

CdTe Photovoltaics: Real and Perceived EHS Risks

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Perceptions

“GreenPeace is deeply concerned with the possibility of the CPA choosing to purchase solar modules that contain toxic metals...Current CdTe panels result in Cd (gaseous) emissions of 0.5g/GWh, equivalent to that of a coal fired power plant. The majority of these emissions (77%) result from mining and utilization of the modules, therefore a comprehensive collection and recycling program would not reduce the environmental impacts of these panels “

Comment to the California Power Authority, 2002

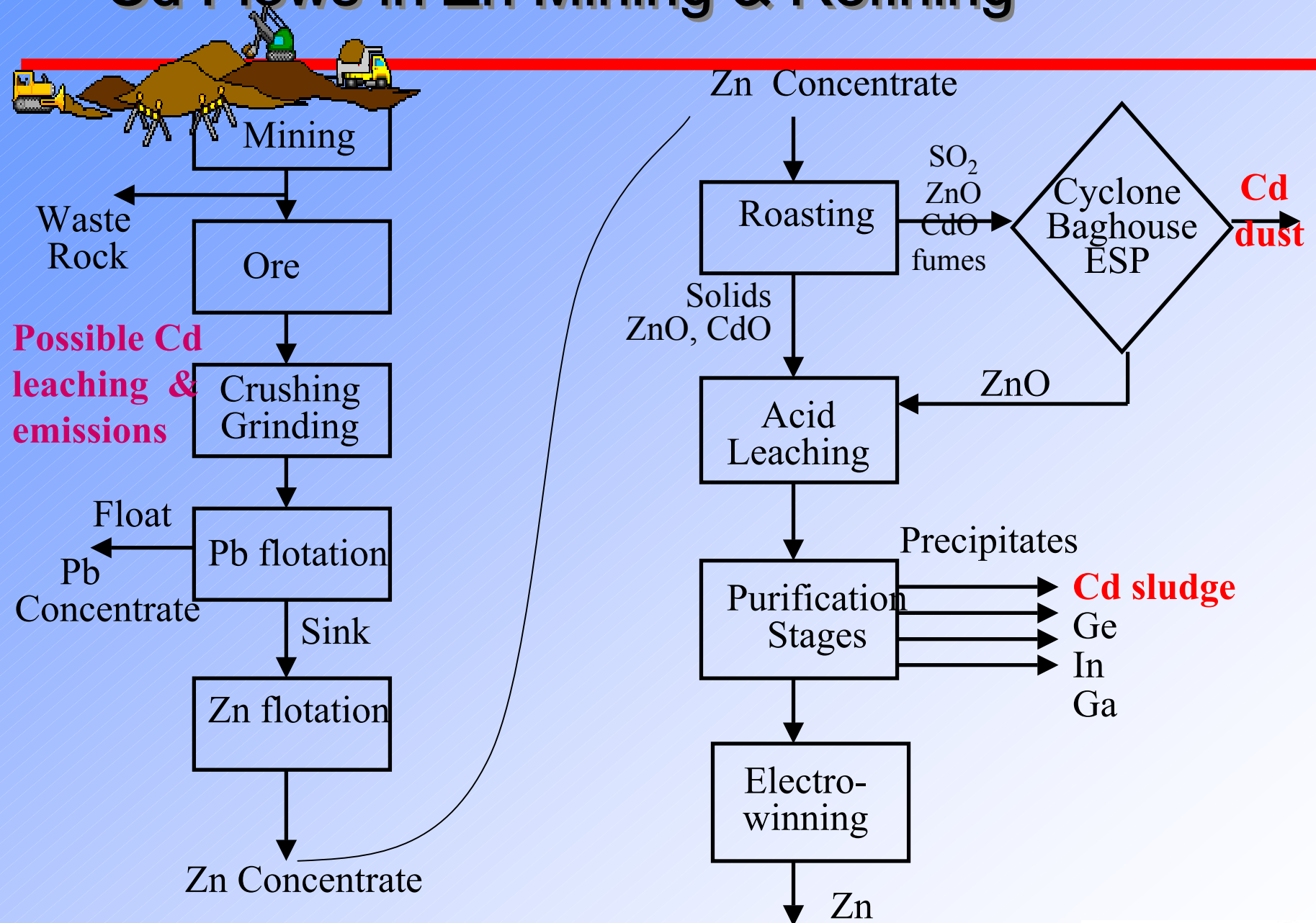
CdTe PV Life-Cycle Stages

1. Mining
2. Production of CdTe
3. Manufacture of CdTe PV modules
4. Utilization of CdTe PV modules
5. Disposal of spent CdTe PV modules

Cd Emissions from Mining: Facts

1. Cd is a byproduct of Zn, Cu and Pb production. The main resource of Cd is CdS in sphalerite (ZnS) ores. The Zn/Cd ratio is 350 to 1.
2. Production of Cd uses emissions and waste of Zn production
3. Cd output is dependent on Zn production, not on Cd demand
4. Before Cd production started in the US, ~85% of Cd from Zn concentrates was lost to the environment
5. Zinc mines in the US also produce:
 - 100 % of Cd, Ge, In, Th
 - 10 % of Ga
 - 3 % of Au,
 - 4 % of Ag

Cd Flows in Zn Mining & Refining

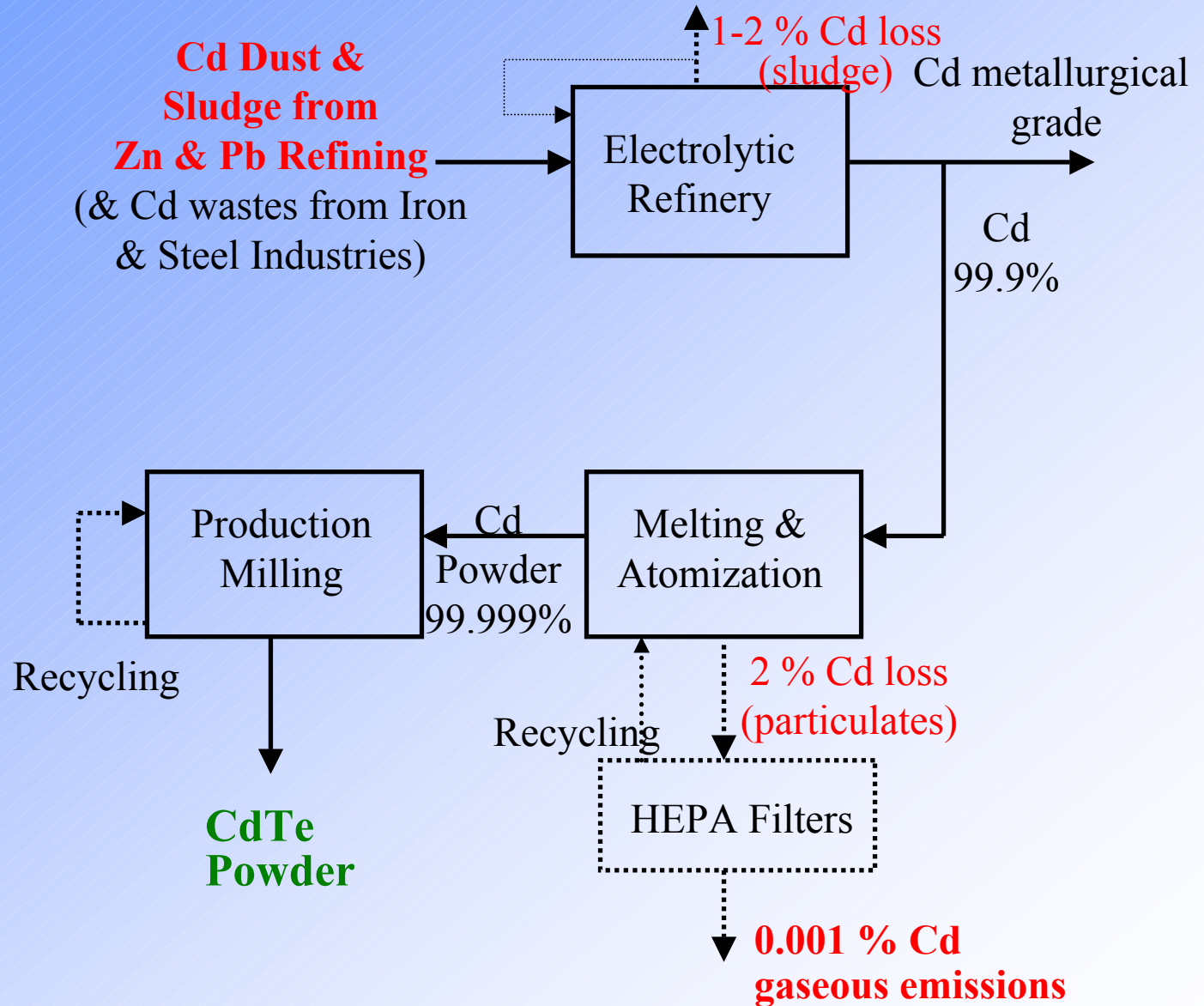


Cd Emissions of Zn-making Processes:

g Cd/ton Zn (% Cd/Zn)

- Roast/leach/electrowinning process: 0.2 (0.008 %)
- Roast/blast furnace smelting: 50 (2 %)
(replaced in Canada and Europe)
- Roast/retort smelting: 100 (4 %)
(not in use any more)

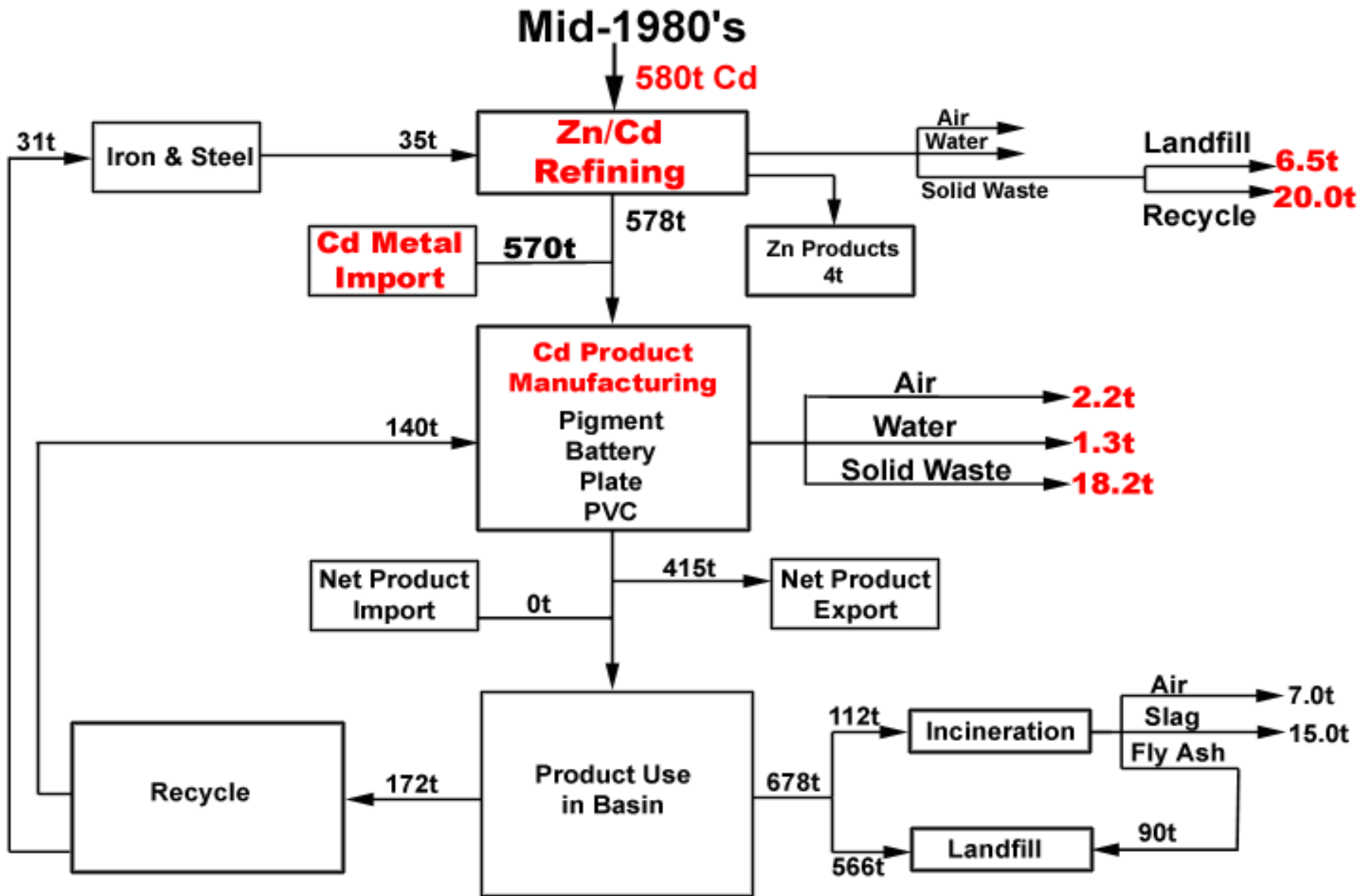
Cd Flows from Cd Concentrates to CdTe



Cd Emissions in CdTe Production

- Cd emissions attributed to CdTe production amount to 0.001% of Cd used (*corresponding to 0.01 g/GWh*)
- Cd is produced as a byproduct of Zn production and can either be put to **beneficial uses** or **discharged** into the environment
- Above statement is supported by:
 - US Bureau of Mines reports
 - Rhine Basin study (the largest application of Systems Analysis on Industrial Metabolism)

Cd Flow in the Rhine Basin



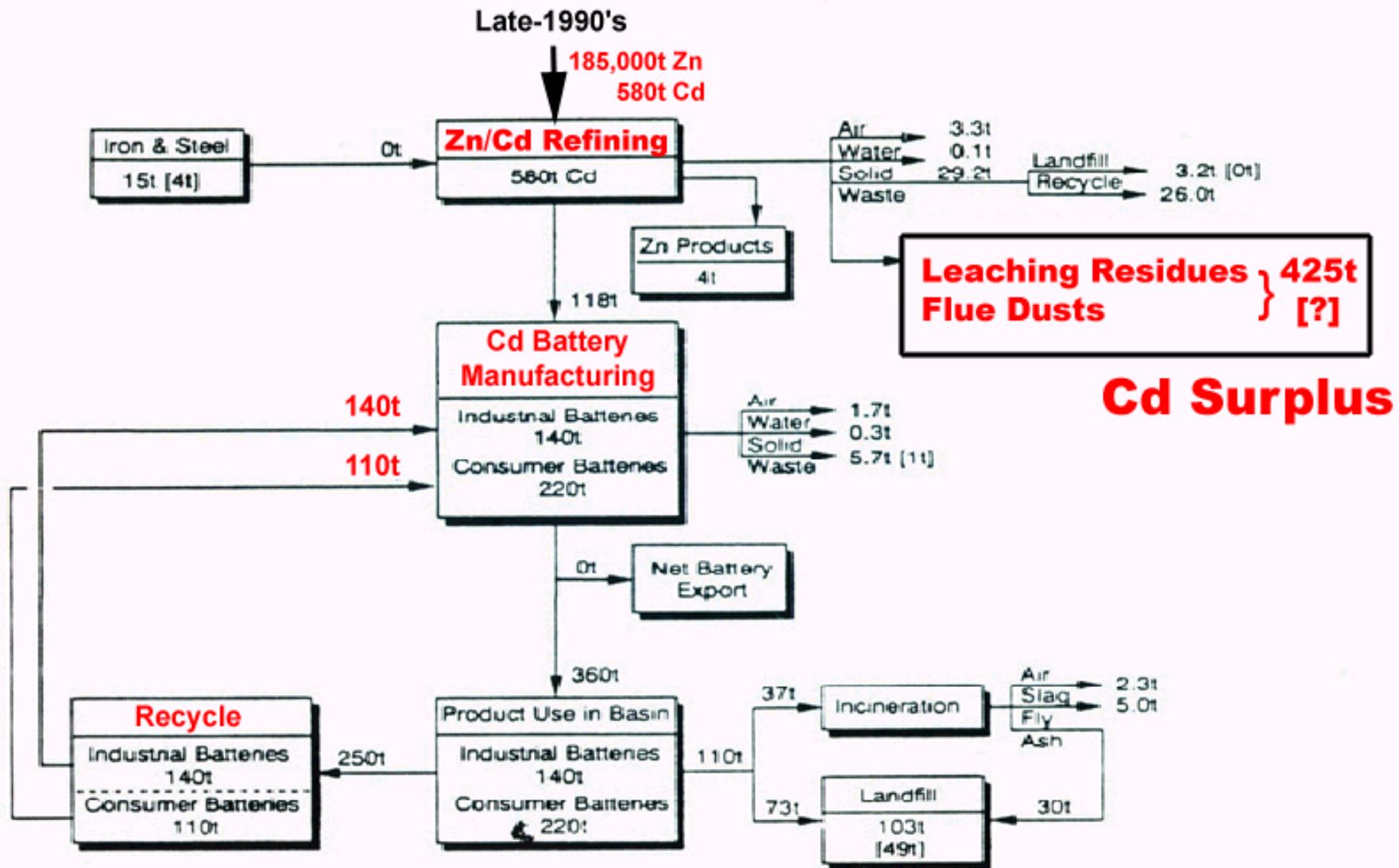
Brookhaven Science Associates

U.S. Department of Energy

Source: Stigliani & Anderberg, Chapter 7, *Industrial Metabolism*, The UN University, 1994

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Rhine Basin: Cd Banning Scenario



Cd Use & Disposal in the Rhine Basin: The effect of banning Cd products

“So, the ultimate effect of banning Cd products and recycling 50% of disposed consumer batteries may be to shift the pollution load from the product disposal phase to the Zn/Cd production phase. This does not imply that banning Cd-containing products is not a wise strategy; rather, it indicates that if such a ban were to be implemented, special provisions would have to be made for the safe handling of surplus Cd wastes generated at the Zn refineries!

One possible option would be to allow the production and use of Cd-containing products with inherently low availability for leaching. The other option, depositing the Cd-containing wastes in safely contained landfills, has other risks”

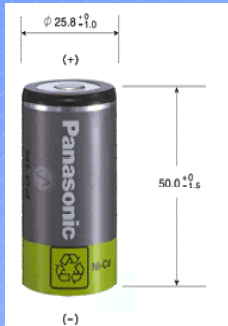
*Source: Stigliani & Anderberg, Chapter 7, Industrial Metabolism,
The United Nations University, 1994*

Cd vs. CdTe PV

Compound	T _{melting} (°C)	T _{boiling} (°C)	Solubility (g/100 cc)	Toxic/ Carcinogen
Cd	321	765	insoluble	yes
Cd(OH) ₂	300	-	2.6e-04	yes
CdTe	1041	-	insoluble	?

- CdTe is much more stable than Cd and Cd(OH)₂ used in batteries
- In addition, CdTe in PV is encapsulated between glass sheets

NiCd Battery to CdTe PV Comparisons



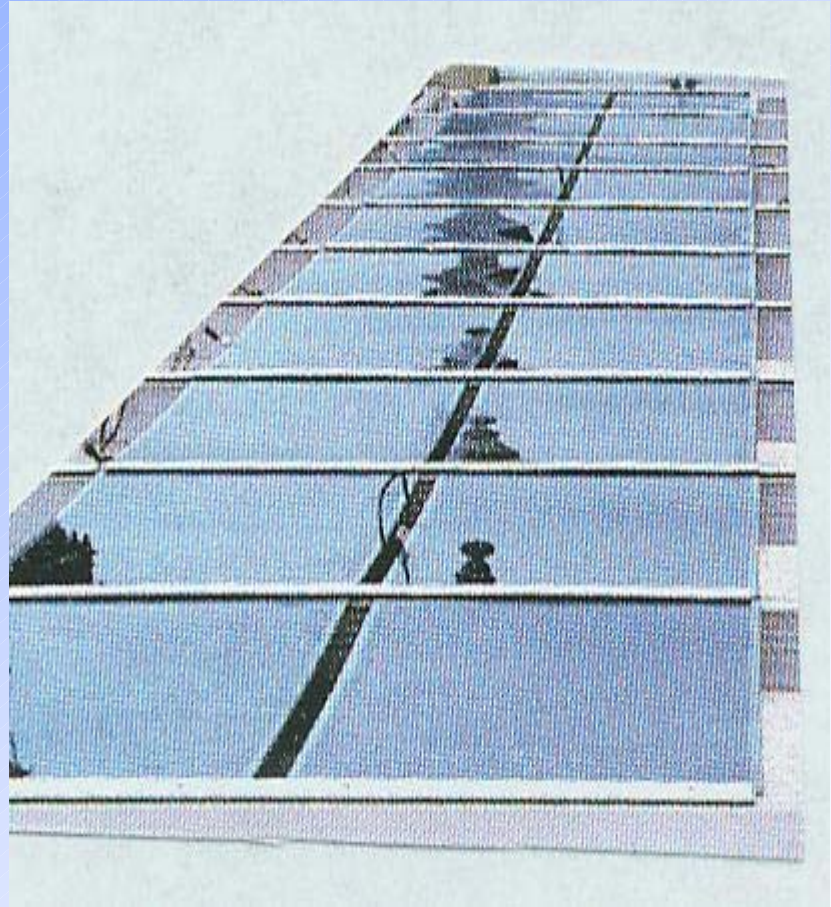
10 g Cd / C-size



7 g Cd/m²

NiCd Battery to CdTe PV Comparisons

7 batteries = 70 g Cd = 1 kW CdTe PV



3265 kg Cd/GWh

1.3 kg Cd/GWh

•Cd in CdTe PV generates 2,500 times more electricity than NiCd batteries

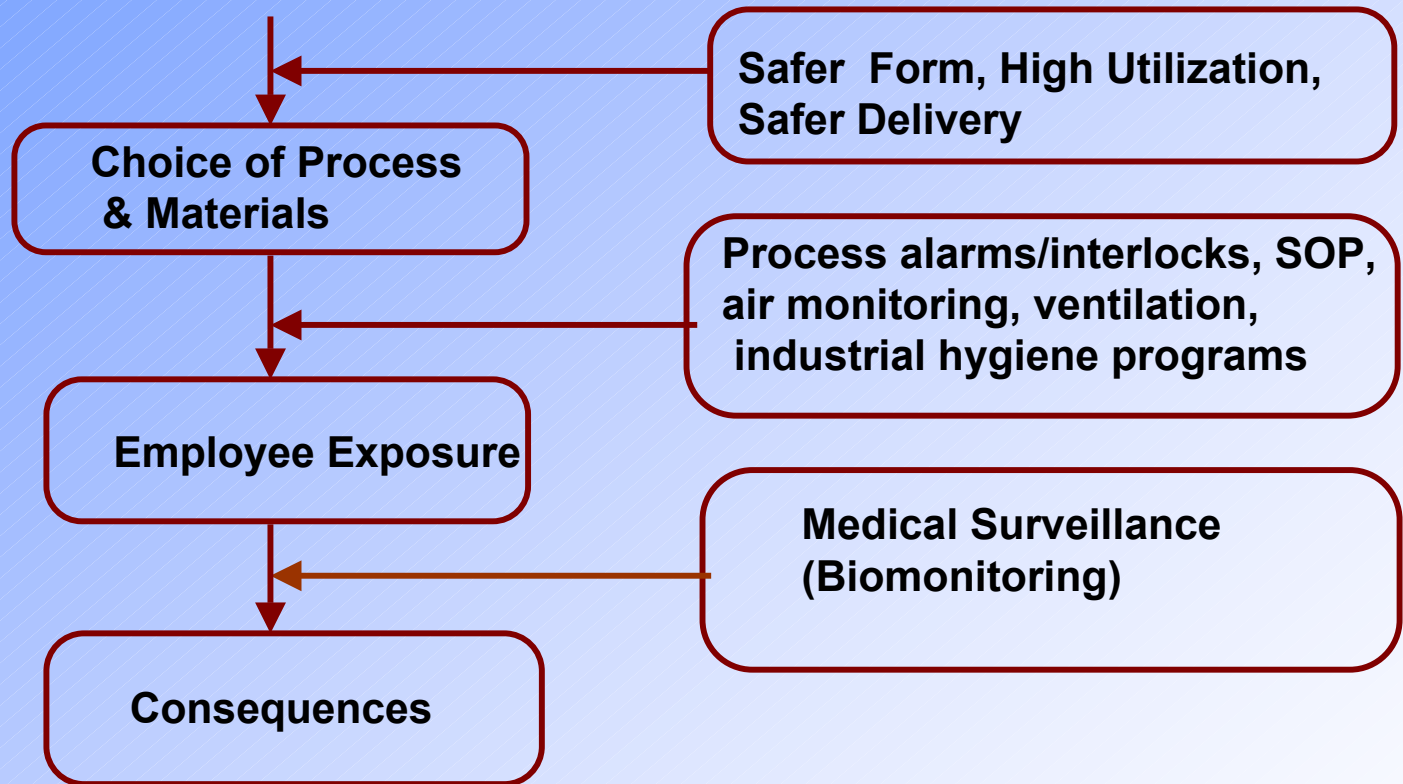
EHS in CdTe PV Manufacturing

Occupational Health

- Inhalation Risks
- Ingestion Risks



Multi-Layer Protection for Occupational Health & Safety



Utilization of CdTe PV Modules

- **Zero emissions under normal conditions**
- **Debate on fire risks**
 - Emissions during residential fires present negligible incremental risk (*Fthenakis, 2001*).
 - “... concern about cumulative emissions from a large number of small PV installations. We can compare them with emissions of Cd and Se from coal-fired power plants” (*Alsema, 1996*).

CdTe Emissions in Residential Fires

- Accidental emissions during fire could amount to 0.01 g/GWh
- It is unlikely that encapsulated CdTe will vaporize in residential fires.
- An experimental study is planned at Brookhaven to quantify the thermal behavior of modules during fires.

Decommissioning of end-of-life CdTe PV modules

- Concerns about disposal in municipal landfills
- Environmental regulations determine the cost and complexity of dealing with end-of-life PV modules
- This issue is not unique to CdTe PV
 - TCLP –EPA
 - STLC and TTLC –California HWCL
- Concerns about PV modules in MW incinerators
- Recycling will resolve most concerns
- Recycling is technically feasible but cost needs to be lowered

Conclusions

- Cd is produced as a byproduct of Zn production and can either be put to *beneficial* uses or *discharged* into the environment
- CdTe in PV is much safer than other current Cd uses.
- CdTe PV uses Cd 2500 times more efficiently than NiCd batteries
- Occupational health risks are well managed -
 - Continuous vigilance is required
- Absolutely no emissions during PV operation
- Risk from fire emissions is minimal
- Disposal of spent modules is an environmental issue –
 - Reducing the amount of CdTe will alleviate the problem
 - Recycling will resolve most environmental concerns

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New CdTe PV website: <http://www.nrel.gov/cdte>

BNL PV EHS website: <http://www.pv.bnl.gov>