



Emerging risks from fires and explosions in solid biofuels - some evidence from Denmark

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Publication date:
2013

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Citation (APA):

Hedlund, F. H. (Author). (2013). Emerging risks from fires and explosions in solid biofuels - some evidence from Denmark. 2D/3D (physical products)

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5th iNTeg-Risk Conference
Stuttgart, May 21-22, 2013

Emerging risks from fires and explosions in solid biofuels - some evidence from Denmark

Frank Huess Hedlund, COWI, DTU

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SOLID BIOFUELS - AN EMERGING RISK?



COWI

Key arguments of this presentation

- › Trend: convert coal fired thermal power plants to solid biomass fuel to reduce carbon dioxide emissions (renewable energy source, CO₂ neutral)
- › Solid biomass fuel (wood pellets) is not only greener and more expensive than coal, it is also more dangerous (fire, explosion)
- › Not classified as a dangerous substance (probably should) – not a "chemical hazard"

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Wood pellet hazards

- › Biomass pellets give off dust in quantities that present a serious dust explosion hazard
- › Compared to coal, the blast from the explosion is more severe and because pellets are sensitive to moisture they are handled in enclosures, which increase the dust explosion risk (both probability and severity) .
- › They easily ignite, from friction or sparks, and may even self-ignite if moist.
- › Smoldering fires are difficult to detect and embers may migrate in the conveyor systems and develop into massive storage fires that cause extensive damage.

An emerging risk issue (ERI)?

- › While wood dust accidents may have been grandfathered as tolerable risks, the **intensification** and complexities that come with the **rapid scale-up** and the **handling of unprecedented quantities** of solid biomass fuels call for increased attention.
- › The number of serious accidents indicate that biomass pellets represent an emerging risk for which proper control strategies have yet to be developed.

Hazards of wood pellets

Table 4.0 Results from testing dust from white pellets and bark pellets							
Test Mode	Test Parameter (dust <63 µm)	Measure	White Dust	Bark Dust	Coal Dust	Lycopodium Spores	Testing Standards
Dust cloud	Auto-ignition Temp (Godbert-Greenwald)	T_c °C	450	450	585	430	ASTM E1491
	Min Ignition Energy	MIE mJoule	17	17	110	17	ASTM E2019
	Max Explosion Pressure	P_{max} bar	8.1	8.4	7.3	7.4	ASTM E1226
	Max Explosion Pressure Rate	dP/dt_{max} bar/sec	537	595	426	511	ASTM E1226
	Deflagration Index	K_{st} bar.m/sec	146	162	124	139	ASTM E1226
	Min Explosible Concentration	MEC g/m ³	70	70	65	30	ASTM E1515
	Limiting Oxygen Concentration	LOC %	10.5	10.5	12.5	14	ASTM E1515 mod
Dust Layer	Hot Surface Ignition Temp (5 mm)	T_s °C	300	310			ASTM E2021
	Hot Surface Ignition Temp (19 mm)	T_s °C	260	250			ASTM E2021
	Auto-ignition Temp	T_L °C	225	215			USBM (Bureau of Mines) RI 5624
	Dust Class (>0 to 200 bar.m/sec)		St 1	St 1	St 1	St 1	ASTM E1226
	Dust Class (Explosion Severity (ES > 0.5))		Class II	Class II			OSHA CPL 03-00-06

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Source: Melin S (2012) Determination of Explosibility of Dust Layers in Pellet Manufacturing Plants. *Wood Pellets Association of Canada*

Ambition in Denmark – the global leader

- > In 2012, the minister for climate change, Martin Lidegaard, hailed the "broadest, greenest, and most long-term energy agreement that has ever been reached in Denmark". The audacious plan would elevate Denmark as "the global leader in the transition to green energy".
- > The ambition is to have 50% of electricity consumption supplied by wind power, and to have more than 35% of final energy consumption supplied from renewable energy sources

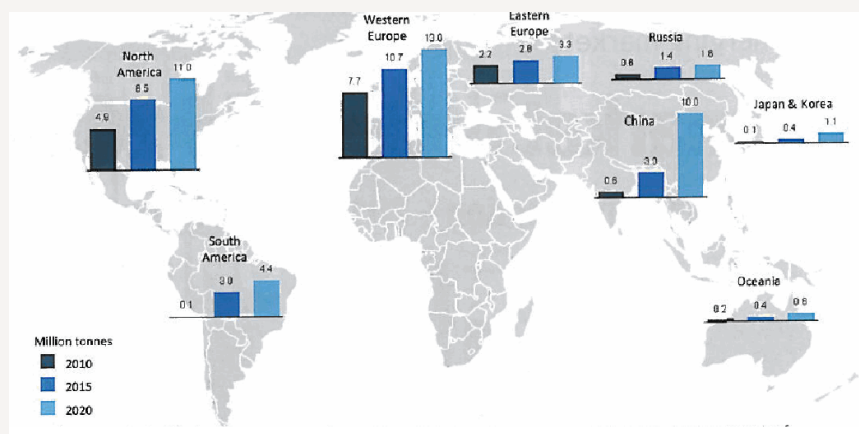
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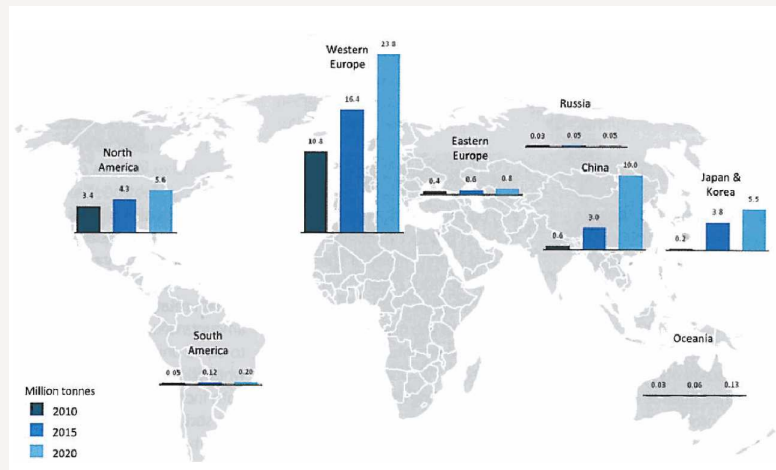
Substitution of coal for solid biomass fuel in thermal power plants - costs

- > A socio-economic analysis estimates a benefit cost ratio of 0.4, i.e. that benefits amount to only 0.40 cent for each Euro spent
- > The net present value for the entire conversion is estimated at minus 5.4 million Euros per MW converted effect
- > Total negative net present value of 15.5 billion Euros for the anticipated Danish biomass conversion
- > For scale and magnitude, this figure corresponds to about 12 percent of Denmark's 2012 gross national product.

Global production, wood pellets



Global consumption, wood pellets (increasing)



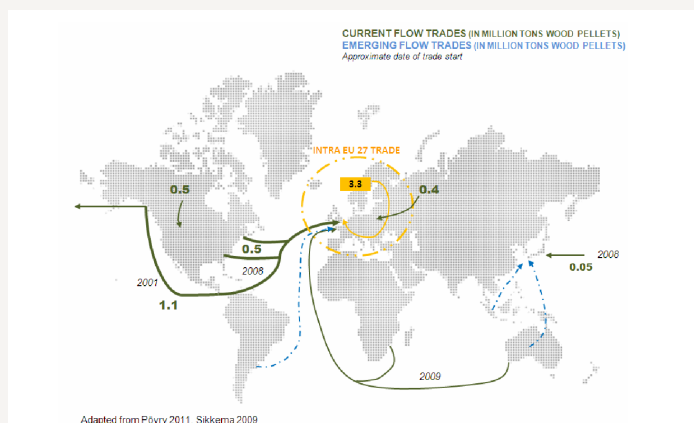
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Source: Verhoest C, Ruckmanns Y (2012) Industrial wood pellets report 2012. Laborelec

Global transport, wood pellets



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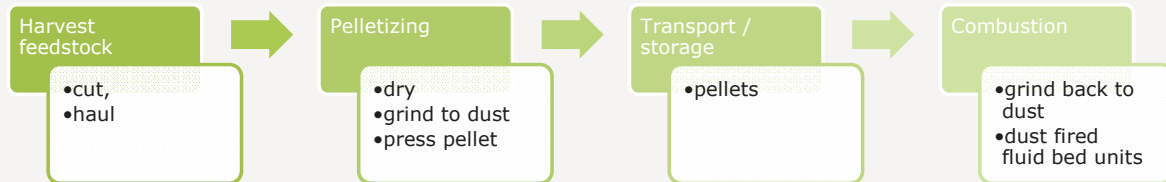
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Source: Verhoest C, Ruckmanns Y (2012) Industrial wood pellets report 2012. Laborelec

Pelletizing for handling, convenience

Wood pellets

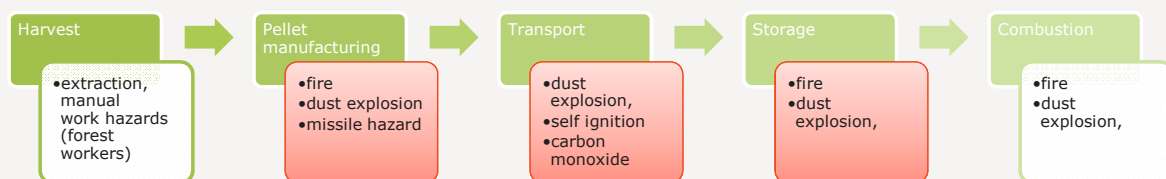


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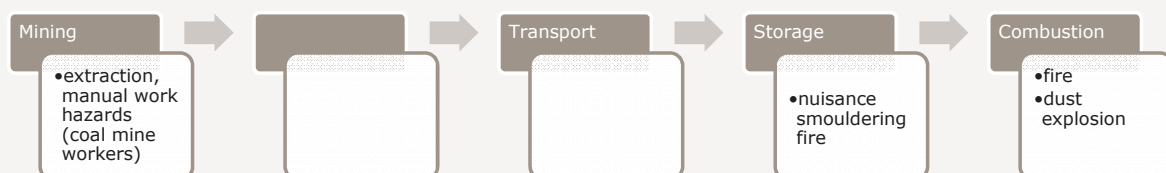
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Main differences: production, handling, storage

Wood pellets



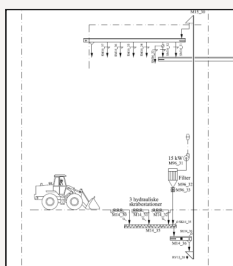
Coal



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Wood pellet producer in Denmark

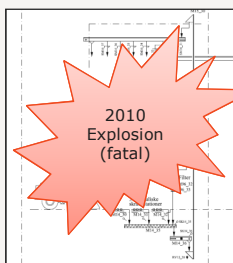


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Source: Company's environmental permit

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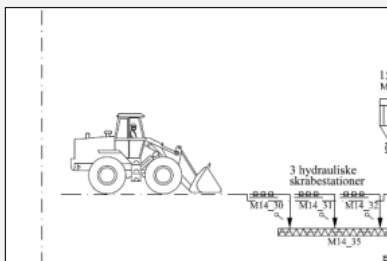
2010 explosion incident - wood pellet producer in Denmark



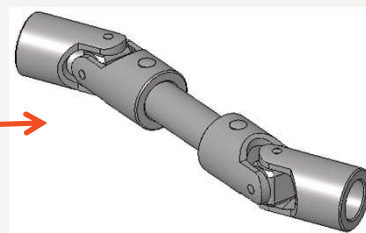
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Source: Company's environmental permit

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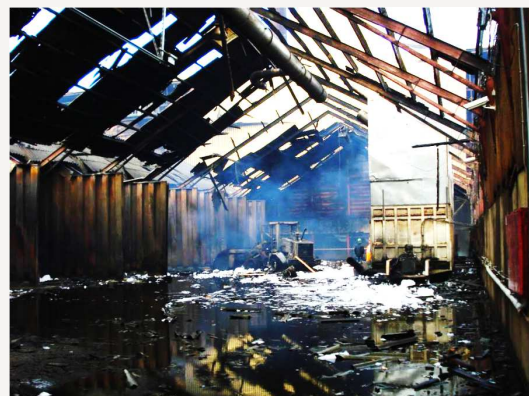
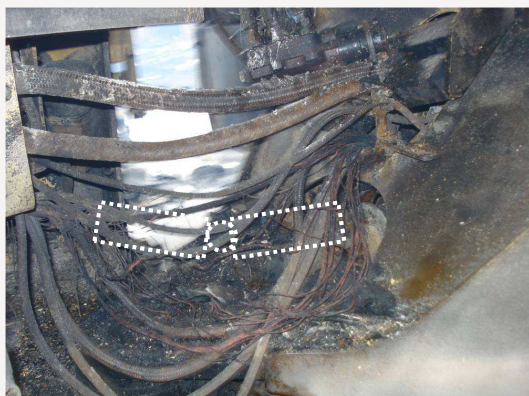
Shaft with cardan joints



Silberwolf, Wikimedia

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Source: local DK workplace authority

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Explosion?



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DK local fire services



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Diffusion flame vs. pre-mixed flame



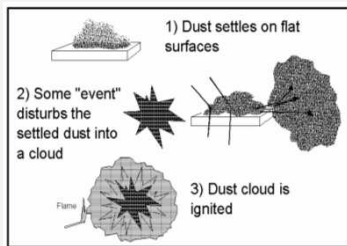
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Luc Viatour, Wikimedia

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Dust, primary explosion makes dust airborne, powerful secondary explosion



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Explosion - Imperial Sugar Company, USA, 2008, with 14 killed and 36 injured



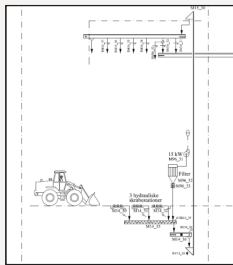
CSB, USA

- > (sugar is not a dangerous substance)
- > There have been two deadly sawmill explosion in Canada this year alone. One of the explosions was powerful enough to blow debris 400 metres away from the sawmill, and shake buildings and rattle windows several kilometres away (Vancouver Sun 2012)
- > (wood dust is not a dangerous substance)

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2002 explosion incident - wood pellet producer in Denmark



Foreign bodies end up in hammer mill, pelletizer

- > inherent generation of friction, sparks
- > *routinely*, fires, explosions in hammer mills , pelletizers
- > In case of fire, how to handle and what to do with contents (dust) ?

Wood pellets



- > The fragmented information available indicate that, the Canadian British Columbia forestry industry had a fatality count of 43 in 2005, well over its annual average of 20.
- > The injury count is not stated.

Wood pellets



- > Because of a large number of incidents and insurance claims from Canadian pellet mills, two insurers have left the pellet sector. The few insurers who remain, have implemented astronomical rates, restrictive terms and provide less capacity. (PMM 2011)
- > Canadian insurance companies have recently told the pellet industry that its performance must improve or else pellet plants will no longer be insurable.

Wood pellets



- > Numerous incidents at port facilities
- > some reports of workers overcome by carbon monoxide emitted by pellets

Wood pellets



- > Fires Denmark, UK, The Netherlands (?)

February 2012, Tilbury Power Station (UK), fire in
4,000 tons wood pellets, 3½ months of repairs

Structural issues

- › Wood dust is not classified as a dangerous substance
- › Accident investigations are kept internal and lessons learnt are not shared widely. This is a familiar and age old problem across industries and there are no indications that this will change without regulatory intervention
- › While wood dust accidents may have been grandfathered as tolerable risks, the intensification and complexities that come with the rapid scale-up and the handling of unprecedented quantities of solid biomass fuels call for increased attention

Emerging risk issues (ERIs)

- > The number of serious accidents indicates that biomass pellets represent an **emerging risk issue (ERI)** for which proper control strategies have yet to be developed.
- > Some evidence of **media-shifting** - that the 'resolution' of a problem within the environmental domain creates a new problem in the workplace safety domain.
- > Seems that minimal consideration has been given to this in environmental LCA studies, or in the audacious (and costly) plan to elevate Denmark as "the global leader in the transition to green energy".

Thank you for your attention !