ANAEROBIC DIGESTION: TECHNOLOGY SELECTION FOR AN ITALIAN STUDY CASE

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SUMMARY

- Introduction
- Technologies for industrial anaerobic digestion
- Objectives
- Comparison
  - Economics
  - Energy
  - Environmental
- Conclusions

INTRODUCTION

STUDY CASE:
SAN ZENO PLANT
Arezzo (IT)

INTRODUCTION

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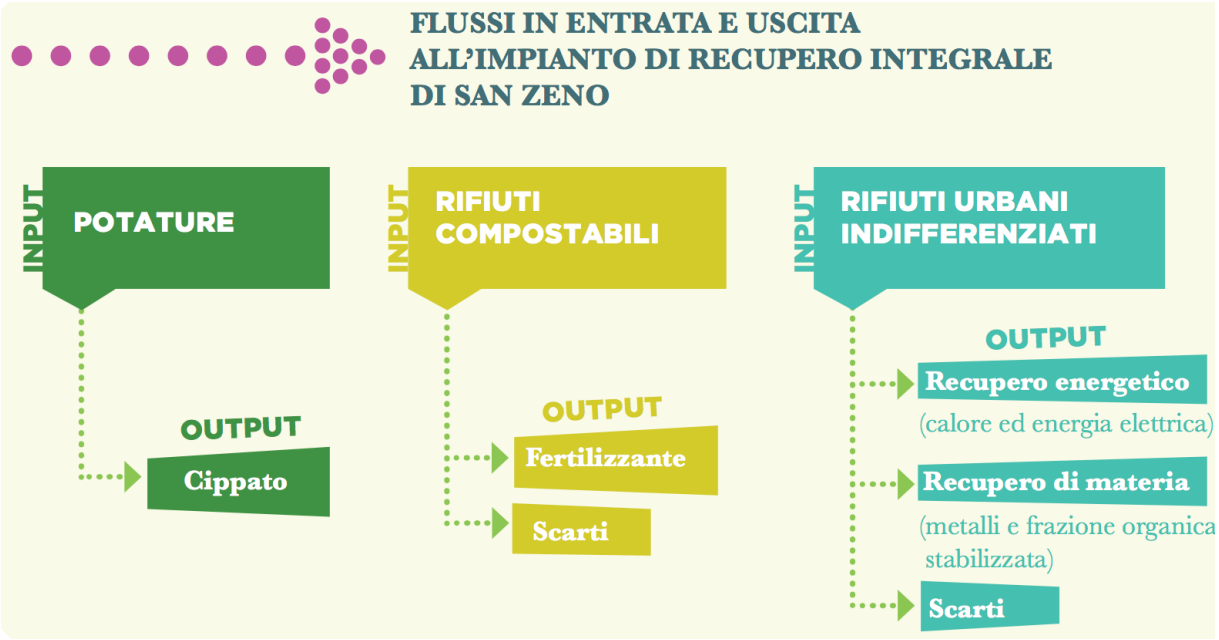
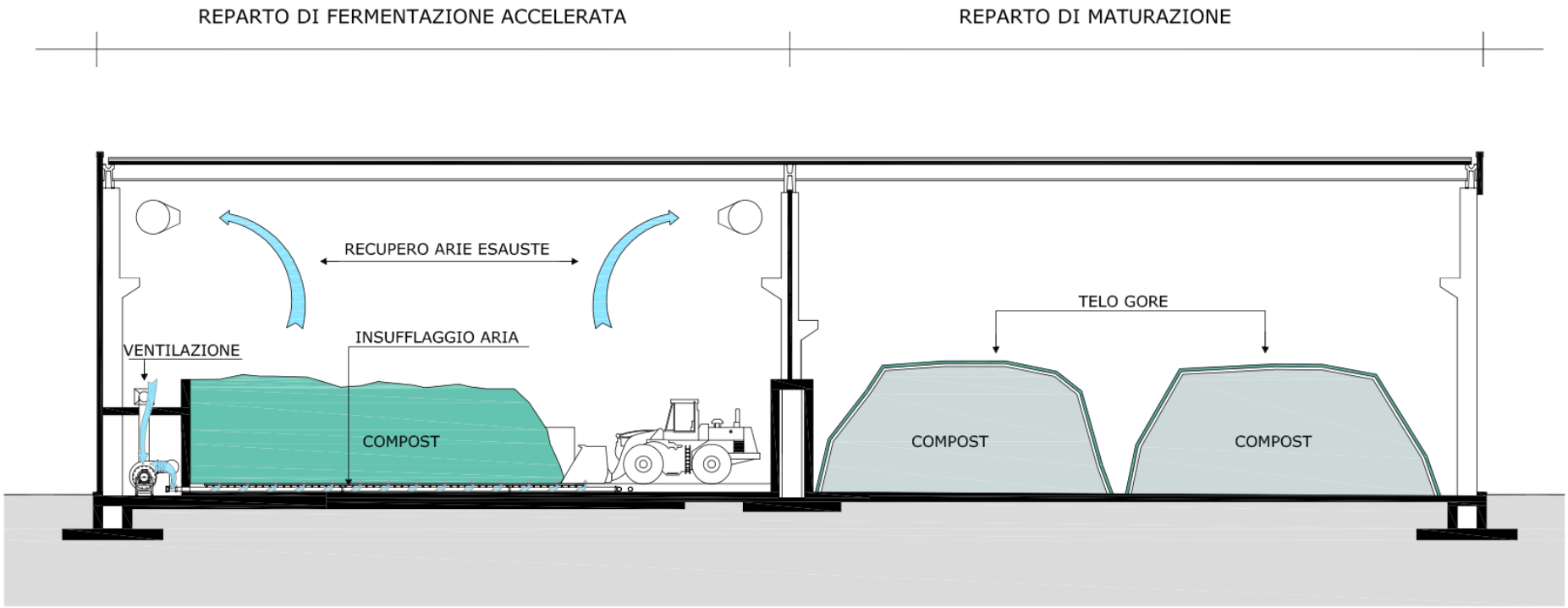
Arezzo (IT)



INTRODUCTION

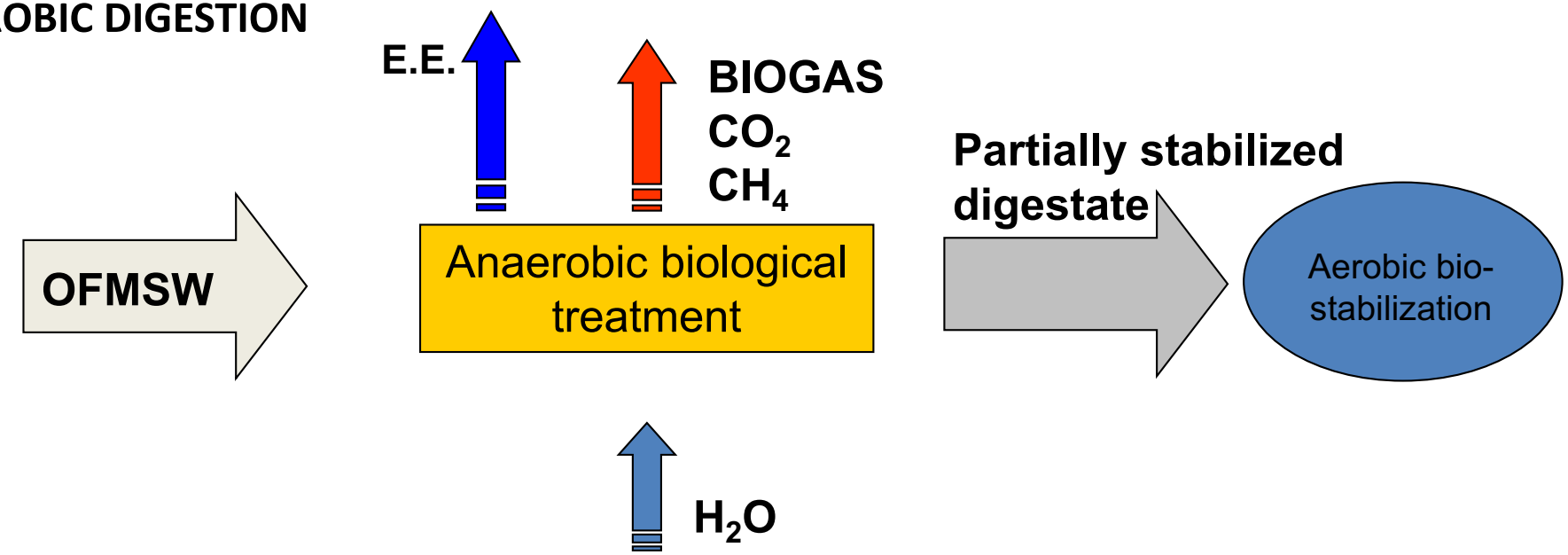


PRESENT: 23,000 t/year SS-OFMSW → composting plant

FUTURE: 35,000 t/year SS-OFMSW → ANAEROBIC DIGESTION + composting

TECHNOLOGIES

ANAEROBIC DIGESTION

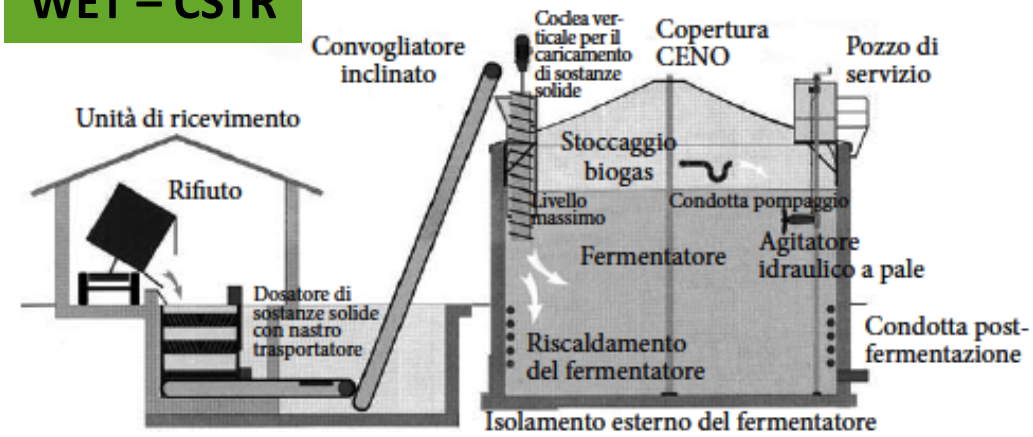


- WET AD, total solids (TS) < 10%.
- DRY AD, total solids (TS) > 20%.

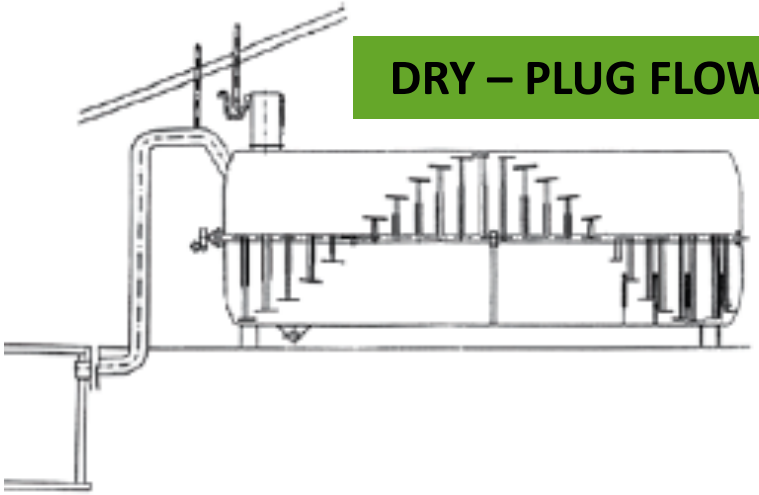
- **mesophilic** (around 37°C)
- **thermophilic** (around 55°C).

TECHNOLOGIES

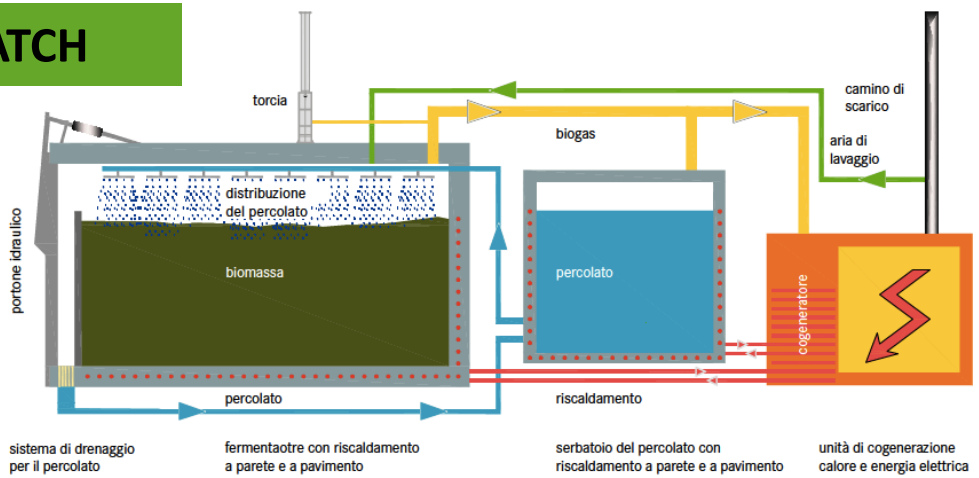
WET – CSTR



DRY – PLUG FLOW



DRY – BATCH



TECHNOLOGIES

Question	WET	DRY (batch)
Is it a consolidated technology in Italy?	yes	no
Devices are available fro a single supplier?	no	no
Is it available on the market for 35.000 t/y size?	yes	yes
Maximum input amount?	No limitation	30,000-40,000
Is it flexible, to increase the input to be processed?	yes	yes
Pre-treatment scraps?	15%-35%	0%
Does it require WWTP nearby to treat WW?	yes	no
Biogas/biomethane production	▲▲	▽ ▽
Revenues from biogas/biomethane	€€€€	€€

AISA IMPIANTI S.p.A. has large experience in MSW treatment, but no experience in wastewater treatment

TECHNOLOGIES

WET anaerobic digestion	
Advantages	**Drawbacks**
➢ Higher biogas/biomethane specific production ➢ Almost zero odours ➢ Lower volume requirements	➢ Wastewater to WWTP ➢ Higher amount of scraps to disposal ➢ More complex
DRY anaerobic digestion	
Advantages	**Drawbacks**
➢ Reactors array, higher flexibility ➢ Lower amount of scraps to disposal ➢ Lower amount of wastewater/digestate to be disposed/treated	➢ Lower biogas/biomethane specific production ➢ Maximum size is lower ➢ Odours: low but present

OBJECTIVES

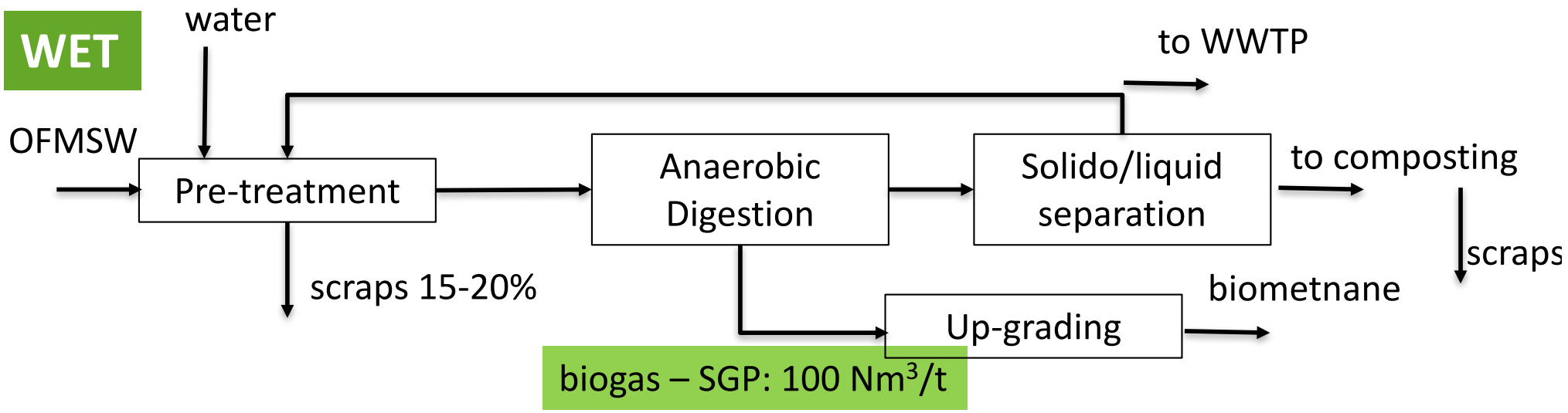
Comparison WET/DRY BATCH

- **Economic balance**
- **Energy balance (primary energy)**
- **Environmental balance (Greenhouse Gases → CO_2equivalent)**

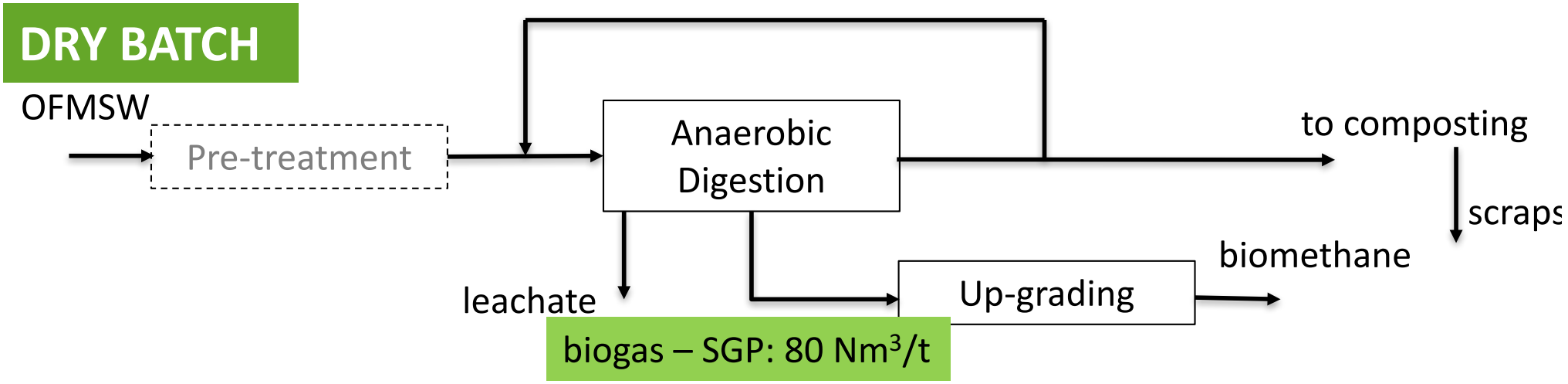
Preliminary sizing, mass balance, energy consumtpion estimations,…

COMPARISON

WET



DRY BATCH



COMPARISON

WET

INVESTMENT: 10.152.000 €

mortage	814.623 €/year

O&M costs	€/year	**Revenues**		
Staff	240.000	SS-OFMSW	35.000	t/y
Maintenance	130.100	Gate fee	70	€/t
Diesel	27.479	Gate fee revenue	2.450.000	€/year
Electricity	135.078	Biomethane	21.267	MWh/year
Disposal costs	1.102.530	Biomethane price	58,5	€/MWh
Miscellaneous expenses	526.285	Biomethane sale revenue	1.244.141	€/year
Total O&M costs	2.161.472	**Total revenues**	3.694.141	€/year

DRY BATCH

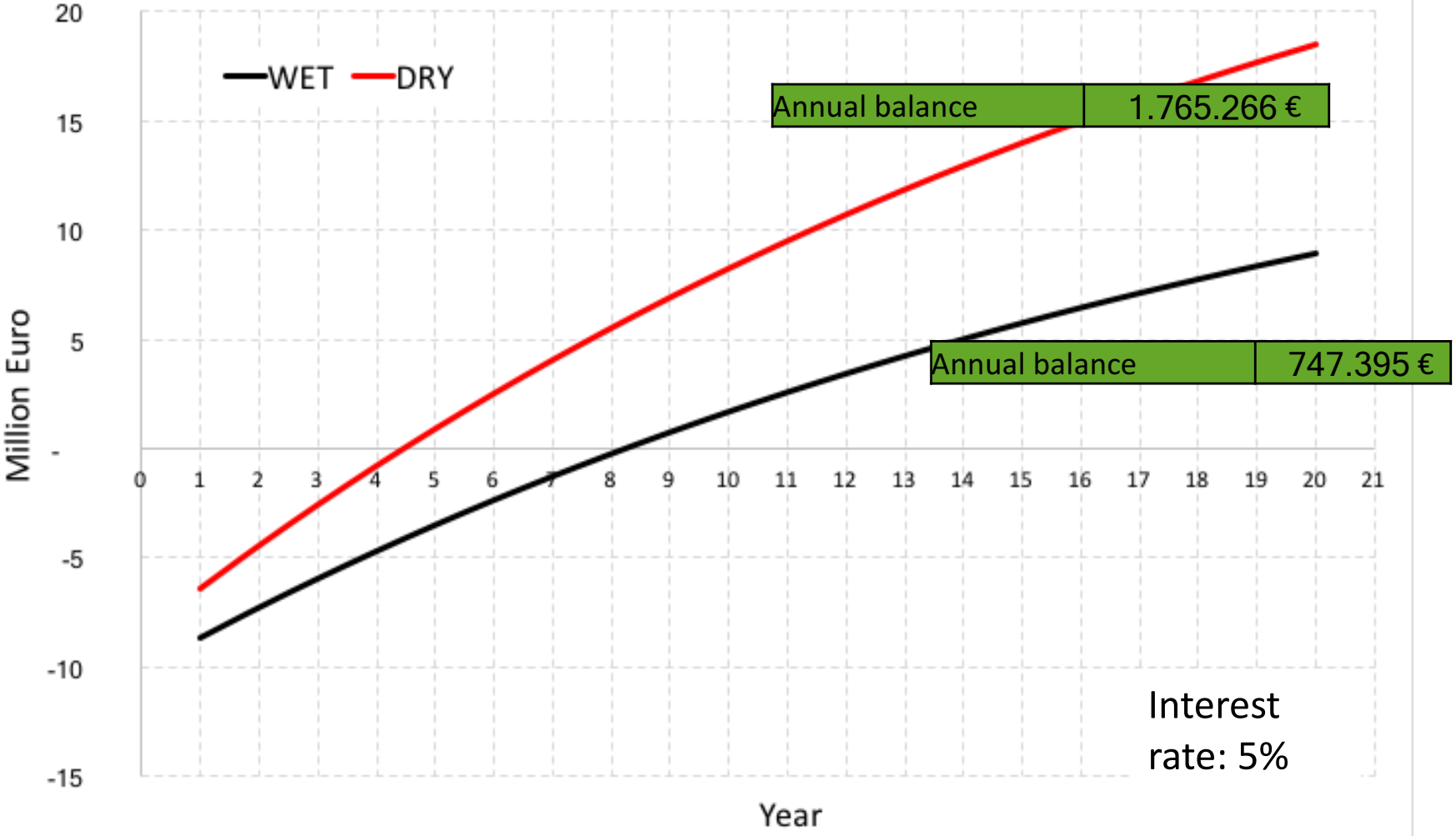
INVESTMENT: 8.429.000 €

mortage	676.365 €/year

O&M costs	€/year	Revenues		
Staff	120.000	SS-OFMSW	35.000	t/y
Maintenance	85.300	Gate fee	70	€/t
Diesel	33.306	Gate fee revenue	2.450.000	€/year
Electricity	53.212	Biomethane	17.014	MWh/year
Disposal costs	583.559	Biomethane price	58,5	€/MWh
Miscellaneous expenses	406.482	Biomethane sale revenue	995.313	€/year
Total O&M costs	1.281.859	**Totale revenues**	4.445.313	€/year

COMPARISON - ECONOMICS

Return of Investments



COMPARISON - ENERGY

		Composting	Dry AD	Wet AD	
Anaerobic Digestion					
Electricity	kWh/y	-	2.560.976	4.695.122	+83%
Diesel	kWh/y	-	276.526	276.526	
Biomethane	kWh/y	-	-16.333.333	-20.416.667	- 25%
Digestate liquid/solid separation	kWh/y	-	-	396.604	
Wastewater treatment	kWh/y	-	5.382	20.601	
Upgrading					
Electricity	kWh/y	-	1.502.439	1.878.049	
Composting					
Electricity	kWh/y	3.844.912	1.299.109	1.408.544	
Diesel	kWh/y	276.526	210.411	228.146	
Transportation to landfill					
Diesel	kWh/y	158.268	158.268	166.186	
Total Primary Energy	kWh/y	4.279.706	-10.320.222	-11.346.889	

- 10%

$$Primary\ Energy = \frac{EE}{\eta_{EE}} \qquad \eta_{EE}=0,41$$

$$TPE\ \Delta\% = \frac{TPE_{DRY} - TPEWE_T}{TPE_{DRY}}$$

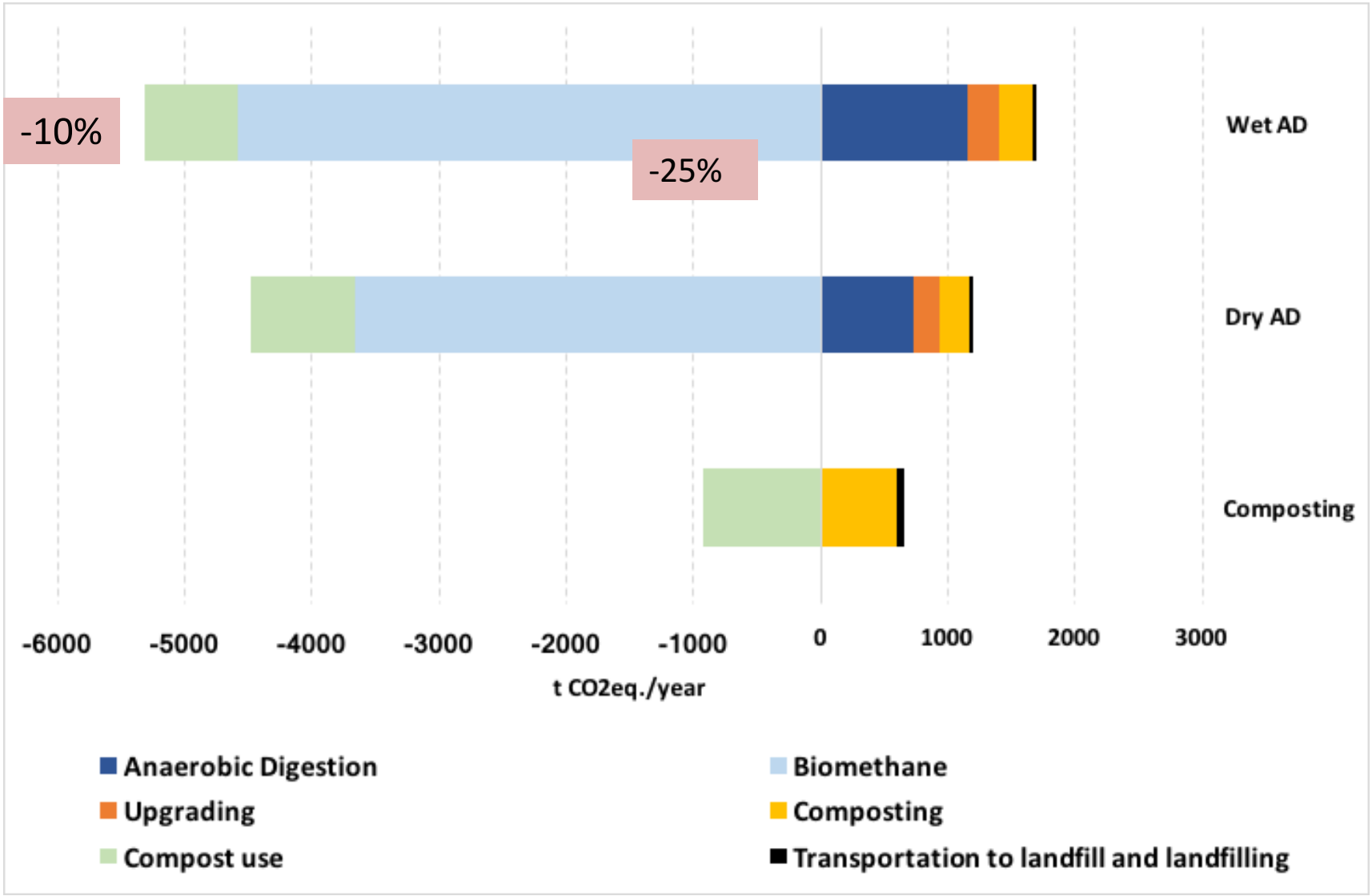
COMPARISON - ENERGY

		Composting	Dry AD	Wet AD
Anaerobic Digestion				
Electricity	%		25%	41%
Diesel	%		3%	2%
Biomethane	%		158%	180%
Digestate liquid/solid separation	%		0%	3%
Wastewater treatment	%		0%	0,2%
Upgrading				
Electricity	%		15%	17%
Composting				
Electricity	%	90%	13%	12%
Diesel	%	6%	2%	2%
Transportation to landfill				
Diesel	%	4%	2%	1%
Total Primary Energy	%	100%	100%	100%

COMPARISON – CO_2

		Composting	Dry AD	Wet AD	
Anaerobic Digestion					
Electricity	kgCO2/y	-	343.350	629.475	
CH4 losses	kgCO2/y	-	299.813	374.766	
Diesel	kgCO2/y	-	87.087	87.087	
Biomethane	kgCO2/y	-	-3.665.439	-4.581.798	-25%
Digestate liquid/solid separation	kgCO2/y	-	-	53.173	
Wastewater treatment	kgCO2/y	-	1.307	5.003	
Water consumption	kgCO2/y	-	-	5.276	
Upgrading					
Electricity	kgCO2/y	-	201.432	251.790	
Composting					
Electricity	kgCO2/y	515.487	174.172	188.843	
Diesel	kgCO2/y	87.087	66.265	71.851	
Compost use	kgCO2/y	-923.738	-818.233	-737.520	
Transportation to landfill and landfilling					
Diesel	kgCO2/y	49.844	25.897	30.328	
Waste landfilling	kgCO2/y	2.636	2.636	3.514	+33%
Total CO_2	kgCO2/y	-268.684	-3.281.715	-3.618.214	-10%

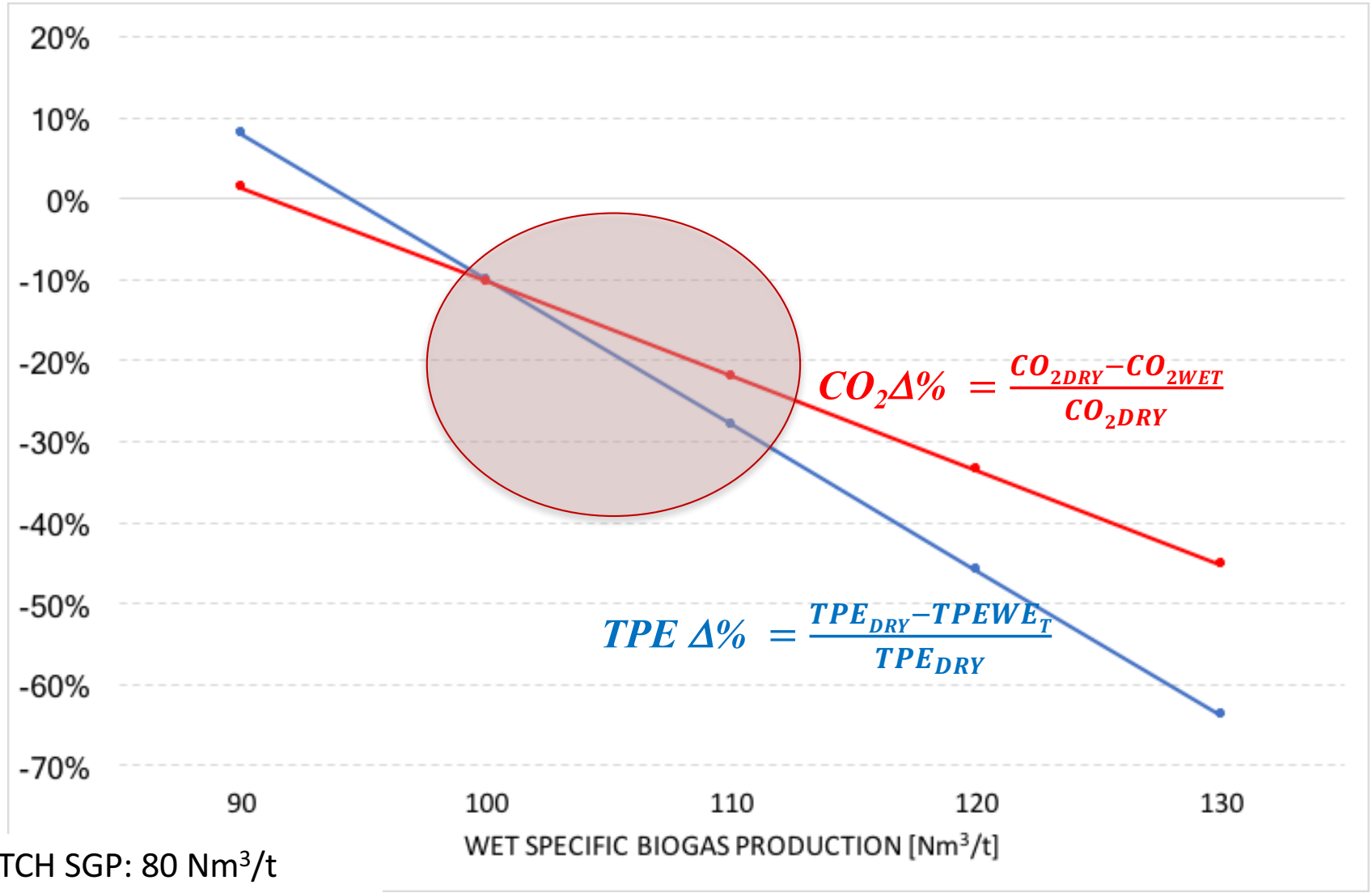
COMPARISON – CO_2



COMPARISON – CO_2

		Composting	Dry AD	Wet AD
Anaerobic Digestion				
Electricity	%		10%	17%
CH4 losses	%		9%	10%
Diesel	%		3%	2%
Biomethane	%		112%	127%
Digestate liquid/solid separation	%		0%	1%
Wastewater treatment	%		0,04%	0,1%
Water consumption	%		0%	0,1%
Upgrading				
Electricity	%		6%	7%
Composting				
Electricity	%		5%	5%
Diesel	%		2%	2%
Compost use	%		25%	20%
Transportation to landfill and landfilling				
Diesel	%		1%	1%
Waste landfilling	%		0%	0%
Total CO_2	%		100%	100%

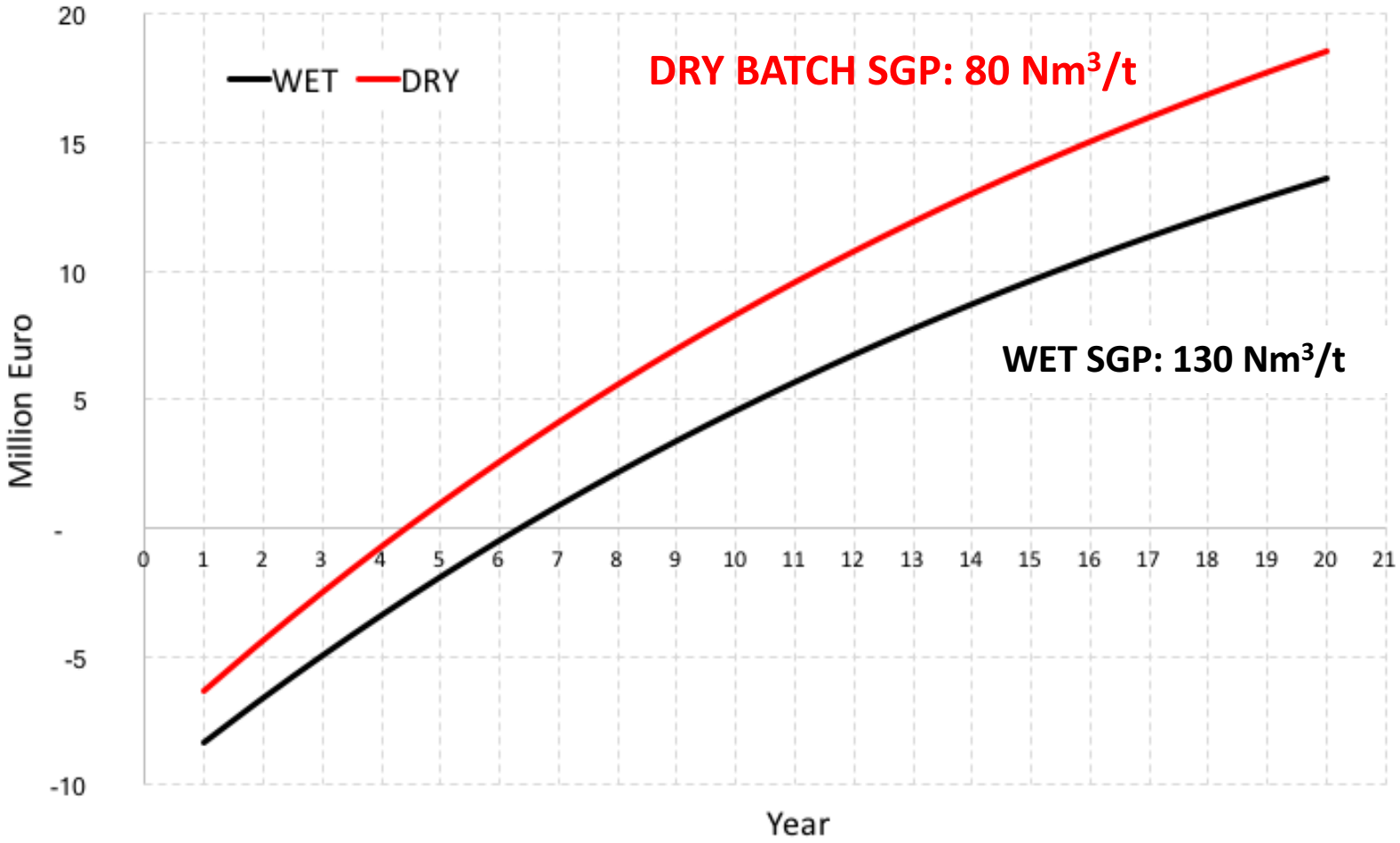
COMPARISON - SGP



DRY BATCH SGP: 80 Nm^3/t

COMPARISON - SGP

Return of Investments



CONCLUSIONS

- The best technology in absolute <u>does not exist</u>
- In the specific case of AISA IMPIANTI S.p.A.:
  - Economic balance favours the BATCH DRY case (for any SPG)
  - Energy and environmental balances are similar for low performances of wet DA (higher savings in wet of 10%); while the difference increases for improved performances of the wet AD
- The key parameter is the SPG
- Electric consumption are significant contributions
- Other processes have lower influence

THANK YOU!

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