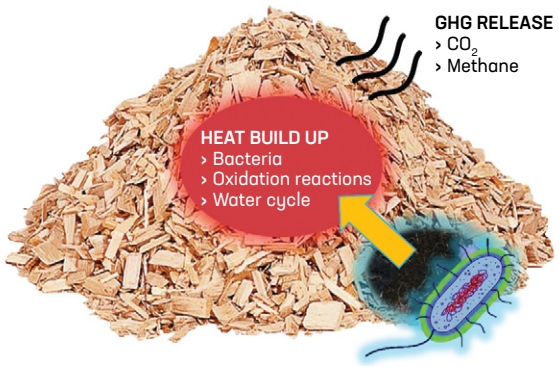
A long term study (459 days) on fresh and aged woodchip piles was conducted in Manitoba, Canada and provided the following results:

- Self-heating fire risk and dry-matter losses did not diminish in older woodchip material.
- Thermal buildup and retention increased with reduced particle size and higher moisture content.
- Disturbing biomass piles can reintegrate microorganisms, reviving the self-heating process.
- Fine particles and compaction should be avoided. Multiple smaller piles with fire breaks should be constructed when possible.

Comparison of top layer fresh and aged wood chip pile temperatures from August 24, 2017 - October 24, 2018



Biomass Pile Heat Generation



4

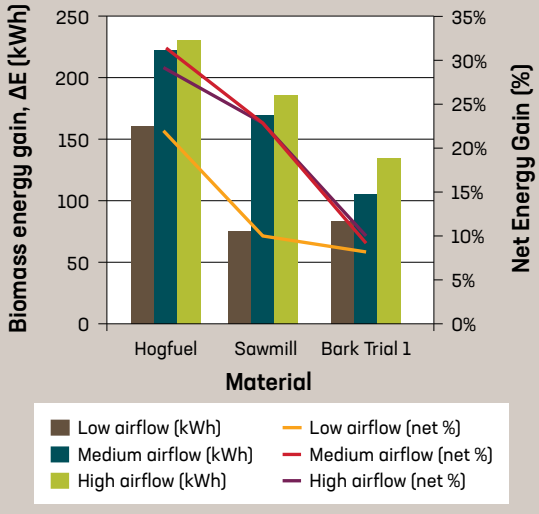
Pre-Treatment Strategies to Control Self-Heating and Optimize Biomass Storage

The heterogeneous nature of woody biomass makes the material challenging to store for long periods without material degradation, freezing, and fire concerns. Pre-treatments may be a way to alleviate this.

- Natural air-drying (NAD) of biomass is of particular interest since potential feedstock material can be conditioned with ambient air without additional energy input.
- NAD as a pre-treatment has high potential for improving the quality, safety and storability of woody biomass.
- NAD without supplemental heat resulted in net energy gains of 9 to 32% compared to untreated biomass material.
- With supplemental heat (quicker drying times), net energy gains ranged from -13 to 3%.

Future improvements in heat recuperation technology when supplemental heat is used should greatly improve these net energy gains.

Energy gains from natural air-drying of hog fuel, woodchips, and bark biomass trials.



To reduce hazards associated with biomass storage, diligence and caution must always be maintained. It is important to note that biological processes continue to occur within storage piles and that many factors such as type of biomass, initial storage conditions and seasonality will influence pile dynamics. The further microorganism activity can be reduced, the lower the self-heating fire risk will be and the more energy can be retained for bioenergy generation. Pre-treatment strategies such as NAD along with strategic pile management can be an effective and economical way to achieve this. It is critical that workers take the time to know all of the storage risks and guidelines outlined by research findings. Monitoring and preparedness will go a long way to maintain safety, optimize biofuel quality and the overall benefits of using woody biomass as a renewable energy source.

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Pineland Forest Nursery

Nova Scotia Power
An Emera Company

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Port Hawkesbury Paper

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RESEARCH PUBLICATIONS - LITERATURE CITED

Krigstin S, Wetzel S, Jayabala N, Helmeste C, Madrali S, Agnew J, Volpe S, 2018. Recent Health and Safety Incident Trends Related to the Storage of Woody Biomass: A Need for Improved Monitoring Strategies. Forests, 9, 538, 1-24.

Krigstin S, Helmeste C, Jia H, Johnson KE, Wetzel S, Volpe S, Faizal W, Ferrero F, 2019. Comparative analysis of bark and woodchip biomass piles for enhancing predictability of self-heating. *Fuel*, 242, 699-709.

Krigstin S, Helmeste C, Wetzel S, Volpe S, 2020. Managing self-heating & fuel quality changes in forest residue wood waste piles. *Biomass and Bioenergy*, 141, 1-12.

Mak J, Landry H, Grieger L, Agnew J, Krigstin S, Helmeste C, Wetzel S, Madrali S, Volpe S, 2020. An Assessment of Ambient and Heated Forced Air Drying Pre-treatments for Enhancing the Quality of Various Forest Biomass Feedstocks. *Frontiers in Energy Research*, 8, 7, 1-11.

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Aussi disponible en français sous le titre : Biomasse : stockage et sécurité

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