Send the Paper to Recycling and the Kitchen Waste Stops Burning

— Kitchen waste at 80 per cent moisture has a lower heating value of **1.4464** MJ/kg, short of the 6 MJ/kg needed to keep burning without fuel — in a town whose waste is half paper, recycling **44.1673** per cent of the paper leaves a residue that no longer keeps burning — [Paper 575]

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— From thinking to syncing. —

Abstract

"Burnable waste" is collected as something that burns, and burned in incinerators.What this paper shows is that wet kitchen waste does not keep burning on its own; it burns by borrowing the heat of the paper mixed in with it, and the more paper is recycled, the less the waste burns.No new theorem or law is claimed. First, the heat of waste is the heat of its dry part less the latent heat of its water——1.4464 MJ/kg for kitchen waste (moisture 0.80) and 14.1558 MJ/kg for paper (moisture 0.10) (Section 2). **Second, kitchen waste can keep burning on its own only below a moisture of 0.565785——kitchen waste at 0.80 is far beyond it** (Section 2). **Third, and this is the core.To keep burning, paper must make up at least 0.358286 of the wet mass——kitchen waste burns because paper burns with it** (Section 3). **Fourth, in a town whose waste is half paper, recycling 44.1673 per cent of the paper leaves a residue that no longer keeps burning——it falls to 7.0950 at 20 per cent, 6.2124 at 40 and 5.0777 MJ/kg at 60** (Section 4). **Fifth, the threshold moves with the criterion——by a moisture criterion the paper must be at least $3/7 = 0.428571$, differing by 0.070285 from the criterion on heating value** (Section 3). **Sixth, the separator is whether the latent heat of the water eats up the heat of the dry part——beyond that moisture, waste turns from something that gives heat into something that takes it** (Section 5). **Keywords**: waste incineration, lower heating value, kitchen waste, paper recycling, self-sustaining combustion.

Scope of this paper (scope note): No new theorem or law is claimed——the formula for the lower heating value and the criteria for sustained burning are standard.The numbers are representative——kitchen waste at moisture 0.80 with 17 MJ/kg in its dry part, paper at 0.10 with 16 MJ/kg, a latent heat of evaporation of 2.442 MJ/kg, a criterion of 6 MJ/kg for burning without fuel and a moisture criterion of 0.5.Ash is not included——ash gives no heat, so including it would make the thresholds stricter.Plastics are not included——plastics have a high heating value, and recycling them works in the same direction.No incinerator is designed——the shape of the furnace, the air supply and the combustion temperature are not treated.Energy and carbon dioxide are not balanced——weighing the fuel added against the benefit of recycling paper lies outside this paper.It is not said that paper should not be recycled.Relation to earlier papers: Paper 464 showed that of the heat taken by sprinkled water, the latent heat of evaporation is 58.53 times that taken through its temperature, so changing the water's temperature changes the effect by only **3.3882** per cent——here too water acts through its latent heat of evaporation rather than its temperature, now on the side that eats the combustion balance.Paper 455 showed that how dry the material is to be decides which stage of drying is rate-limiting——the same moisture content decides the speed of drying there and whether waste burns here.Paper 300 showed that sharing a root is decidable——the thresholds of the moisture criterion and the heating-value criterion come from the same latent heat, yet their numbers do not agree.What is added is finding the moisture limit **0.565785** for kitchen waste on its own by a closed form and by bisection, finding the share of paper **0.358286** needed to keep burning, setting out how the heating value of the residue falls as paper is recycled and confirming the threshold of **44.1673** per cent, showing that the choice of criterion moves the threshold by **0.070285**, and placing the separator on the contest between the latent heat of the water and the heat of the dry part.

1. Notation and the Question

Setting: in 1 kg of waste (wet mass) with a water fraction w, dry-part heating value H_d and latent heat of evaporation L, the lower heating value is

$$H(w) = (1 - w)\,H_d - w\,L.$$

Mixing two kinds of waste in the wet-mass proportion $p : (1 - p)$ mixes their heating values in the same proportion.

Observation 1.1

"burnable waste" is collected as something that burns.Whether it burns, though, is set by the difference between the heat it holds and the heat its water takes away in evaporating——wet waste put in a fire can take more heat than it gives.

Question: **does kitchen waste keep burning on its own?What happens to the remaining waste when paper is recycled?**

2. Kitchen Waste and Paper

Computation 2.1: **lower heating values from the representative values.**

waste	moisture	dry-part heat	lower heating value
kitchen waste	0.80	17 MJ/kg	**1.4464** MJ/kg
paper	0.10	16 MJ/kg	**14.1558** MJ/kg
criterion for sustained burning			6 MJ/kg

> **Observation 2.2**
>
> **most of the heat of kitchen waste goes into evaporating its water.Its dry part holds 3.4 MJ per kg of wet mass, of which about 1.95 MJ is taken by the water——what remains is less than a quarter of the criterion.**

Computation 2.3: **the moisture limit for kitchen waste to keep burning on its own, from $H(w) = 6$, is $w^{*} = (H_d - 6)/(H_d + L) = \mathbf{0.565785}$ (the closed form and bisection agree to 10^{-9}).**

> **Observation 2.4**
>
> **kitchen waste at 0.80 is far beyond the limit of 0.565785.Kitchen waste does not keep burning on its own ——the kitchen waste burning in an incinerator is not burning by its own heat.**

3. Mixed, It Burns

Computation 3.1: **paper mixed in at a wet-mass share p.The threshold for sustained burning is $p^{*} = \mathbf{0.358286}$ (at that share the heating value returns to 6 to 10^{-12}).**

share of paper	lower heating value	
0.50	**7.8011** MJ/kg	keeps burning
0.40	**6.5302** MJ/kg	keeps burning
0.36	**6.0218** MJ/kg	keeps burning
0.30	**5.2592** MJ/kg	needs fuel
0.20	**3.9883** MJ/kg	needs fuel

> **Observation 3.2**
>
> **this is the core.Kitchen waste burns because paper burns with it——below a paper share of 0.358286 the whole mixture stops burning on its own, and fuel must be added to the furnace.**

Computation 3.3: **by the other criterion, moisture at most 0.5.The threshold is $p = (0.80 - 0.50)/(0.80 - 0.10) = 3/7 = \mathbf{0.428571}$, matching $3/7$ to 10^{-12}.**

> **Observation 3.4**
>
> **the threshold moves with the criterion used to say “keeps burning”.By heating value it is 0.358286, by moisture 0.428571, a difference of $\mathbf{0.070285}$——the threshold is not a constant of physics but a function of the criterion adopted.**

4. When Paper Is Recycled

Computation 4.1: **a town whose waste is half paper and half kitchen waste by wet mass recycles part of its paper and burns the rest.**

paper recycled	paper in the residue	heating value of the residue
0 per cent	**0.500000**	**7.8011** MJ/kg
20 per cent	**0.444444**	**7.0950** MJ/kg
40 per cent	**0.375000**	**6.2124** MJ/kg
60 per cent	**0.285714**	**5.0777** MJ/kg

> **Observation 4.2**
>
> **once 44.1673 per cent of the paper is recycled, the residue no longer keeps burning.At that share its heating value returns exactly to the criterion of 6 (to 10^{-9})——before recycling reaches half, the incinerator has to add fuel.**

> **Observation 4.3**
>
> **recycling paper and incinerating waste compete for the same paper.What makes “burnable waste” burnable is the paper in it——the more paper is taken out, the more what remains is wet kitchen waste.**

5. The Separator

> **Observation 5.1**
>
> **the separator is whether the latent heat of the water eats up the heat of the dry part.Below the moisture limit of 0.565785, waste is on the side that gives heat——beyond it, waste moves to the side that takes heat, and can be burned only by borrowing the heat of something else.**

Observation 5.2

as in Paper 464, water acts through its latent heat.There the latent heat of evaporation of sprinkled water was 58.53 times the heat taken through its temperature, and changing its temperature changed the effect by only 3.3882 per cent——here the same latent heat of evaporation appears on the side that eats the combustion balance.

Observation 5.3

the quantity of Paper 455, in another role.There, how dry the material was to be decided which stage of drying was rate-limiting——the same moisture content decides the speed of drying there and whether waste burns here.

Observation 5.4

one root under Paper 300, yet the numbers differ.The moisture criterion and the heating-value criterion both come from the latent heat of the water eating the heat of the dry part——still their thresholds differ by 0.070285. Sharing a root and agreeing in number are different things.

Observation 5.5

what is not said.It is not said that paper should not be recycled——weighing the fuel added against the benefit of recycling lies outside this paper. What is shown is that the two efforts compete for the same paper, so advancing one changes the conditions of the other.

6. Roll Call and Closing

1. **kitchen waste 1.4464, paper 14.1558 MJ/kg** (Computation 2.1): **heat less the latent heat of water.**
2. **moisture limit for kitchen waste 0.565785** (Computation 2.3): **0.80 is far beyond.**
3. **paper must be at least 0.358286** (Computation 3.1): **the core.**
4. **paper at 0.30 gives 5.2592 MJ/kg** (Computation 3.1): **fuel needed.**
5. **by moisture, 0.428571** (Computation 3.3): **3/7.**

6. **the two criteria differ by 0.070285** (Observation 3.4): **a threshold set by the criterion.**
7. **recycling 44.1673 per cent of the paper stops the burning** (Observation 4.2): **before half.**
8. **5.0777 MJ/kg at 60 per cent recycled** (Computation 4.1): **below the criterion.**
9. **the separator is whether latent heat eats the dry heat** (Observation 5.1): **giving heat or taking it.**
10. **one root, different numbers** (Observation 5.4): **the gap between two criteria.**

Closing: **“Burnable waste” is collected as something that burns, and burned in incinerators.Yet wet kitchen waste does not keep burning on its own——the lower heating value is the heat of the dry part less the latent heat of evaporation of the water, 1.4464 MJ/kg for kitchen waste at moisture 0.80 and 14.1558 MJ/kg for paper at 0.10. Against a criterion of 6 MJ/kg for burning without fuel, kitchen waste can keep burning on its own only below a moisture of 0.565785, and it lies far beyond.Kitchen waste burns because paper burns with it——below a paper share of 0.358286 of the wet mass the whole mixture stops burning on its own. In a town whose waste is half paper, recycling 44.1673 per cent of the paper brings the residue exactly to the criterion, and beyond that fuel must be added to the furnace. The threshold also moves with the criterion: by moisture it is $3/7 = 0.428571$, differing by 0.070285 from the heating-value criterion.The separator is whether the latent heat of the water eats up the heat of the dry part——waste beyond the limit moves from giving heat to taking it and can be burned only with the heat of something else. Under Paper 300 the two criteria share the root of latent heat, yet their thresholds do not agree.Placed among the earlier papers——as in Paper 464, water acts through its latent heat of evaporation rather than its temperature, here eating the combustion balance. The moisture content of Paper 455 decides the speed of drying there and whether waste burns here.To be honest——the numbers are representative, with neither ash nor plastics included. No incinerator was designed, and the fuel added was not weighed against the benefit of recycling. Nor is it said that paper should not be recycled: what is shown is that the two efforts compete for the same paper.**

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