Packaging Plastics Life Cycle Analysis:

Virgin and Recycled PET, HDPE, and PP Pellets

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LCAs

Done by Franklin Associates, now ERG.

Highly credible LCA practitioner.
Follows ISO 14040 and 14044 standards

vPET: used 2013-2015 data

vHDPE and **vPP:** used 2003-2010 data,
2010 report to be updated

rPET, rHDPE, rPP: used 2015-2017 data

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Who is APR?

International trade association

The Voice of Plastics Recycling®

Companies committed to the success of plastics recycling

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Increase Supply

Enhance Quality

Expand Demand

Communicate Value

APR Primary Goals

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The ONLY organization focused EXCLUSIVELY on plastics recycling:

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LCA

- **Functional Unit:** 1,000 lbs pellets
- **Boundary & Scope**: All three resins,
  - **Cradle** (from the earth) - to - **gate** (factory)
- **Inventory**: “The heat and mass balance”
- **Impact:** “Aggregated data”
  - energy, GWP, acid rain, eutrophication, smog, O^3 depletion, solid waste, water use, plus renewable v. non-renewable energy.
  - Did not include land: the bio weakness.

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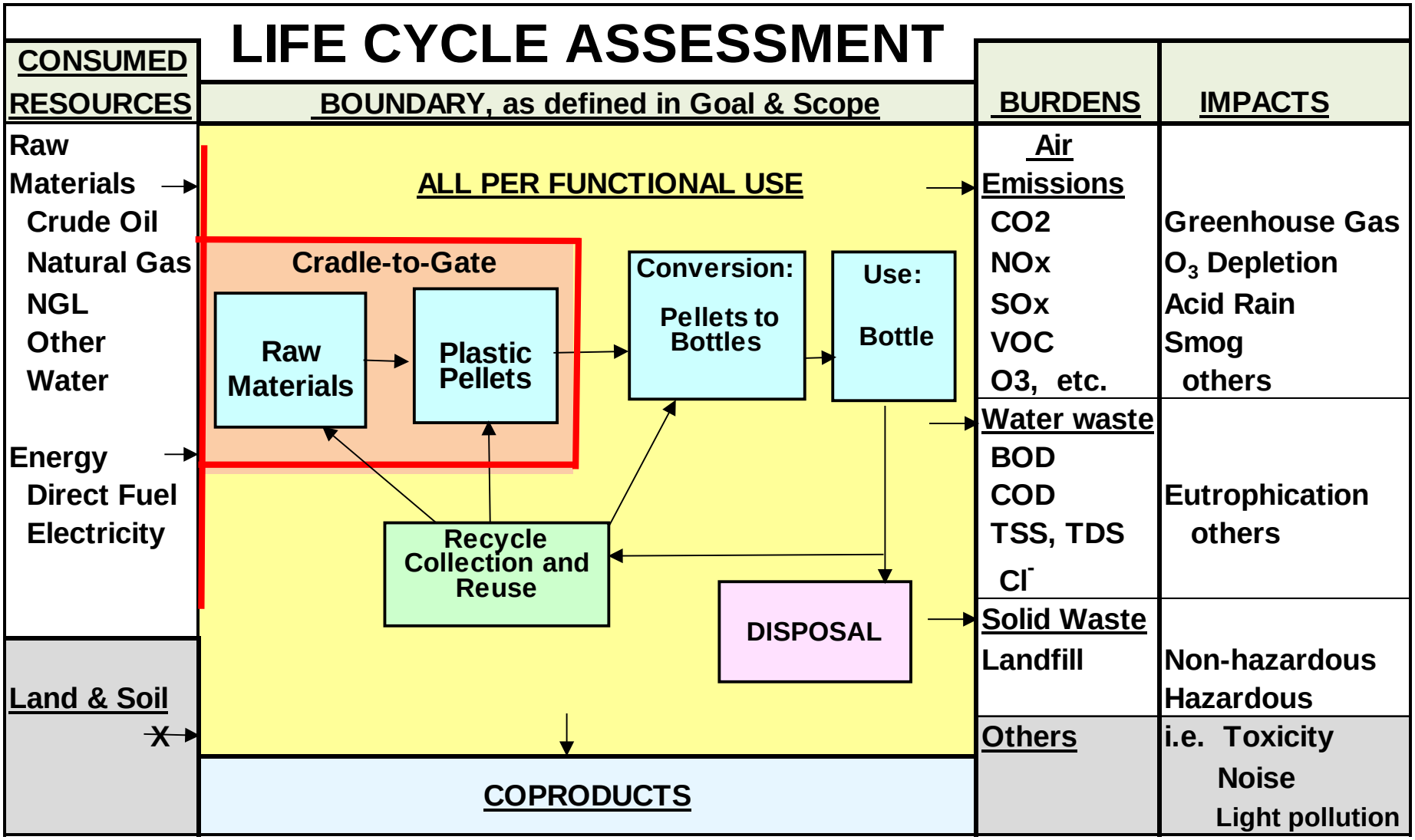
LIFE CYCLE ASSESSMENT



Important Stuff

- **ENERGY** drives most of the emissions
- **ENERGY** has three components
  - **Embedded energy** (fuel value)
  - **Transport energy** – energy to move stuff
  - **Process energy** – energy to transform raw materials
- **Expended energy** (process & transport) is energy used and gone.
  Embedded energy may or may not be lost.

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Side Note on ‘Embedded Energy

- By convention

  PAPER has **no** Embedded Energy

  PLASTICS made from **fossil fuels have** Embedded Energy

  PLASTICS made from **plants have no** Embedded Energy

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Problematic Stuff - Water

- Tracking water use is tricky
  - We do not destroy water, only make it less or more available for use.
- Water use can be
  - Related to raw material extraction
  - Related to process contact or content
  - For cooling for electricity and processes
  - Of varying quality
  - From surface, aquifer, or seawater sources

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Boring, but important, Stuff

- Allocation assumptions:
  - **CUTOFF**: The embedded energy stays with first use (virgin material use). So, recycled plastic has no embedded energy.
  - **Open Loop**: The embedded energy is shared with all uses.
    - By convention, “all” equals “2”

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So, How many uses of atoms?

- For **75%** recycling rate and recycled content:
  4 times? 6 times? 8 times used?
- For **95%** recycling rate and recycled content:
  4 times? 6 times? 8 times used?
- What does "**2 uses**" imply?

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So, How many uses of atoms?

Uses of Molecules		Recycled Content %						
		0%	10%	25%	50%	75%	95%	100%
Recycling Rate %	0%	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	10%	1.10	1.10	1.10	1.11	1.11	1.11	1.11
	25%	1.25	1.26	1.27	1.29	1.31	1.33	1.33
	50%	1.50	1.53	1.57	1.67	1.80	1.95	2.00
	75%	1.75	1.81	1.92	2.20	2.71	3.61	4.00
	95%	1.95	2.05	2.25	2.81	4.30	10.74	20.00
	100%	2.0	2.1	2.3	3.0	5.0	21.0	∞

SO, ON TO THE PLASTICS PACKAGING STORY

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Collection of Recycled Plastics

	Curbside	Dropoff	Deposit	CRV	Commericial MRF	Commericial Other
PET	54%	5%	17%	16%	2%	6%
HDPE	62%	5%	5%	4%	23%	2%
PP	95%	5%				

Curbside Recycling Truck Composition, by weight		
PET	2.8%	
HDPE	1.5%	
PP	0.3%	5.5%
Other plastic	0.9%	
Paper & cardboard	61.8%	
Metal	7.1%	
Glass	3.5%	
Other Packaging	11.4%	
Trash	10.7%	← was 3% in 2010

Virgin PET Energy

ENERGY	MBtu/K lb. 2011	2019	Δ
Total	30.3	26.4	-13%
Feedstock	16.4	15.8	-4%
Process & Transport	13.9	10.6	-24%

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Recycled PET Energy

ENERGY	MBtu/K lb.		
Cutoff assumption	2011	2019	Δ
Total	6.2	6.4	3%
Feedstock	0	0	
Process & Transport	6.2	6.4	3% (same)

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2019 rPET v. vPET Energy

ENERGY	MBtu/K lb.			
	vPET	rPET	Δ	r/v%
Total	26.4	6.4	20.0	24%
Feedstock	15.8	0	15.8	0%
Expended	10.6	6.4	4.2	60%

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vPET Global Warming Potential

Global Warming Potential (GHG, GWP)	lb. CO_2 Eq/K lb.		
	2011	2019	Δ
CO_2 Equivalents	2733	2259	-17%

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rPET Global Warming Potential

Global Warming Potential (GHG, GWP)	lb. CO_2 Eq/K lb.		
	2011	2019	Δ
CO_2 Equivalents	1147	913	-20%

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2019 rPET v. vPET GWP

Global Warming Potential (GHG, GWP)	lb. CO_2 Eq/K lb.		
	vPET	rPET	Δ
CO_2 Equivalents	2259	913	1346
		→	40%

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2019 rPET v. vPET Water Use

Water Use	Gallons/K lb.		
	vPET	rPET	Δ
Gallons water	1321	1236	85 6% (same)
oil & gas	25%		
electricity	39%		
PET resin	6%	8%	

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2019 rPET v. vPET Solid Waste

Solid Waste	lb. waste/K lb.		
	vPET	rPET	r/v%
Contaminants	0	330.3	
Process	107	57.7	54%
Total	107	388	363%

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2019 rPET v. vPET Other Impacts

Other Impacts

	vPET	rPET	r/v%
acidification	7.8	3.2	41%
eutrophication	0.48	0.26	54%
smog	153	43	28%

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HDPE, Virgin and Recycled

- Same basic story as for PET, rHDPE with mixed year data shows
  - Less energy consumed vs virgin HDPE
  - Less Greenhouse Gas emissions
  - Less Other Impacts
  - Contamination hurts economics and environmental benefits for rHDPE
- PP story similar to the HDPE story

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Changes, 2010 to 2019

- New process data, improved processes, some new polymer synthesis processes (some new for PET)
- More single stream collection; more contamination in recycled plastic bales
- Less recycled material from PRFs
- CNG-powered collection trucks
- Different factories; different sized factories
- More participating resin makers & reclaimers
- Electricity via natural gas instead of coal

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Equivalencies
Energy and Greenhouse Gas

Per the Franklin/ERG report (mixing years):

- The **total energy** saved by **recycling PET, HDPE, and PP** rigid packaging equals the household electricity of 1.97 million households – exceeds

Los Angeles and San Jose households.

- The **GHG** reduction by recycling PET, HDPE, and PP rigid packaging equals taking 509,000 cars off the road –

the cars in Napa and San Francisco counties

National savings.

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Equivalencies 2019, PET California CRV bottles

- The annual **Total Energy** saved by recycling PET CRV bottles exceeds the annual **household electricity use** in **Sacramento.**

- The annual **Expended Energy** saved by recycling PET CRV bottles exceeds the annual **household electricity use** in **Berkeley.**

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Equivalencies 2019, PET California CRV bottles

- The annual **Greenhouse Gas Emissions** avoided by recycling PET CRV bottles equals 52,000 cars taken off the road, about the cars registered in **Palo Alto, Davis,** or **Encinitas**

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USING RECYCLED PLASTIC SAVES ENERGY AND LOWERS EMISSIONS

Reduce energy consumption by at least 79%.

Reduce GHG emissions by at least 67%.

Recycling and using recycled materials is good for manufacturers, consumers, and the planet.

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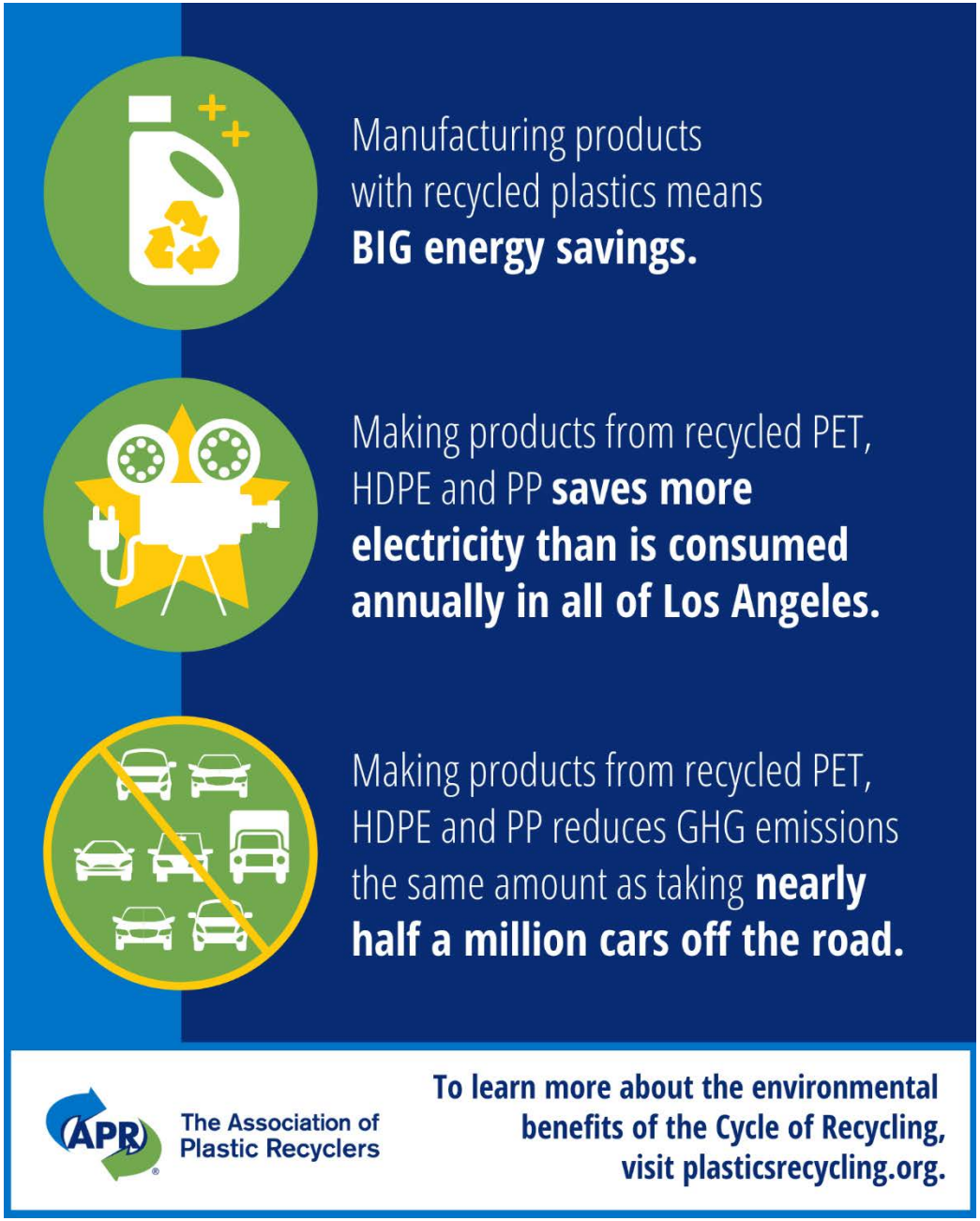
Manufacturing products with recycled plastics means **BIG energy savings.**
Making products from recycled PET, HDPE and PP **saves more electricity than is consumed annually in all of Los Angeles.**
Making products from recycled PET, HDPE and PP reduces GHG emissions the same amount as taking **nearly half a million cars off the road.**
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To learn more about the environmental benefits of the Cycle of Recycling, visit plasticsrecycling.org.

Comparisons

- For full LCA comparisons one must compare **equal functional units**.
  - Compare 16 oz. containers
  - Do not compare lbs. PET vs. lbs. glass

- Can compare old and new plastics data of same scope for **improvement**.

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Future

- Today we understand **Energy** and **Global Warming Potential** (some controversy about atmospheric lifetime of CO_2)
- We tally **Acidification** and **Smog** and **Eutrophication**, but no easy equivalences
- New impact '**critical issues**':
  - **"Water Footprint"**
  - **"Land Footprint & Habitat Destruction"**

These will be the 'new' issues for renewable materials.

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RECYCLING DOESN'T END IN THE BIN
Do your part to complete the Cycle of Recycling.
Recycle plastic products.
1
Buy products made from recycled materials.
2
Learn more at plasticsrecycling.org.
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THANKS

QUESTIONS?

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