Traveling University

Development of an Energy and Resources Master Plan for **Aguascalientes**

UT · CIDE · Universidad Autónoma de Aguascalientes · Universidad Panamericana · UPA Universidad Politécnica de Aguascalientes · Centro de Investigaciones en Optica, A.C. · Hochschule Trier Umwelt-Campus Birkenfeld · IfaS Institut für angewandtes Stoffstrommanagement · Secretaría de Medio Ambiente

Students from across the world traveling together to work on international projects€

€ with the help of organization and communication team,

Organization Team

- Organize meetings and communication
- Coordinate and arrange teams
- Prepare presentation

€ doctors to look for inefficiencies,

MFM Team

- Collect data
- Evaluate data
- Deduce potentials

€so we can look for innovative technical solutions,

Tech Team

- Design alternative solutions
- Implement new tech. options
- Show energy efficient ways

Finance Team

- Develop business plan
- Check profitability
- Conduct fundraising

We need to know the current situation of the yearly material flow, so€

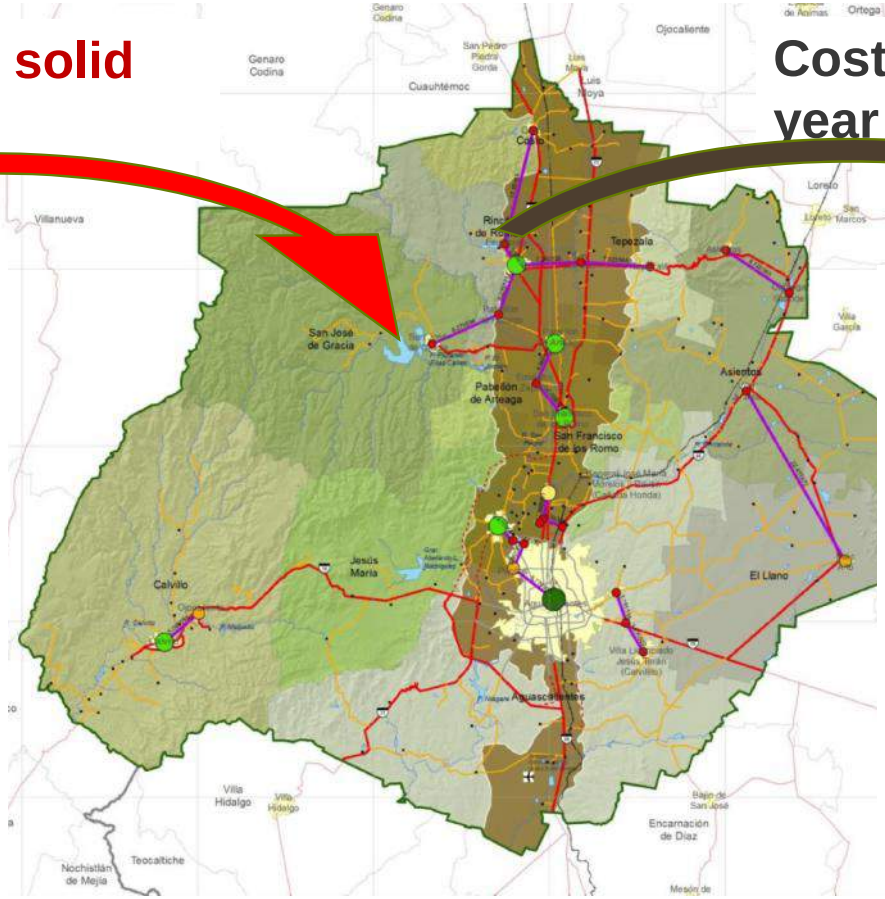
Electricity, water and solid waste in a year

Power supply:
4,872,000 MWh/a

Waste Water:
83,500,000 m^3

State Solid waste
350,000 t/a

Aquifer recovery:
315,410,250,00 m^3



Costs and aquifer deficit in a year

Electricity: 2,464,800 MWh/a
• $ 4,732,416,000

Waste Water treatment:
$ 70,140,000

Solid waste treatment:
$ 34,300,000

Aquifer: -151,000,000 m^3

to potentially improve the energy and resource efficiency in Aguascalientes.

Sun irradiation: 48.9 MWh/m²/a → **94,000 $/m²/a**

Organic Waste: 160,000 t/a → 96,000 t/a compost →**$1,316,000**

→ 4.3 MW_{el} → 37,410 MWh → **$71, 800 /a**

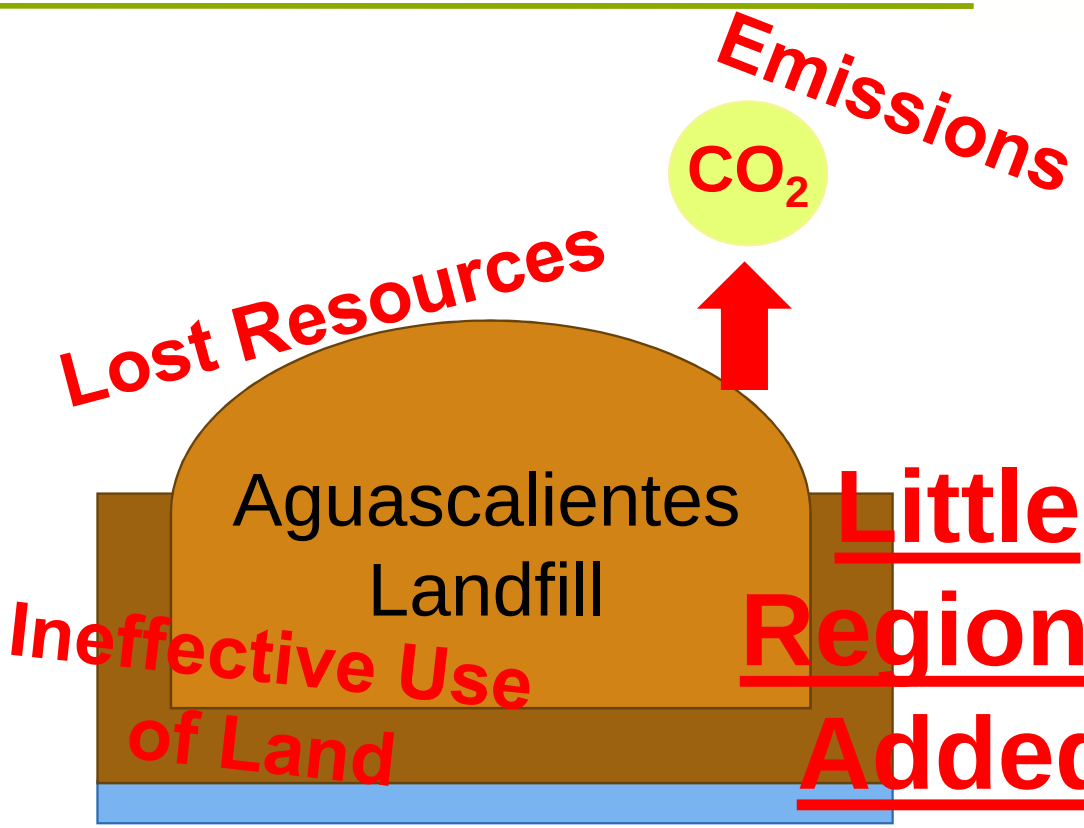
Reuse of treated water: 83,500,000 m³ → **$41,750,000 $ (in Agriculture)**

Improvement of water efficiency by 50%

Aguascalientes Waste Management & Valorization Project

Status Quo

- 1 main landfill
- 1000 tons of waste/day
- 6% recycling
- 90 pesos/ton of waste paid by municipalities to drop off waste
- 300 pesos/ton of waste paid by the private sector to drop off waste
- 98 pesos/ton of waste paid by the operator for treatment of all waste



Current Situation - Aguascalientes Landfill

Status Quo: Energ*f*aVerde de Aguascalientes

Landfill Gas

7,008,000 m€/a

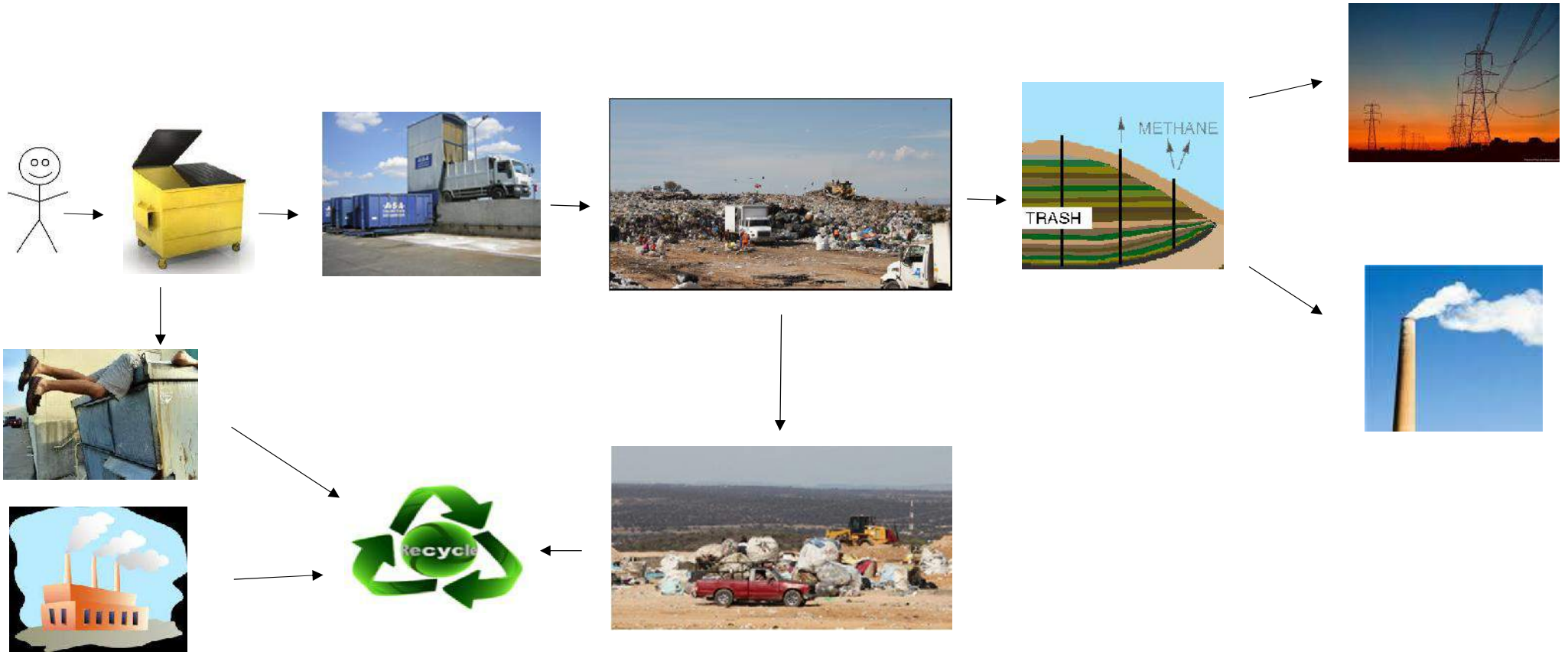
Methane Gas Capture

3,714,240 m€/a

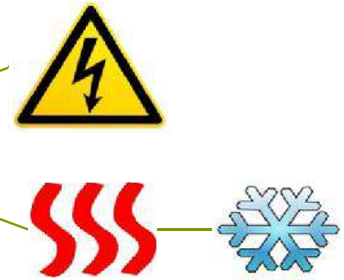
Energy to Nissan

37,142 MWh/a

Current Waste System



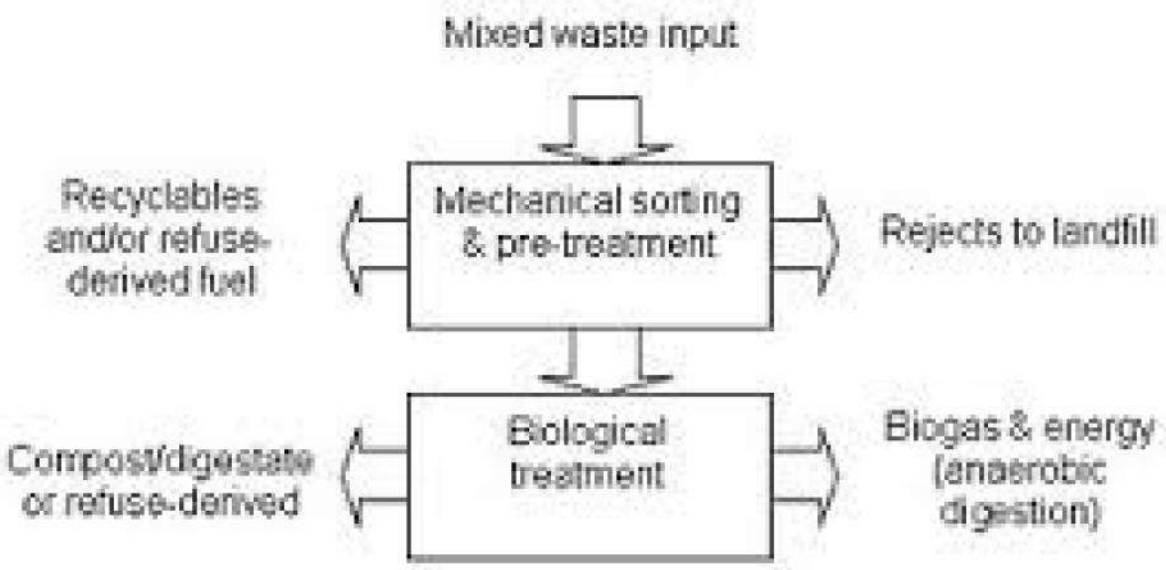
Future Waste System



PV Foil and Rain Water Collection Project

Future Waste Collection-Separation Options

Mechanical Biological Treatment



Organized Scavenger Collection & Separation

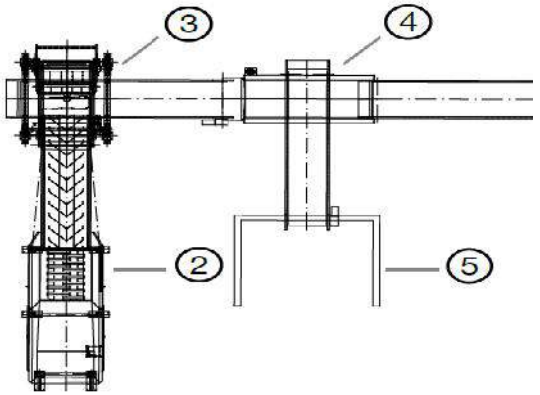
Comparison: Status Quo & Future Use of Potentials

Resource	Resource Used	Status Quo		Future Potential	
		Matter	Energy	Matter	Energy
Landfill Trash	Methane Gas	3,714,240 m³/a	37,142 MWh/a	3,714,240 m³/a	**37,142 MWh/a**
Organic Waste	Biogas	5,605,670 biogas m³/a	28,028 MWh/a	16,016,200 biogas m³/a	**80,081 MWh/a**
Paper, Plastic, Textiles	RDF	0 t/a	0 t/a	81,000 t/a	**324,000 MWh**
Paper, Plastic, Glass, Metals, Textiles	Recycling	21,900 t/a		98,221 t/a	
Organic MSW	Compost	0 t/a		96,097 t/a	

Future Potentials = Money

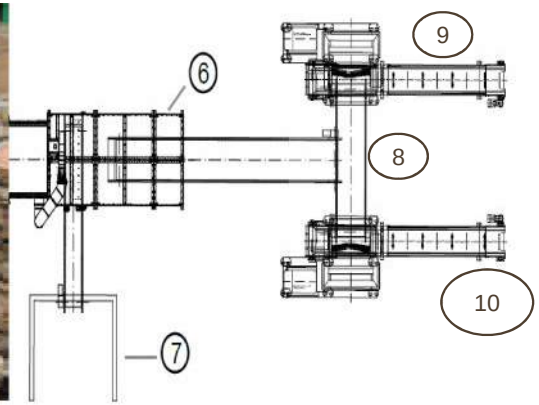
Sellable Resource	Amount of Resource	Price/unit	Income/a
Paper	35,624 tons	$920/ton	**$32,774,080**
Plastic	35,478 tons	$3000/ton	**$106,434,000**
Glass	10,402 tons	$420/ton	**$4,368,840**
Metal	6,716 tons	$3355/ton	**$22,532,180**
Compost	96,097 tons	$40/$m^3$	**$10,982,514**

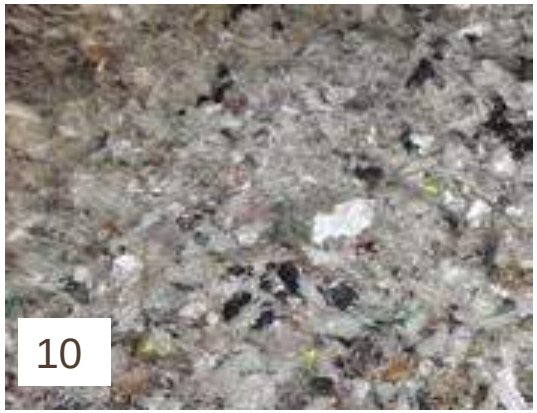
Waste to Value „ Separation/Production Process 1/2



1. Large material - sorted by hand
2. Shredder <400mm
3. Electromagnetic conveyer belt
4. Disc screen
5. Organic waste

Waste to Value „ Separation/Production Process 2/2





6. Windshifter
7. Heavy material
8. Light material
9. PET
10. RDF

81,000t RDF/a
Calorific Value 15,000 kJ/kg
Value $ 130,000,000

Photovoltaic Foil

5 cells in an area of 5 ha = 50,000 m…

→ 2,5 MWp
→ 5 GWh/a

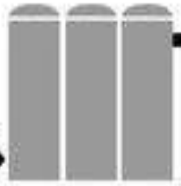
Rain Water Collection

500 mm Precipitation
→ 30,000,000 l/a

Solve the leaching problems

cold

asorption chiller



Biomethan

gas grid

gas treatment

Cogeneration

heat

Higher caloric value

Raw biogas

power

gas engine

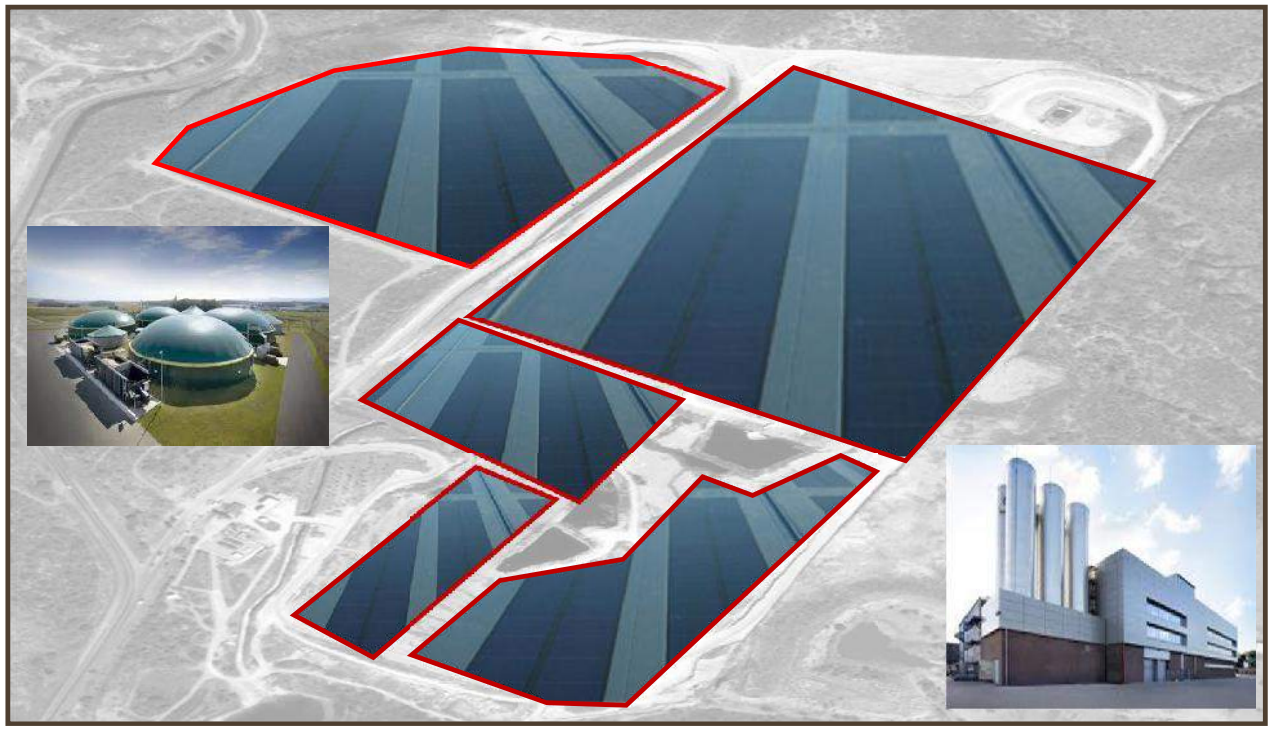
generator

power grid

pit

160,000 t/a biomass
→ 80,000 MWh/a

The Future of the Aguascalientes Landfill



, 77 new jobs
, Better working conditions
, ecofriendly
, Improved available technology
, CO_2 emission savings
→ 42,500 t/a

Sustainable

Waste Water Treatment Plants in Aguascalientes

OUTLOOK

- Status Quo (Current Situation)
- Opportunities
- Solutions

STATUS QUO

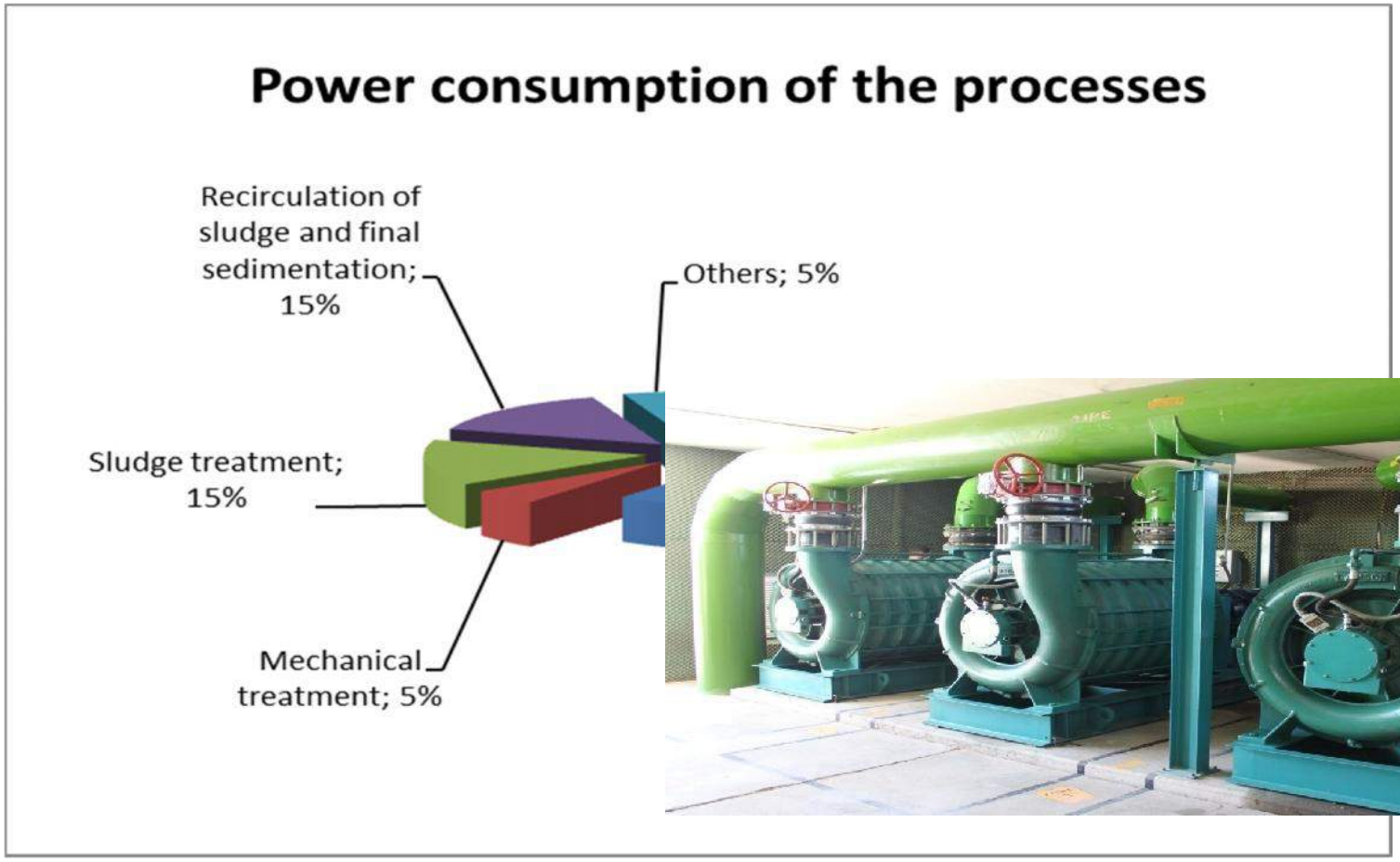
Los Arellano WWTP *2014 Averages*

2014 (Monthly)	Capacity (L/Sec)	Total Monthly Consumption ($kWh_{electric}$)	Price per kWh ($)	Total Payment ($)	Sludge Output (m^3)	Mass Load (Kg/m^3)	Mass Content (kg)	Mass Content (Tons)
AVERAGE	300	217,661	1.57	341,662.47	1800	1400	8495.4	8.4

Los Arellano WWTP *2015 Averages*

2015 Averages (Daily)	PH	Temperature ^{O}C	SST (mg/L)	COD mg/L	BOD mg/L	NH_3-N mg/L	P_{TOTAL} mg/L
INPUT	7.9	23	413	717	136	53	10.5
OUTPUT	7.4	23	9	31	4	15	1.7

Power Consumption



WWTP Daily statistics: Aguascalientes

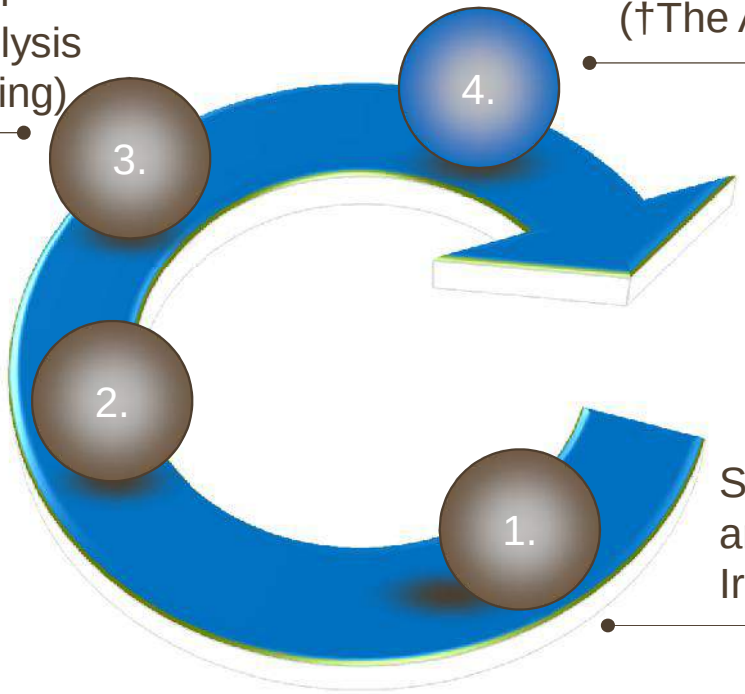
WWTP	Municipal	Plant Name	No. of Habitants Connected	Installed Capacity (l/s)	Amount of sludge generated (m^3/day)
Plant 1	Aguascalientes	La Ciudad	547000	2000	**717**
Plant 2	Aguascalientes	Los Arellano	36000	300	**47**
Plant 3	Aguascalientes	Los Pocitos	46080	100	**60**
Plant 4	Pabellón de Arteaga	Pabellón de Arteaga	22176	60	**29**
Plant 5	Rincón de Romos	Rincón de Romos	31104	90	**41**
Plant 6	Aguascalientes	Presa el Cedazo	43200	300	**57**

HOW€.

Opportunities for Improvement on WWTP

Resource Utilization
(f. e. Thermal hydrolysis
for Methane Capturing)

PV System
(†The Add-On Value‡)



Increased Efficiency
and Effectiveness of
Pumps and Engines

Sludge for Biogas Digesters
and Treated Water for
Irrigation

Total Daily Useful Energy Potential

1.

WWTP	Plant Name	Mass Content (kg/day)	Volume Tons/day	Total Ene Potenti (kWh)	Electricity Potential h electric)	Thermal Potential (kWh thermal)	Losses (kWh)
Plant 1	La Ciud				6	7,454.43	2,484.81
Plant 2	Lc						163.53
Plant 3	L						209.32
Plant 4	P						100.74
Plant 5	F						141.29
Plant 6	Presa el Cedazo	4,360.91	4.36	1,308	23.31	588.72	196.24
TOTAL		73,243.11	73.24	21,972.93	8,789.17	9,887.82	3,295.94

18,677 kWh/day

560,310 kWh/month

6,823,716 kWh/year

2.

Technical Solutions

Auto-Aeration Control Mechanism

2014	Maximum Consumption (kW)	Total Consumptio	s)	Total Payment ($)	Liters/ Second Processed	Cubic Meters Processed (M³)	Sludge Output (M³)
AVERAGE	402	217 [illegible]	697	341,662	153.25	404,253	60

30 %

152,362.7 kWh

$102,498 saving per month

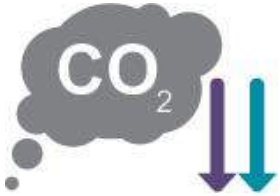
2.

Waste Water Treatment „ Impressions and possibilities

Energy saving 30-50%!

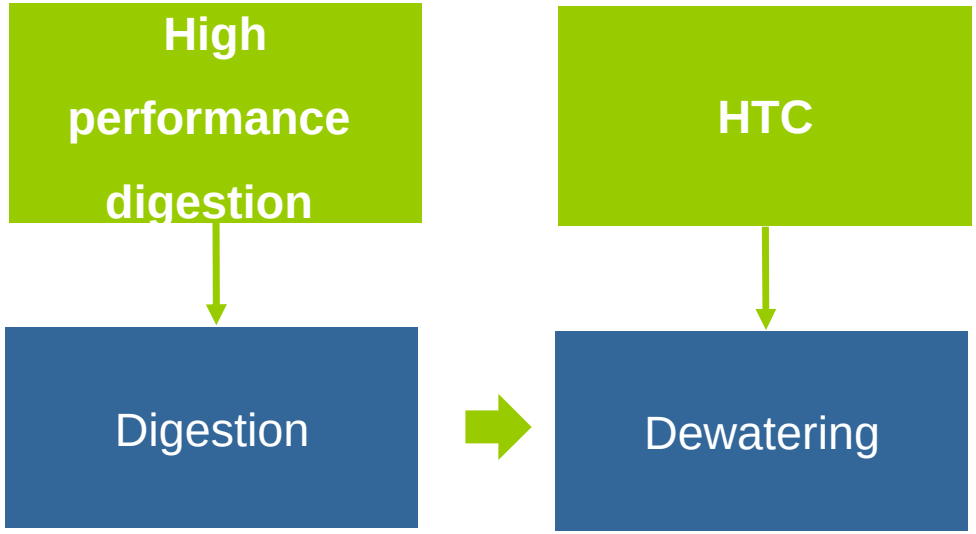
Carbon Savings

Electricity [kWh/a]	**3,208,048**
Thermal energy [kWh/a]	**3,609,054**
Electricity [CO_2 t/MWh]	0.5
CO2 Reduction [t]	**1,604**
Diesel [CO_2 t/MWh]	2.5
CO2 Reduction [t]	**9,023**
Total CO_2 Reduction [t]	**10,627**
Certificate [$/t$CO_2$]	30
Total Sales	**$ 318,810**
Tax for CO_2 emission [$/t$CO_2$]	50
Tax savings	**$ 531,350**



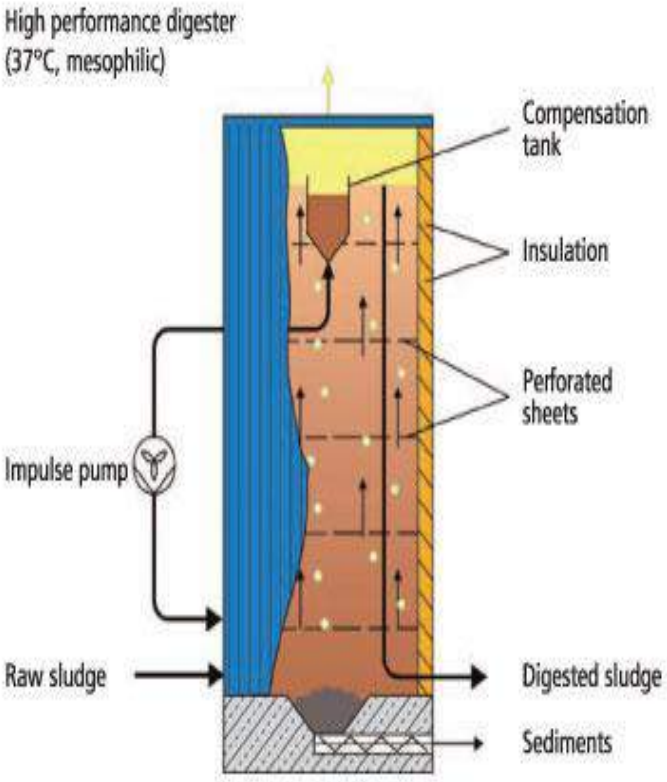
3.

Sludge Treatment Options



3.

High Performance Digester



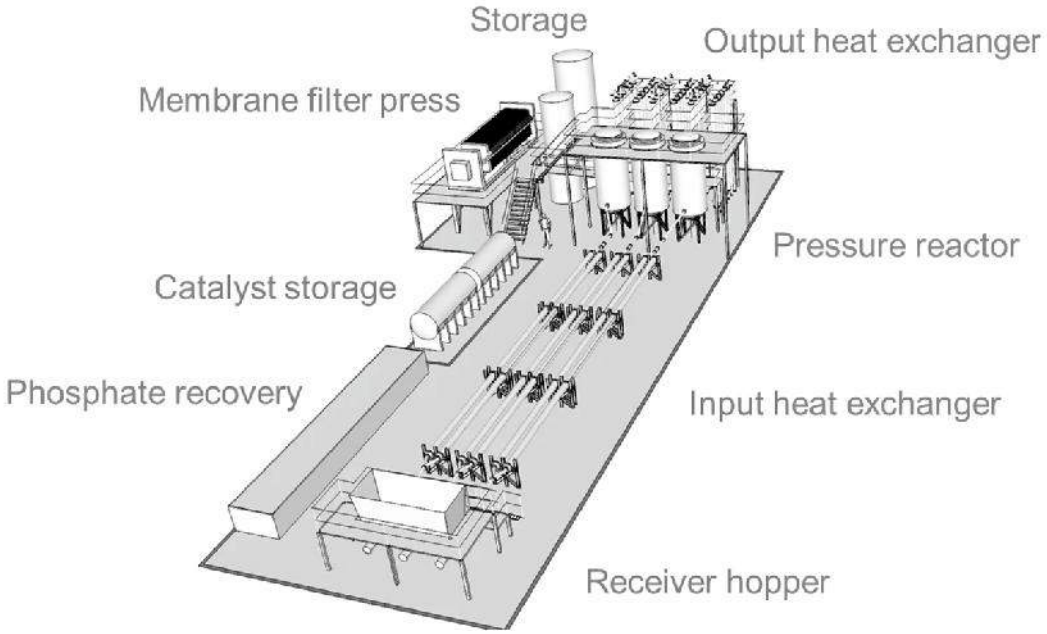
Advantages:

- High degradation rate (7 days)
- Reduced capital investment
- Low energy consumption
- Absence of surface foam problems
- Small digester size and footprint
- **Approved technology**
- **Available on the market**

3.

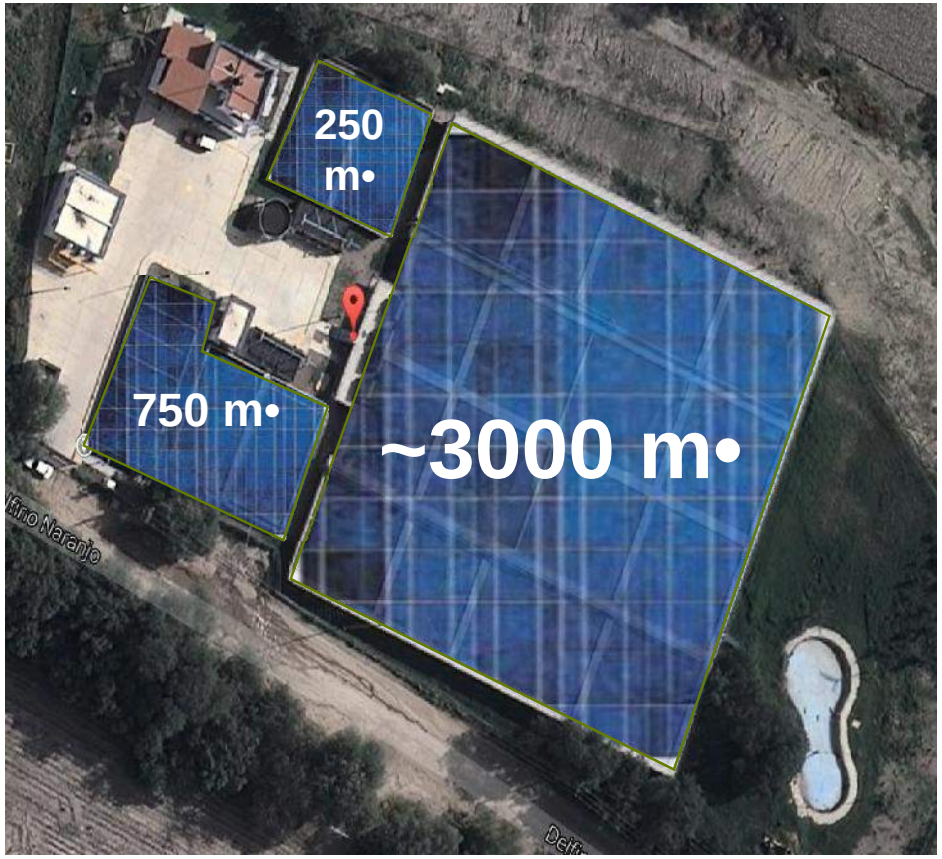
HTC - Hydro-Thermal Carbonization

- Ultra dewatering of sewage sludge to **70% dry matter content**
- Integrated **stabilization and sterilization** of sewage sludge
- **Input:**
  - 72 kWh/t sewage sludge → Heat
  - 14 kWh/t sewage sludge → Electricity
  - Sewage sludge
- **Output:**
  - HTC-Coal
  - Irrigation water



4.

PV-System „
Example Los Arellano



, 4000 m… PV

→ 500 kW_P nominal power

→**1,000,000 kWh electricity production p.a.**

With a annual consumption of 2,640,000 kWh we supply

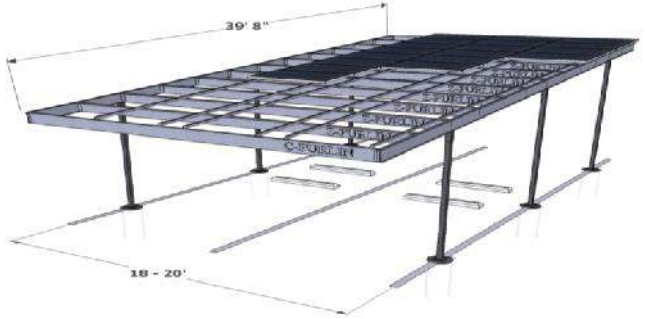
40%

of energy demand only with PV.

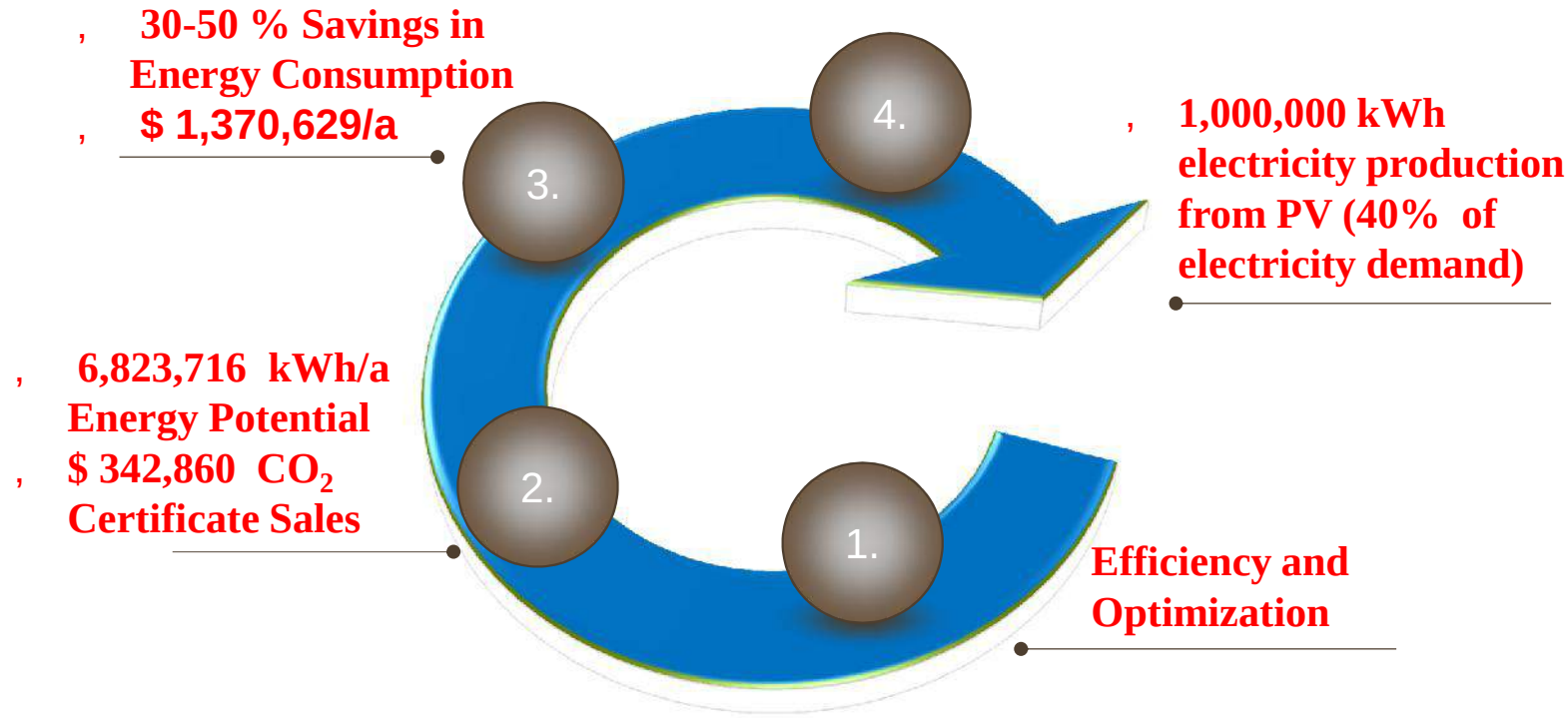
4.

PV-System „
more than just electrity

- PV cools the treatment process
- Evaporation cools the PV
- Possibility of rain water collection

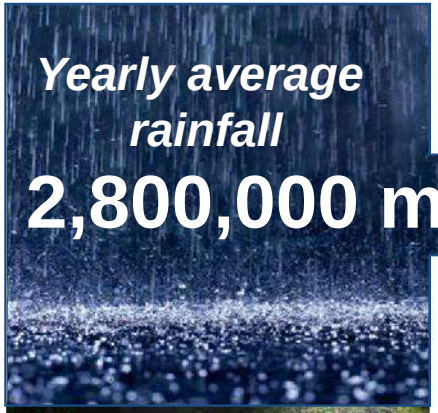


Conclusion


, 30-50 % Savings in Energy Consumption
, $ 1,370,629/a
3.
4.
, 1,000,000 kWh electricity production from PV (40% of electricity demand)
, 6,823,716 kWh/a Energy Potential
, $ 342,860 CO_2 Certificate Sales
2.
1.
Efficiency and Optimization

Water Analysis and Efficiency Solutions for Aguascalientes

Water-Flow in Aguascalientes



Evaporation

82%

Infiltration

465,000 m€

Status Quo

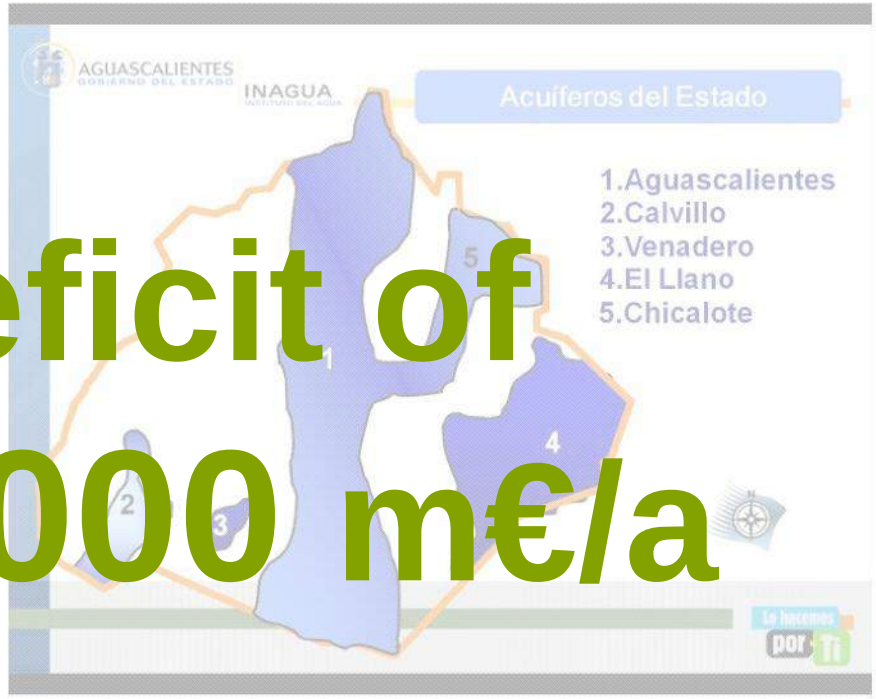
- **618 hm€** Total annual water consumption of Aguascalientes
- **487 hm€**(~80%) consumed by Agriculture
  - Mainly flow by gravity and sprinkler irrigation methods
  - **345 hm€**of the water is supplied by aquifers

Sources of water „
Aquifers in Aguascalientes

- 315 hm³ average recovery p.a.
- 466 hm³ total yearly extraction
- 345 hm³ is extracted by Agriculture

-> 75%

Total deficit of 151,000,000 m€/a



http://www.aguascalientes.gob.mx/inagua/inagua/aguas.aspx

Water concession system in Aguascalientes

CONAGUA
Comisión Nacional del Agua

- Farmer does not possess own well
- He is supplied by CONAGUA with a concession

INAGUA
INSTITUTO DEL AGUA

- Farmer owns the well
- INAGUA gives him the concession with the amount he can extract

Water concession system in Aguascalientes

Year 1

- *10,000 m€ concession*
- *- 8,000 m€ demand*
- *= 2,000 m€surplus*

Year 2

- ***The 2,000 m€ saved are taken away!***
- Only 8,000 mˆ of the concession last

- **No motivation to save water**
- **No intentions to invest**
- **No need to use and storage rainwater**

Policy Recommendation

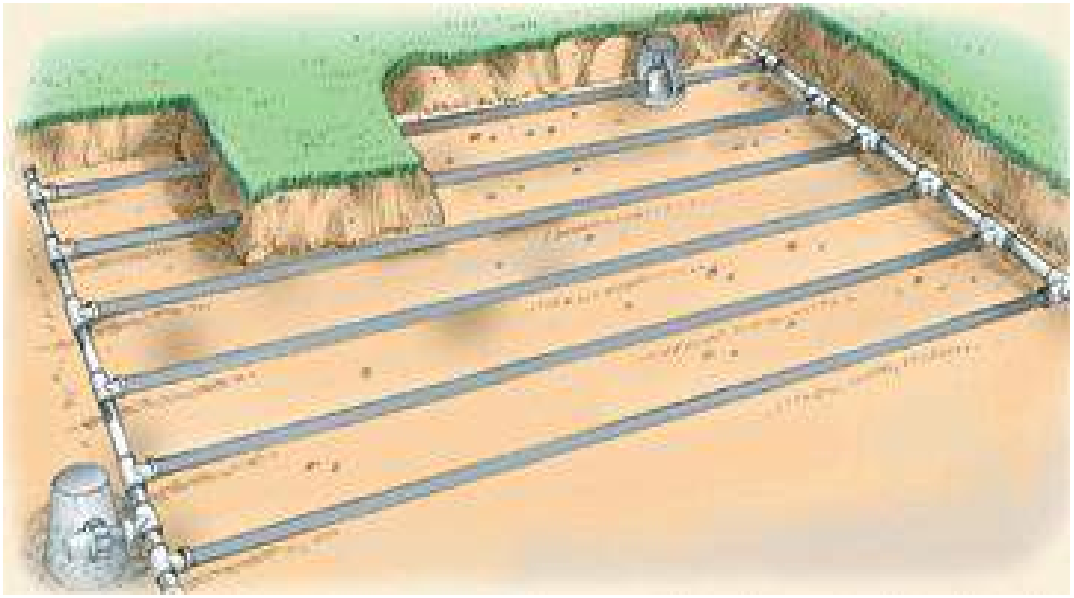
- **New incentives model**
- **Remuneration for saving water.**

Possible long-term solution:

Law reform

Efficient Irrigation: Subsurface Irrigation

Subsurface irrigation: *35% Water efficiency*



http://www.hometips.com/diy-how-to/lawn-drip-irrigation-subsurface.html

Permatube: *40% efficiency compared to subsurface*

http://www.wfs-net.de

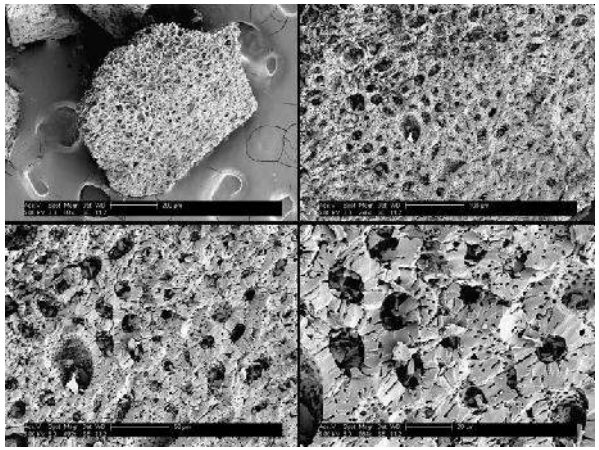
Biomass to Biochar

, Soil advantages:

- , More fertility
- , Food security
- , Cropland diversity
- , Chemical and fertilizer input reduction

Water advantages:

- Good water quality
- 20% more water absorption



~~**Water exploitation**~~

crop yield.

New sustainable landuse pattern: enhacing facility with Biochar

Eucaliptus

Huisache

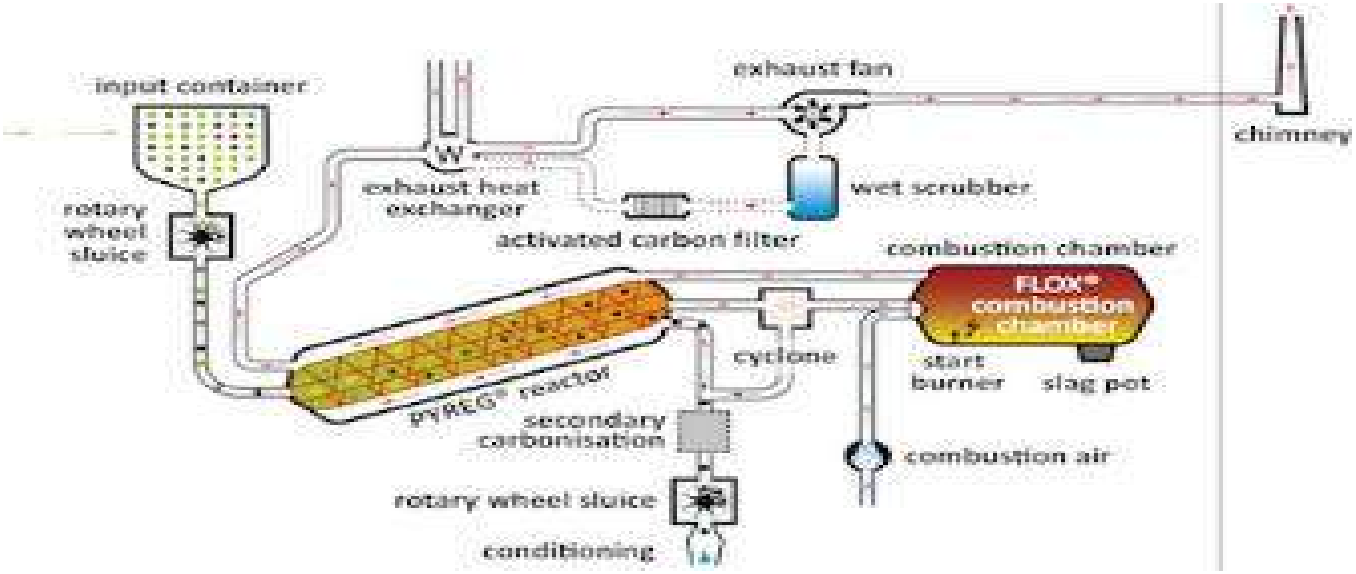
Mimosa

Source: pyreg.com

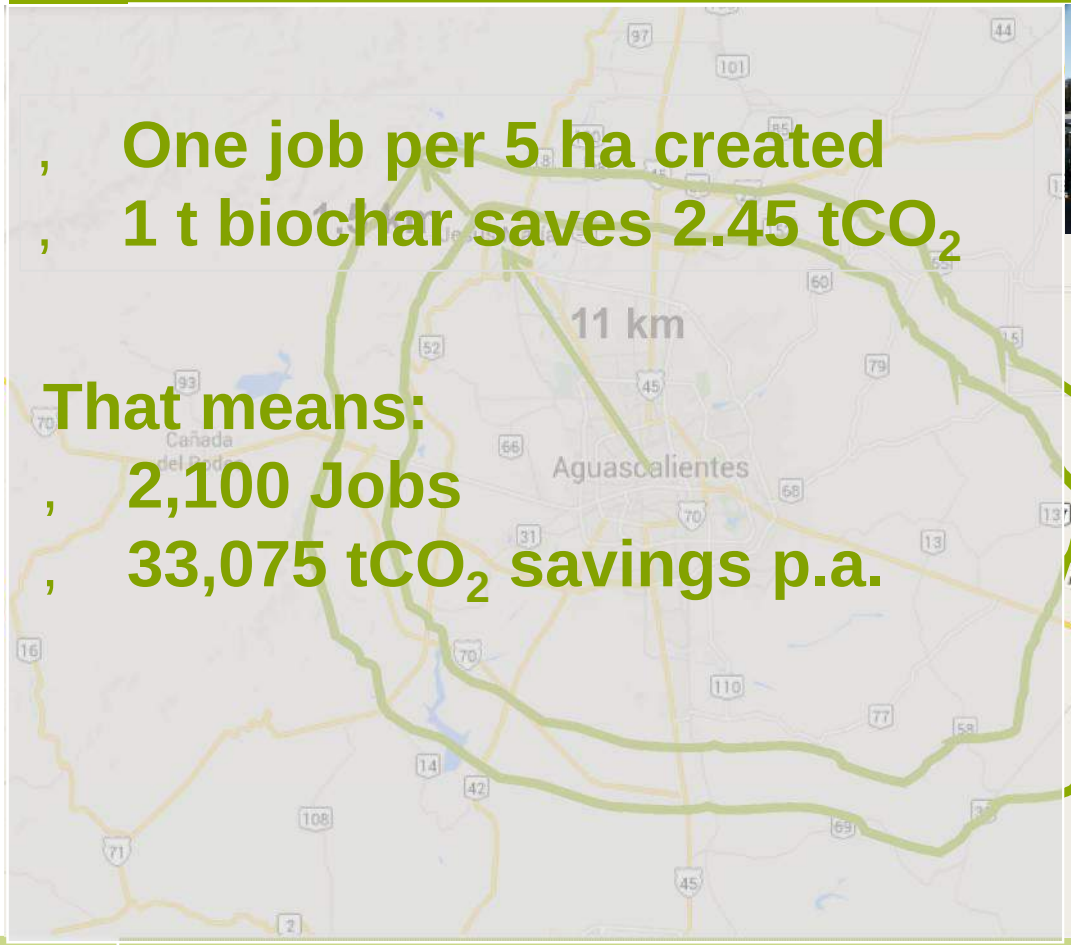
Mimosa is key to success

- Less demanding biomass
  - **Irrigation with waste water**
  - 6,000mˆ water demand p.a.
  - 8 t/ha/a yield
  - →234 ha to feed 1 Pyreg unit
  - Calorific Value: **17,7 MJ/kg**

- Input Pyreg Unit, **1200 t/a**
- Fuel requirement > **10 MJ / kg**



The sustainable fourth ring of Aguascalientes



- One job per 5 ha created
- 1 t biochar saves 2.45 tCO_2

That means:

- 2,100 Jobs
- 33,075 tCO_2 savings p.a.

Available 2,000 l/s

- 63,000,000 m€ p.a.

6,000 m€/ha p.a.

- 10,500 ha possible
- 5 t/ha dry mass

Pyreg 1,200 t/ha p.a.

- 45 Pyreg units possible

300 t biochar p.a.

- 45 Pyreg = 13,500 t/a

Conclusion

	Efficiency	total percentage	Water demand [m³/ha]	Investement [$]
Usual irrigation	0%	100%	6,000	0
Drip irrigation	35%	65%	3,900	63,210
Biochar -20% water	20%	52%	3,120	240,800

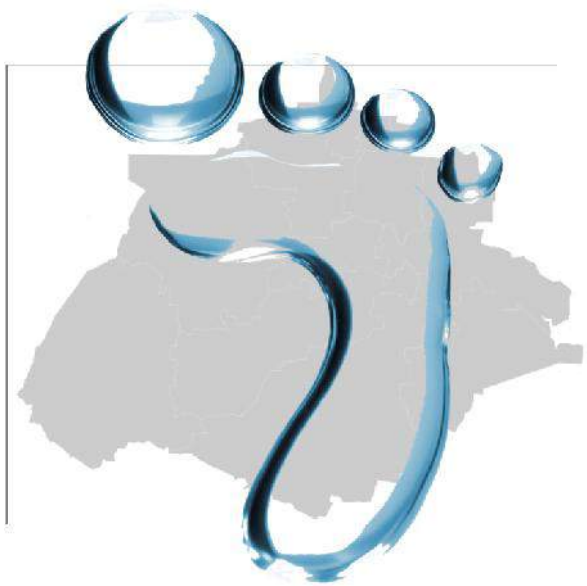
- 151,000,000mˆ deficit
- 2,880 mˆ/ha water saving

→ 52,430 ha of high efficient irrigation are enough to equalize the deficit

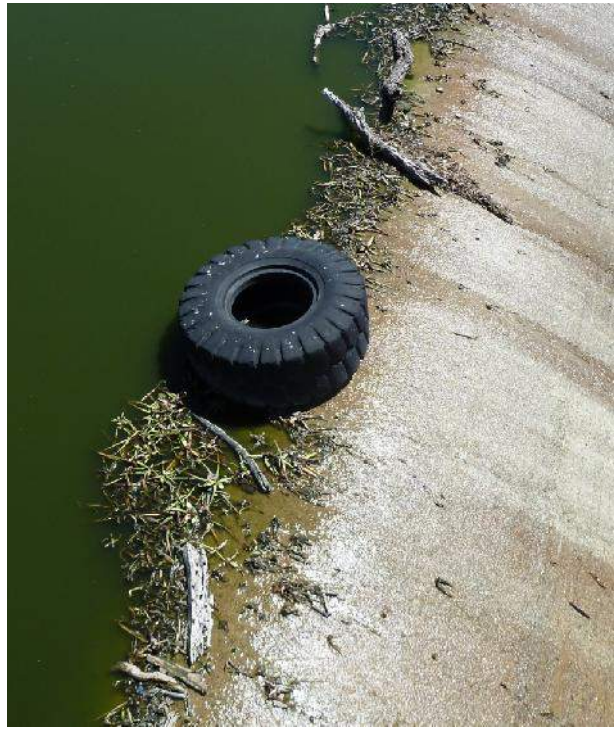
This is **31%** of Aguascalientes‰agricultural area

Conclusion

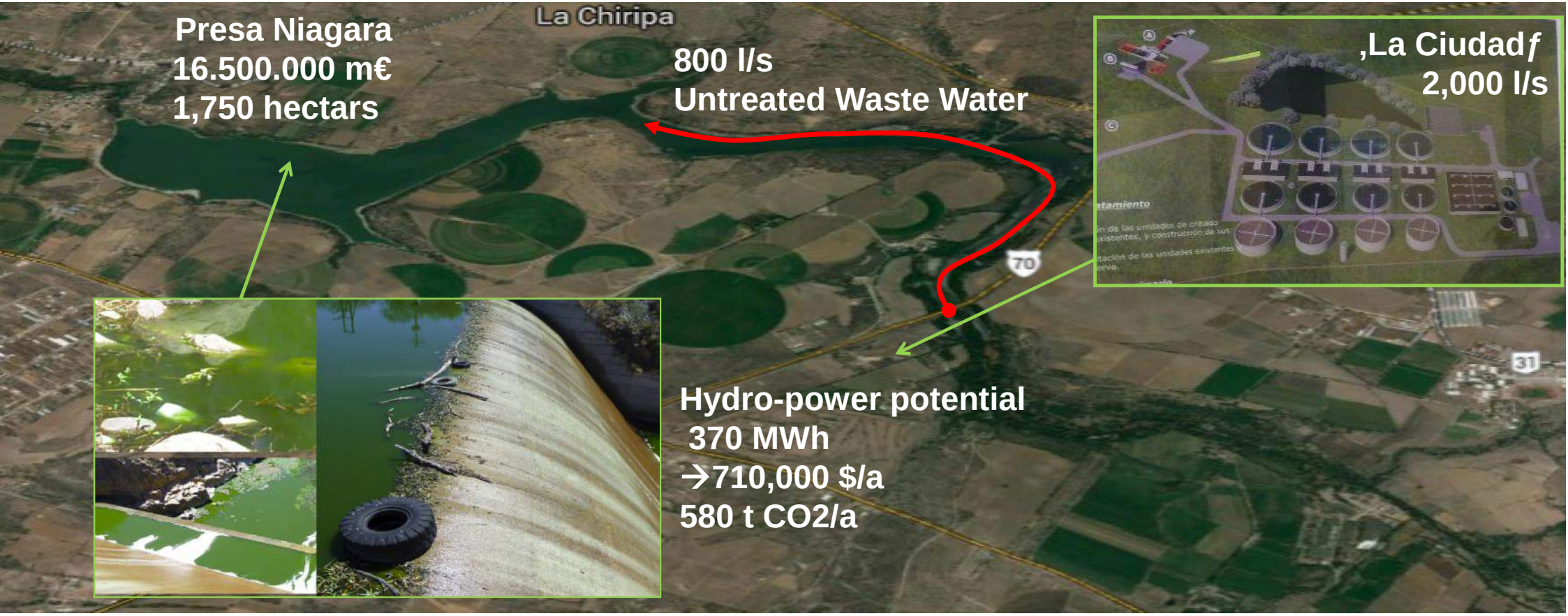
, Efficient irrigation systems to reduce the water footprint, save money and give Aguascalientes a higher regional added value.



Nutrient Mining for improving Water Quality

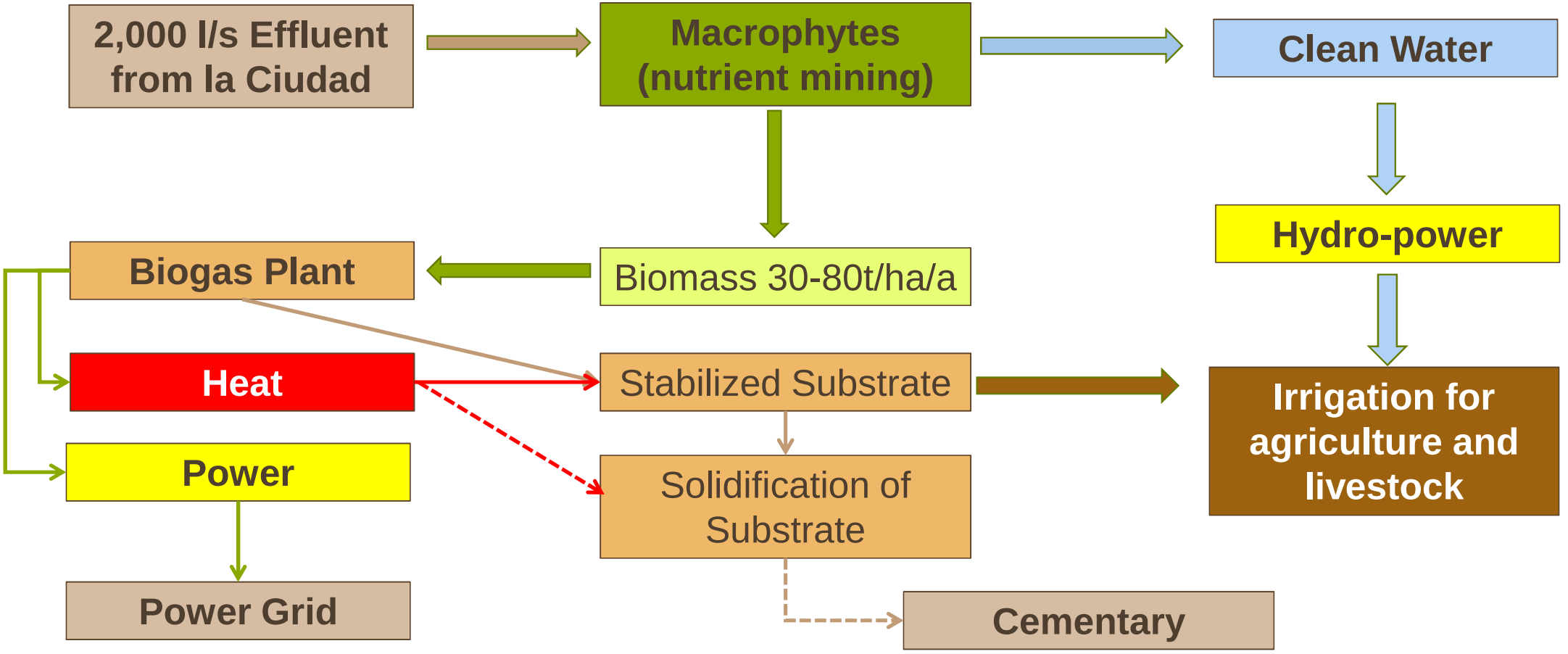


Status quo: unused water at Niagara



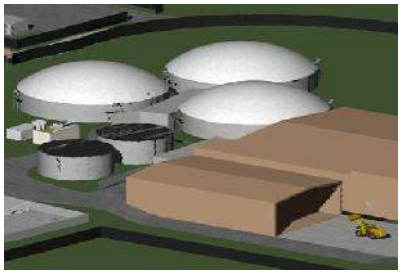
Solution: duckweed (lemna)!!

Material flow using nutrient mining



Ecological, Economic and Social Potentials






Yield potential: 1,400 hectars covered (80%) → 120,000 t/a

19,500 MWh/a electricity
23,000 MWh/a heat/cold

76,000 t/a organic fertilizer

10 new jobs (governmental tax income)

9,750 t/a reduction of CO_2 Emissions

ROLE MODEL IN E
CONSUMPTION A
APPLIC

STATUS QUO

Demand:

- **324,000 kWh/a (electricity)**
- **4,000n^3/a(water)**

Possibe energy savings

FLUORESCENT LED

ACTUAL CONSUMPTION
170,000 kWh/a

40% savings

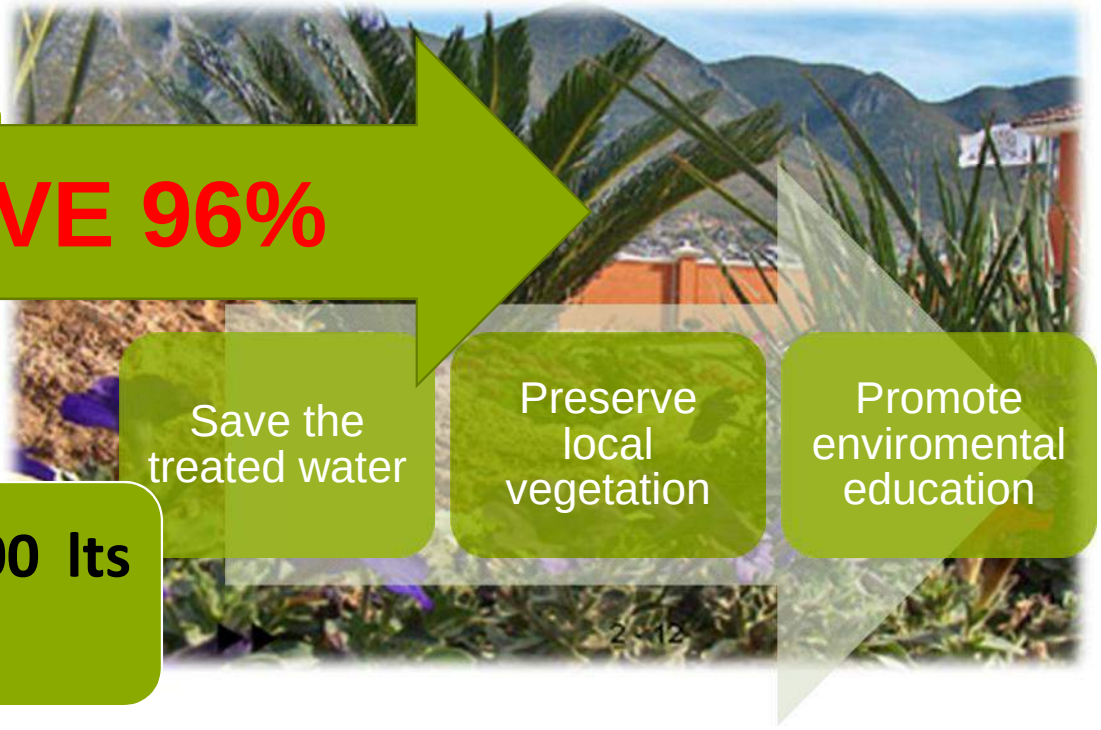
CONSUMED AFTER TECHNOLOGY UPDATE
102,000 kWh/a

Water Efficiency

Desertic Garden

Consumed treated water currently 60,800 lt per month.

SAVE 96%



- Save the treated water
- Preserve local vegetation
- Promote enviromental education

The desert garden would spend 2,600 lts of water per month.

ENERGY AND WATER CONSUMPTION AFTER SOLUTIONS ARE IMPLEMENTED

ELECTRICITY:

BEFORE ENERGY SAVINGS	AFTER ENERGY SAVINGS	SAVED
324,000 kWh/a	234,000 kWh/a	27% savings

WATER:

BEFORE WATER SAVINGS	AFTER WATER SAVINGS	SAVED
4000 m^3/a	2100 m^3/a	47% savings

PV SYSTEM TO COVER ENERGY DEMAND 100%

SELF SUFFICIENCY AT NIGHT

LET%s TALK MONEY

ACTUAL ENERGY CONSUMPTION	PRICE OF ACTUAL ENERGY CONSUMPTION	ENERGY CONSUMPTION AFTER ENERGY SAVINGS	PRICE OF ENERGY AFTER SAVINGS	INVESTMENT IN PHOTOVOLTAIC	PAYBACK PERIOD
324,000 kWh/a	**600,000** $/a	234,000kWh/a	**450,000** $/a	1.9 Million $	8 years

ACTUAL WATER COSNUMPTION	PRICE OF ACTUAL WATER CONSUMPTION	WATER COSNUMPTION AFTER SAVINGS	PRICE OF WATER AFTER SAVINGS	INVESTMENTS IN WATER CAPTURE	PAYBACK PERDIOD
4000m^3/a	**75,000** $/a	2100 m^3/a	**38,000**$/a	80, 000 $	2.1 years

ENERGY CONSUMED BY COOLING AND LIGHTING	PRICE OF ACTUAL ENERGY CONSUMPTION	ENERGY CONSUMED AFTER L&C	PRICE OF ENERGY AFTER SAVINGS	INVESTMENT IN ELECTRICITY	PAYBACK PERIOD
175,000kWh/a	, **350,000** $/a	110,000kWh/a	**220,000** $/a	185,000 $	1.5 years

Finance

Finance - Approach

- Financial statement to measure operating performance and profitability
- Components:
  - Profit and Loss Account
  - Cash Flow Statement
  - Key Performance Indicators

  → Annual review

Finance - Photovoltaics

	Terms	Landfill (values)	Waste water (values)
Key figures	Total investment [$]	65,000,000	17,100,000
	Installed capacity [kWp]	2,500	500
	Total produced electricity [kWh]	95,400,000	19,000,000
	Total CO_2 emissions saved [t]	48,000	9,500
KPIs	LCOE [$/kWh]	1.27	1.20
	IRR [%]	13	13.8
	PBP [a]	8	9
	NPV [$]	26,000,000	8,500,000

Finance - Biogas

	Terms	Landfill (values)	Anaerobic sludge stabilization (values)
Key figures	Total investment [$]	186,000,000	37,820,000
	Total electricity potential [kWh/a]	17,300,000	3,200,000
	Total heat/ cold potential [kWh/a]	5,420,000	3,600,000
	Total CO_2 emissions saved [t]	8,650	10,627
KPIs	LCOE [$/kWh]	1.3	1.3
	IRR [%]	9,66	8.5
	PBP [a]	14	11
	NPV [$]	47,880,000	13,000,000

Finance - Separation sytstem

	Terms	Separation (values)
K.F.	Total investment [$]	625,000,000
	Revenue [a]	113,000,000
KPIs	IRR [%]	8
	PBP [a]	10
	NPV [$]	25,000,000

Finance - Nutrient mining

	Terms	Nutrient mining (values)
Key figures	Total investment [$]	233,063,424
	Gas production [mˆ qas_{eq}]	6,160,000
	Total electricity yield [MWh]	19,500
	Total heat/ cold potential [MWh]	23,000
	Total CO_2 emissions reduction [t]	9,750
KPIs	IRR [%]	8.08
	PBP [a]	16
	NPV [$]	71,923,113

Finance - Water efficiency*

*assumption: 1kWh = 1m³

	Terms	Energy used [kWh]	Cost of energy: Farmer [$]	Cost of energy: Government [$]	Cost of energy: Total [$]
Key figures	Energy [$/kWh]	1	0.5	1.29	1.79
	Without drip irrigation and biochar	6,000	3,000	7,740	10,740
	With drip irrigation and biochar	3,120	1,560	4024	5584
	Yield increase p.a. [%; $]	20; 11,000			4544
	Irrigation subsidies [$/a]	7,500			
	Total income for investment $23,044 p.a.				
	Total investment $ 286.000				
KPIs	NPV [$]				2,664
	PBP [a]				20
	IRR [%]				4.12

Finance - Pyreg

Terms		Pyreg
Key figures	Initial investment [$]	6,840,000
	Saved CO_2 absorption [t]	14,440
	Market price [$/t]	5570
KPIs	IRR [%]	7.8
	PBP [a]	14
	NPV [$]	2,565,000

Total Financial Conclusion

Plant	Investment	NPV [$]	MWh/a $_{el}$	MWh/a$_{th}$	Total t CO_2 /a	Saved water m€/a	Jobs Created
Resource Center	251,000,000	53,800,000	37,000	44,000	42,500	33000	77
Waste Water	876,000,000	21,500,000	4,200	3,600	10,650	4,833,000	7
Agriculture [ha]	286,000	2,664	n.A	n.A.	n.A.	**2,880**	2100
Pyreg	2,600,000	180,000	n.A	n.A	3,600	n.A	250
Nutrient Water	233,000,000	72,000,000	19,500	23,000	9,750	n.A.	>10
CIDE	2,165,000	n.A	0.265	n.A	162	1,900	2
LED street	78,420,000	42,100,000	5,085	n.A.	4,000	n.A.	3
Total	1,444,000,000	189,580,000	66,050	70,600	70,662	4,870,000	2,550

Traveling University

Thank You for your Attention

Aguascalientes

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