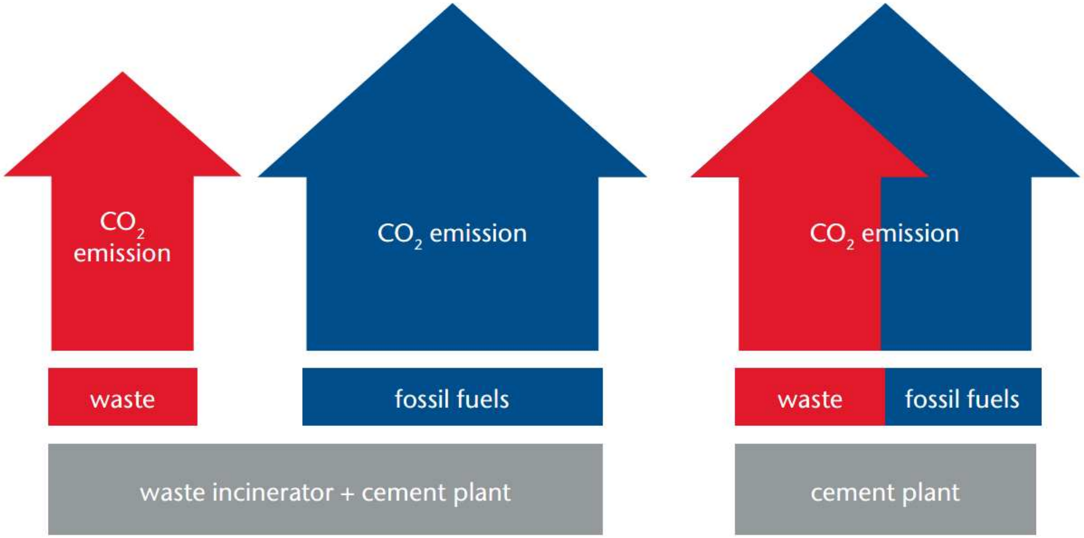
水泥製程燃料替代的減碳效益



亞泥花蓮廠 首席副廠長 陳志賢
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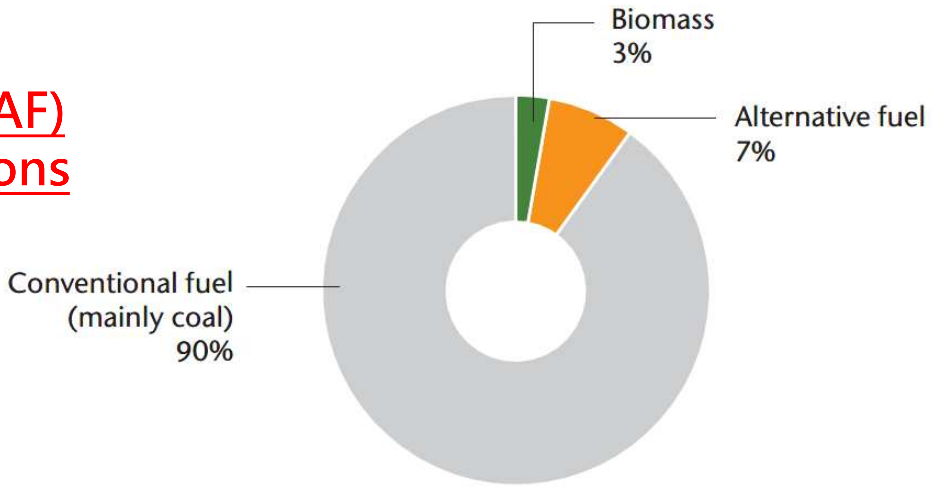
Switching to alternative fuels

全球水泥製程熱能消耗：

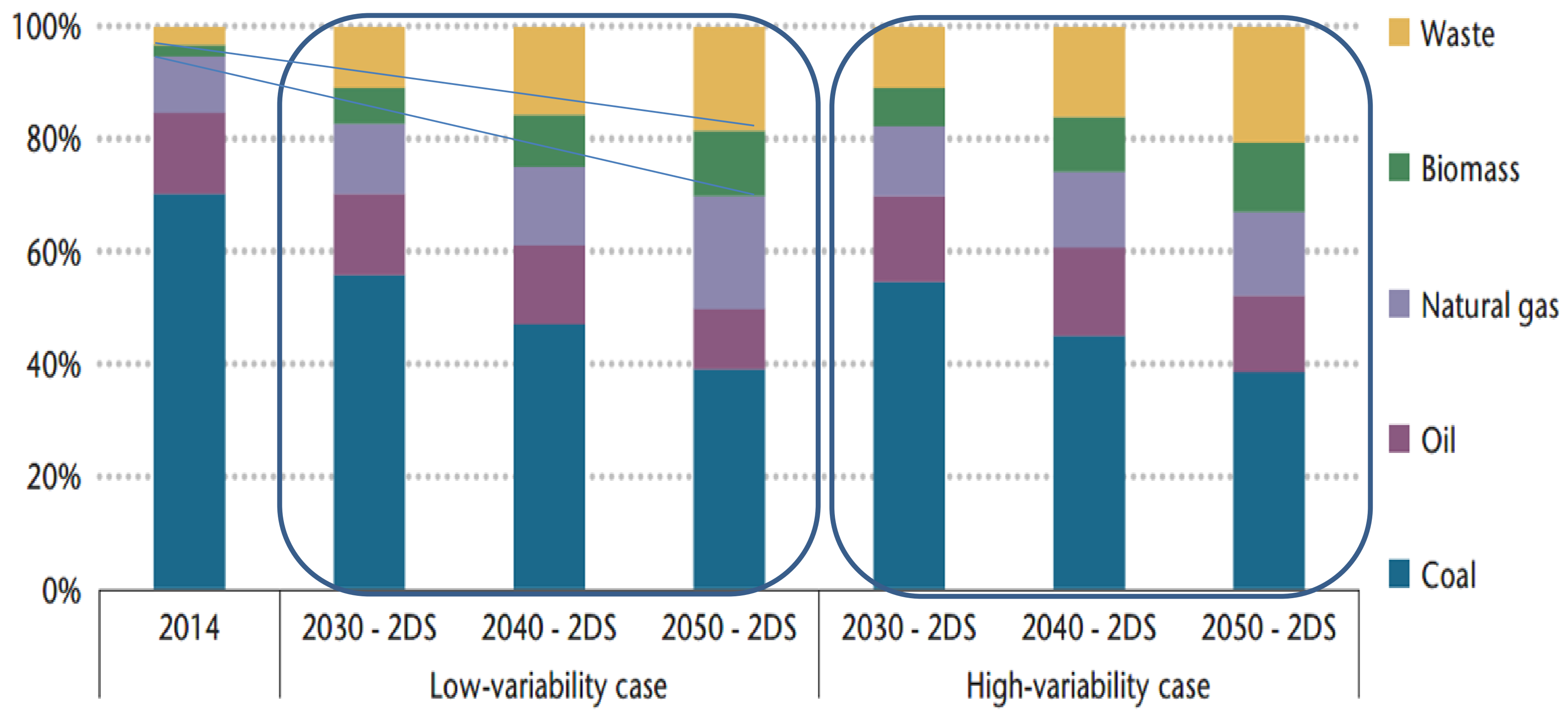
70%煤、
24%油及天然氣、
>5%生質(biomass)及廢棄物(AF = biogenic + non-biogenic sources)

轉換使用較傳統燃料低碳強度(low carbon intensive)之替代燃料，在2℃的情境(2 degree Celsius Scenario)及參考技術情境(Reference Technology Scenario)下，全球在2050年前可達成降低9億公噸或12%二氧化碳排放。

生質(biomass)及biogenic廢棄物(AF)
= neutral in terms of CO_2 emissions



Global thermal energy mix in cement in the 2DS



Note: Waste includes biogenic and non-biogenic waste sources.

KEY MESSAGE: The share of fossil fuels in the cement thermal energy demand decreases from 94% to 67-70% in the 2DS by 2050 due to a greater use of waste and biomass.

典型作為水泥窯替代燃料之廢棄物，有些完全是或部分是生質燃料：

- 廢棄的或切片的輪胎
- 廢油及溶劑
- 經前處理的或原始的產業廢棄物，包括造紙產業之石灰污泥
- 非可再生之塑膠、紡織及紙類殘渣
- 都市固態廢棄物衍生之燃料
- 水及廢水處理廠之污泥
- 完全生質：

  動物、原木、木屑、再生木、回收紙、農業殘渣(稻殼、鋸木屑)、下水道污泥、農作物

為了支持碳排減量策略，最終使用者對於生質能的來源將越發競爭，可能導致生質價格攀高。因為水泥窯能使用之燃料範圍廣，主要設備無須大幅修改，使得其使用生質燃料相較於使用單一燃料之其他工業製造程序更具有成本效益優勢。

Regional Implementation to 2030

將生質及廢棄物再利用作為水泥生產之燃料，世界各國差異很大。

水泥廠能夠高比例的再利用替代燃料的國家，一般均著重在設定排放限制及執行禁止掩埋的政策，而非去限制產業再利用替代燃料之特性。

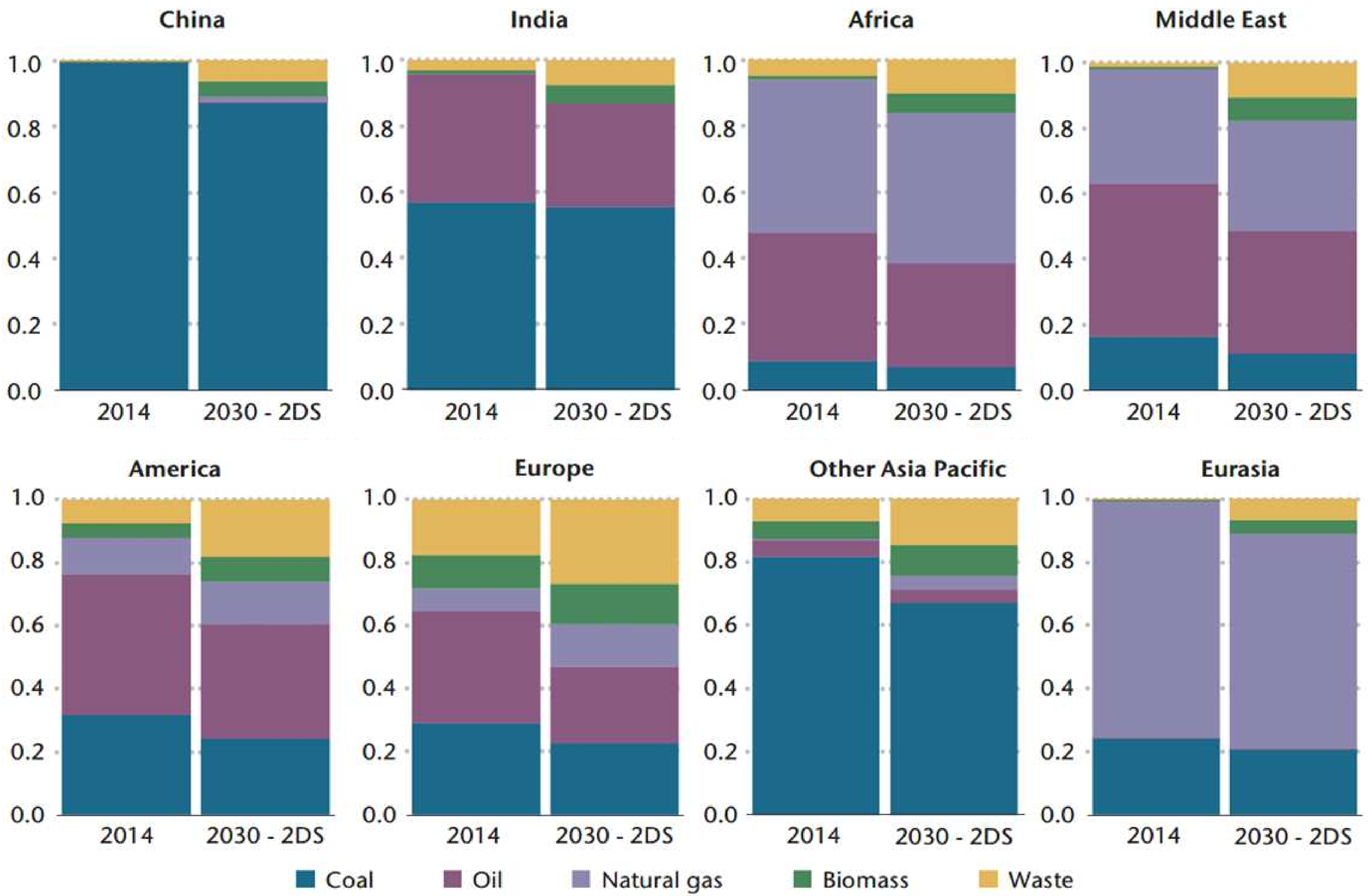
此舉可讓水泥廠具有彈性，能夠去處理其認為最具有競爭力之替代燃料組合。

Ex: 德國及捷克替代燃料取代水泥窯熱能需求的60%。

相對於傳統化石燃料，水泥窯若使用高比例含水量高、熱值低之替代燃料時，則必須承擔燒成耗熱提高(例如：50-70Mcal/噸熟料)以及耗電量增加(2-4KWh/噸熟料)的結果。

用於窯頭最低淨熱值>4,800～5,200(kcal/kg)【一般有機物2,400～4300】

Regional thermal energy mix in cement in the 2DS



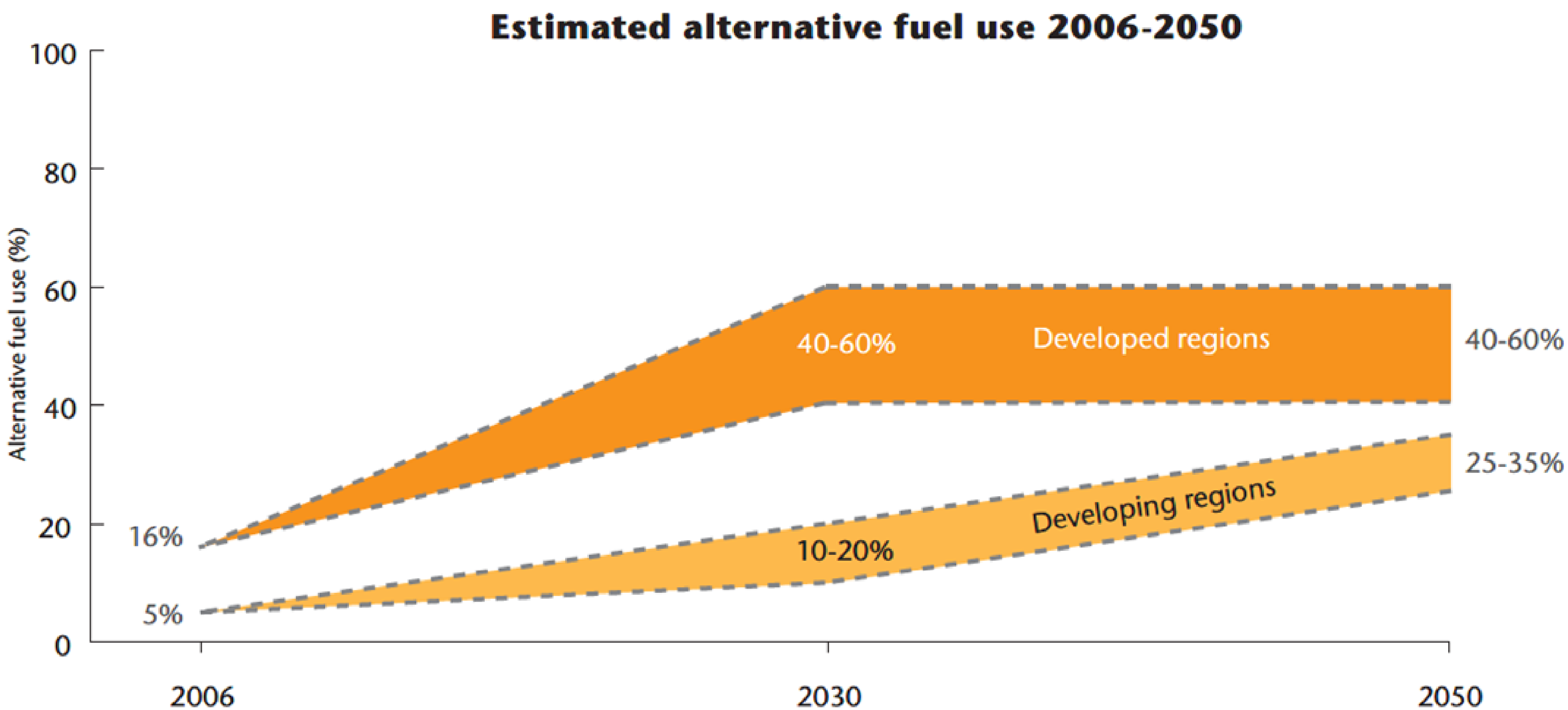
Notes: Results shown for the thermal energy fuel mix of cement are based on the low-variability case of the 2DS. Waste includes biogenic and non-biogenic waste sources.

Annex II: Calculation of the baseline used in roadmap model by IEA

	2006	Baseline 2050 (low)	Baseline 2050 (high)	Roadmap 2050 (low demand)	Roadmap 2050 (high demand)
GLOBAL INDICES					
% clinker	79	75	74	71	73
% alternative fuels (incl biomass)*	3	4	4	37	37
GJ/t clinker	4.2	3.5	3.5	3.3	3.2
kWh/t cement (excl CCS)	111	95	95	92	92
t CO_2 / t cement	800	693	636	426	352**
GLOBAL VOLUMES					
Cement production, million t	2,559	3,657	4,397	3,657	4,397
CO_2 emissions (excluding CCS), million t	2,047	2,337	2,796	2,052	2,521

*IEA uses 40% biomass in alternative fuels

**The low specific emissions in the high demand case, 352t CO_2/t cement, must be achieved to meet the IEA BLUE scenario. This requires the ambitious capture and storage of approximately 221kg CO_2 per tonne of cement produced in 2050.



Source: ECRA Technology Papers (2009), Getting the Numbers Right data 2006 (WBCSD), IEA (2009)

Note: the maximum levels in each region depend on competition from other industries for alternative fuels

Challenges to Implementation

理論上，水泥窯能夠100%使用替代燃料。

實際上，影響水泥窯使用替代燃料之限制因素，包括：

- 熱值過低
- 水分含量過高
- 氯含量過高
- 其他微量元素含量過高

例如：汞、鎘及鉈等金屬，必須妥善加以管控；並將水泥窯粉塵適當移除。

為確保組成均勻、妥善燃燒並且盡量降低潛在會造成問題物質的含量，替代燃料經常必須加以前處理。

影響水泥產業執行替代燃料再利用之不利因素

- 廢棄物管理法規：當地法規未能促成水泥窯之能源回收，而係採掩埋或其他效率低的熱處理方式；
- 當地廢棄物收集網絡未臻充足；
- 社會對於水泥廠協同處理廢棄物燃料之接受度不高：人們過度擔憂有害物的排放，縱然經由一管控良好水泥廠之排放量並不會造成特定問題時亦然。
- 複雜的行政官僚制度：獲得許可通常需經歷一冗長的過程，以及多項不同的行政要求。

IPCC 1996 and 2006 guidelines for national GHG inventories

- ***CO_2 from biomass fuels** is considered climate neutral, because emissions can be compensated by re-growth of biomass in the short term. CO_2 from biomass fuels is reported as a "memo item", but excluded from the national emissions totals.*

- ***CO_2 from fossil fuel-derived wastes** (also called **alternative fossil fuels** or **fossil AF**), in contrast, is not a priori climate-neutral. According to IPCC guidelines, GHG emissions from industrial waste-to-energy conversion are reported in the "energy" source category of national inventories.*

- ***CO_2 from mixed fuels with biomass and fossil fractions:** In the case that biofuels are combusted jointly with fossil fuels (e.g. pretreated industrial and/or domestic wastes), a split between the fossil and non-fossil fraction of the fuel should be established and the emission factors applied to the appropriate fractions.*

- *Direct CO_2 from combustion of* ***biomass*** *(including biomass fuels, biomass wastes and the biomass fraction of mixed fuels) shall be 3 Direct Greenhouse Gas Emissions from Cement Manufacturing Cement Sustainability Initiative reported as a memo item, but excluded from emissions totals. The IPCC default emission factor of* ***110*** *(kg CO_2/GJ) for solid biomass shall be used, except where other, reliable emission factors are available. This value lies in the range of different values for solid biofuels, which are specified as default emission factors in IPCC 2006.*

- *Direct CO_2 from combustion of* ***fossil*** *AF and the fossil fraction of mixed fuels shall be calculated and included in the direct CO_2 emissions* ***(gross emissions*** *and* ***gross emission including CO_2 from on-site power generation,*** *i.e.* ***total direct CO_2 emissions).*** *CO_2 emission factors depend on the type of AF or mixed fuel used and, therefore, shall be specified at plant level where practical. In the absence of plant- or company-specific data, companies shall use the default emission factors provided in the spreadsheet, which are based on measurements and estimates compiled by the CSI Task Force.*

- *Some AF, for example used tires and impregnated saw dust, contain both fossil and biomass carbon. These fuels shall be treated as mixed fuels and the CO_2 emissions shall be separated in their fossil and biogenic part.*
- *This is done by determining the share of the biogenic carbon in the fuel's overall carbon content, according to international standards (e.g. EN 15440).*
- *For some fuel types, this share is difficult and costly to measure, and very variable. Companies are advised to use a conservative approach in determining the biogenic carbon content, meaning that the biogenic carbon content should not be overestimated.*
- *A fossil carbon content of 100% shall be assumed for fuel types in case of a lack of reliable information on their biogenic carbon content until more precise data becomes available.*

BS EN 15440:2011

Incorporating corrigendum October 2011

BSI Standards Publication

Solid recovered fuels — Methods for the determination of biomass content

6.2 Applicable methods

For the determination of biomass content three methods are available:

1) the determination of the biomass content based on the selective dissolution method (SDM) (see Annex A). The determination of the biomass content based on the selective dissolution method is based on the property of biomass that it can be dissolved in a sulphuric acid / hydrogen peroxide mixture;

2) the determination of the biomass content based on the manual sorting method (MS). This method is suitable for samples with a particle size > 10 mm (see Annex B);

3) the determination of the biomass content based on the ^{14}C method. This method is suitable for samples of all types of fuel (see Annex C).

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	生物質燃料燃燒產生的CO_2	噸 CO_2/年
=	∑【生物質燃料**用量** (不包括原料和燃料的烘乾)	噸/年
	X 生物質燃料的**平均熱量低值** (= 淨熱值)	吉焦/噸
	X 生物質燃料**CO_2 排放係數**	千克 CO_2/吉焦
	X 1/1000】	噸/千克
+	∑【其它廢料**用量**	噸/年
	X 其它廢料的**生物質比例**	[% 生物碳/總碳
	X 其它廢料的生物質燃料的**平均熱量低值** (= 淨熱值)	吉焦/噸
	X 其它廢料的生物質燃料**CO_2 排放係數**	千克 CO_2/吉焦
	X 1/1000】	噸/千克

生物質燃料	IPCC 預設值 千克 CO_2/吉焦
乾化污泥	110
木材、木炭、未經防腐處理的鋸末	110
紙、紙板盒	110
農業廢物、有機廢物、紡織廢物	110
動物粉、動物骨粉、動物脂肪	89
其它生物質	110

替代化石燃料 (其它廢料生物質)	IPCC 預設值 千克 CO_2/吉焦
廢油、溶劑、輪胎	110
垃圾衍生燃料包括塑膠	110
防腐鋸末	110
混合工業廢料	110
生物和混合柴油	110
其它廢料	110

替代化石燃料(其它廢料生物質)之非生物質成分燃燒產生的CO_2，如何計算？

Emissions	
	CO_2 from raw materials
+	CO_2 from conventional fossil fuels
+	CO_2 from alternative fossil fuels (fossil wastes)
+	CO_2 from fossil carbon of mixed (alternative) fuels covering CO_2 from all kiln fuels and all non-kiln fuels including CO_2 from on-site power generation
=	**Total direct emissions**

Memo items
CO_2 from biomass fuels CO_2 from biogenic carbon of mixed (alternative) fuels
Indirect CO_2 (bought electricity & clinker)

簡報完畢 敬請指教