OPTIMIZATION OF POWER GENERATION AND ENERGY EFFICIENCY (OGE&EE)

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NAMA Market Place
LAC Carbon Forum
28-30 September 2016
Panama City, Panama

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

INDC of Ecuador

Unconditioned Contribution

The Ecuador is committed to reduce between 20.4% to 25% of its GHG emissions by the year 2025.
(Uncertainty 10%)

NAMA – Hydropower Development

- Operation 8 hydroelectric projects by 2017 (2.827 MW installed capacity)

NAMA – Program of Efficient Cooking

- Replacement of 1’500.000 gas cookers for induction cookers

NAMA – Optimization of Power Generation and Energy Efficiency

- Partial implementation of OGE&EE Program (Petroamazonas flaring dimishing)

Conditioned Contribution

The Ecuador is committed to reduce between 37.5% to 45.8% of their GHG emission by the year 2025.
(Uncertainty 10%)

- Implementation of all the Master Plan Electrification more than 39 hydroelectric projects (7.661 MW installed capacity)
- 4'300.000 replacement of gas cookers for induction cookers
- Full implementation of OGE&EE
- Optimization of the transport sector

NAMA OGE&EE
Background: Oil & Gas Value Chain Management

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

Ministerio del Ambiente

Hydrocarbons Secretary (SHE)

Ensures the subscription of contracts and correct execution of their activities

Hydrocarbon Agency for Regulation and Control (ARCH)

Regulates, controls and supervises

Value Chain





Exploration → **Production** → **Transportation** → **Refining** → **Marketing & Commerce**

Upstream | **Midstream** | **Downstream**

- **State Owned Companies:**

PETROAMAZONAS EP

NON PROFIT COMPANY (!)

- **Private Companies**

EP PETROECUADOR

- **Trans-Ecuadorian Oil Pipeline system (SOTE)**
- **Private Companies**

Client & supplier and/or receiver loads from/of

Flopec
EMPRESA PÚBLICA FLOTA PETROLERA ECUAT

State Owed Oil Fleet Company

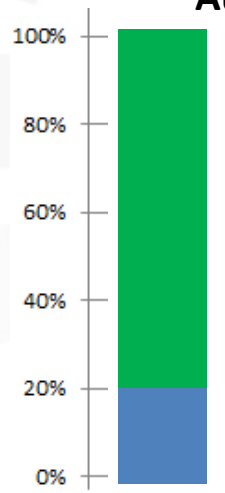
NAMA OGE&EE
Petroamazonas EP: Budget and Finance

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

Ministerio del Ambiente

Audited Oil Production

Total= 559,434.72 barrels



PETROAMAZONAS EP

Private Companies

OIL

Exports

PETROECUADOR

Refining

EXPORT OF REFINED PRODUCTS

DOMESTIC MARKET SUPPLY

Central Bank of Ecuador

State Banking Accounts

Ministry of Finance

State Budget

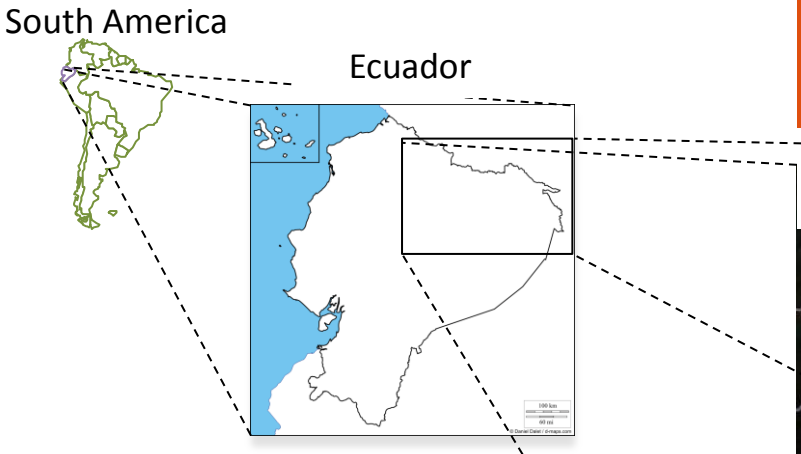
Annually it distributes the approved budget

Part goes to

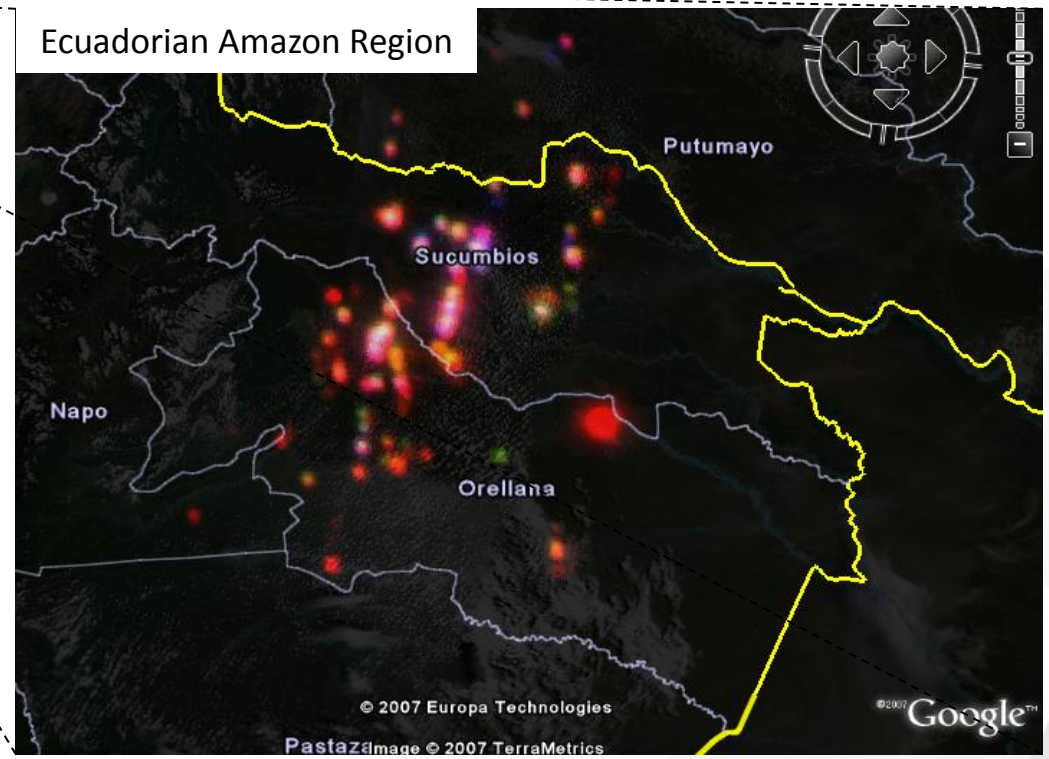
State Oil Owned Companies

- Upstream → PETROAMAZONAS EP
- Down and Midstream → PETROECUADOR
- Shipping → Flopec

NAMA OGE&EE
Sector Context: Baseline



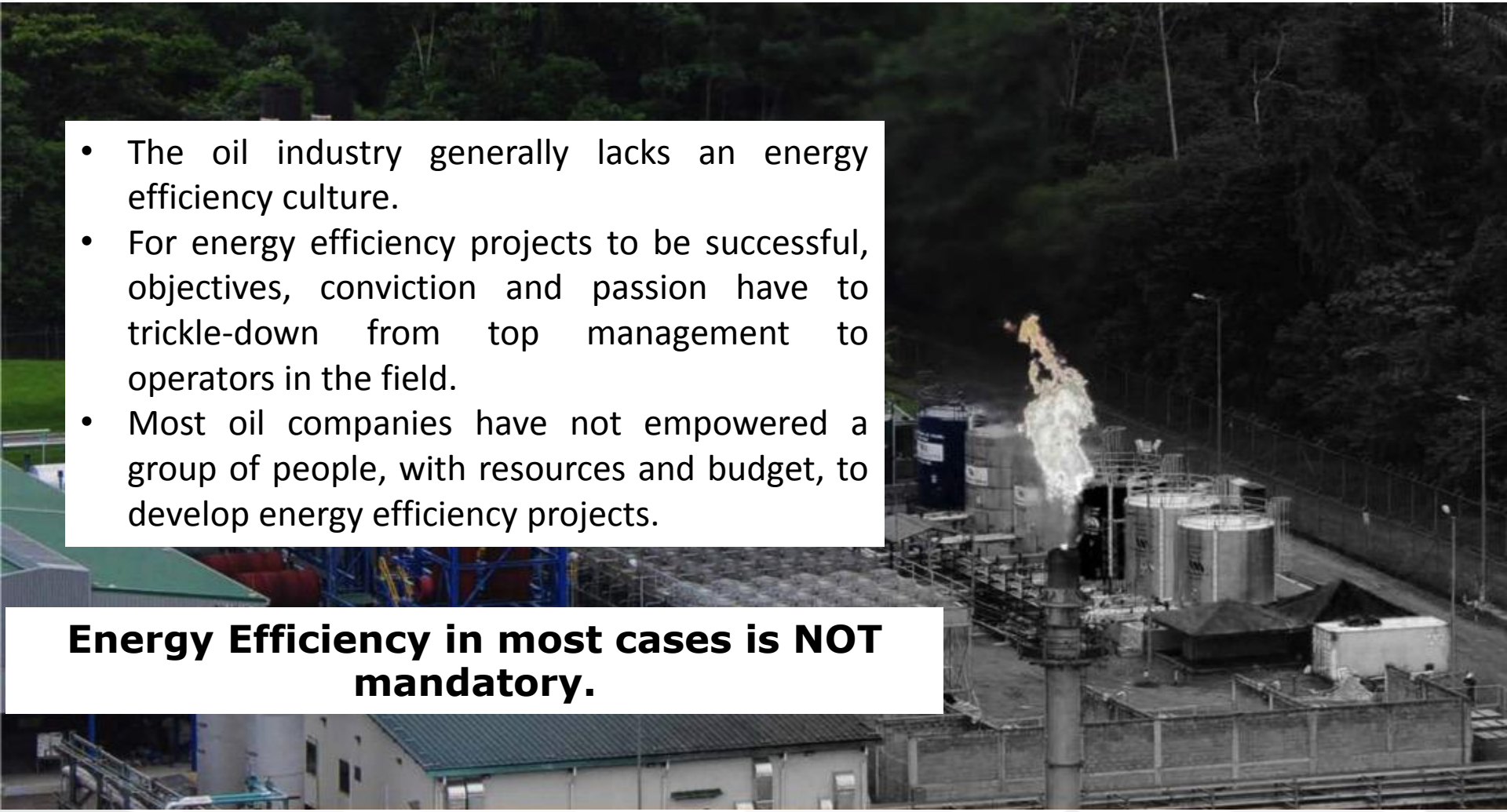
The existing Business Environment in the oil industry (still) shows high levels of gas flaring in the Ecuadorian Amazon Region



KEY INDICATORS

- Only 15 MW of additional gas / crude power generation facilities was developed, which represents no more than 4.4% of the total power demand in the year 2023 (by means of the OGE&EE Program the State is developing over 300 MW).
- Over 100 million cubic feet of associated gas were burned per day whereby its value in BOE represents over USD 14 billion.
- Overall utilization factor in the range of 30-35% which means that for every 1 MW power demand it had to install ~3 MW (by means of the OGE&EE Program the overall utilization factor will increase to > 70%).

NAMA OGE&EE
Common Practice / Organizational Behavior



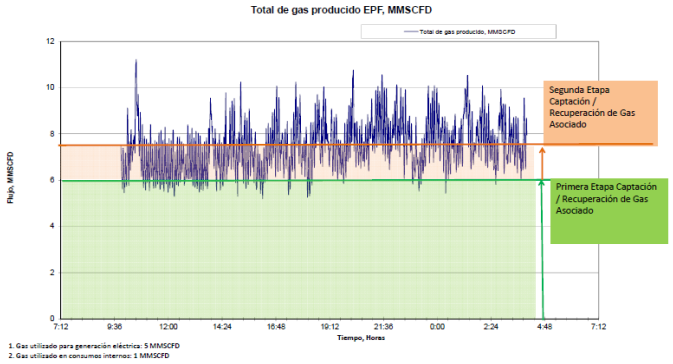
- The oil industry generally lacks an energy efficiency culture.
- For energy efficiency projects to be successful, objectives, conviction and passion have to trickle-down from top management to operators in the field.
- Most oil companies have not empowered a group of people, with resources and budget, to develop energy efficiency projects.

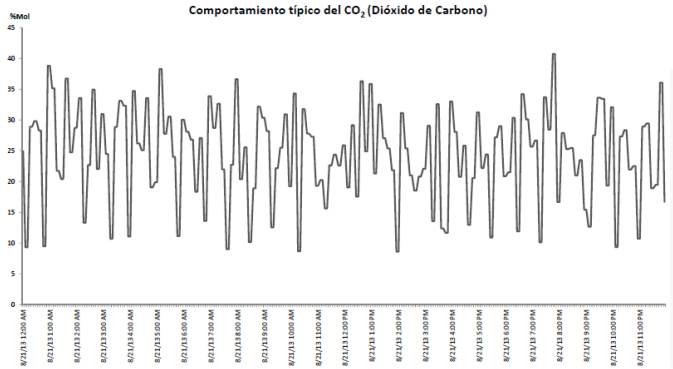
Energy Efficiency in most cases is NOT mandatory.

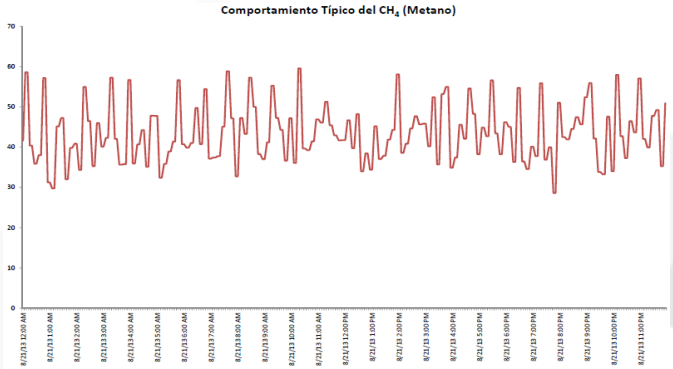
NAMA OGE&EE
Technical Barriers

Associated Gas Challenges:
UNSTABLE, UNRELIABLE and UNPREDICTABLE

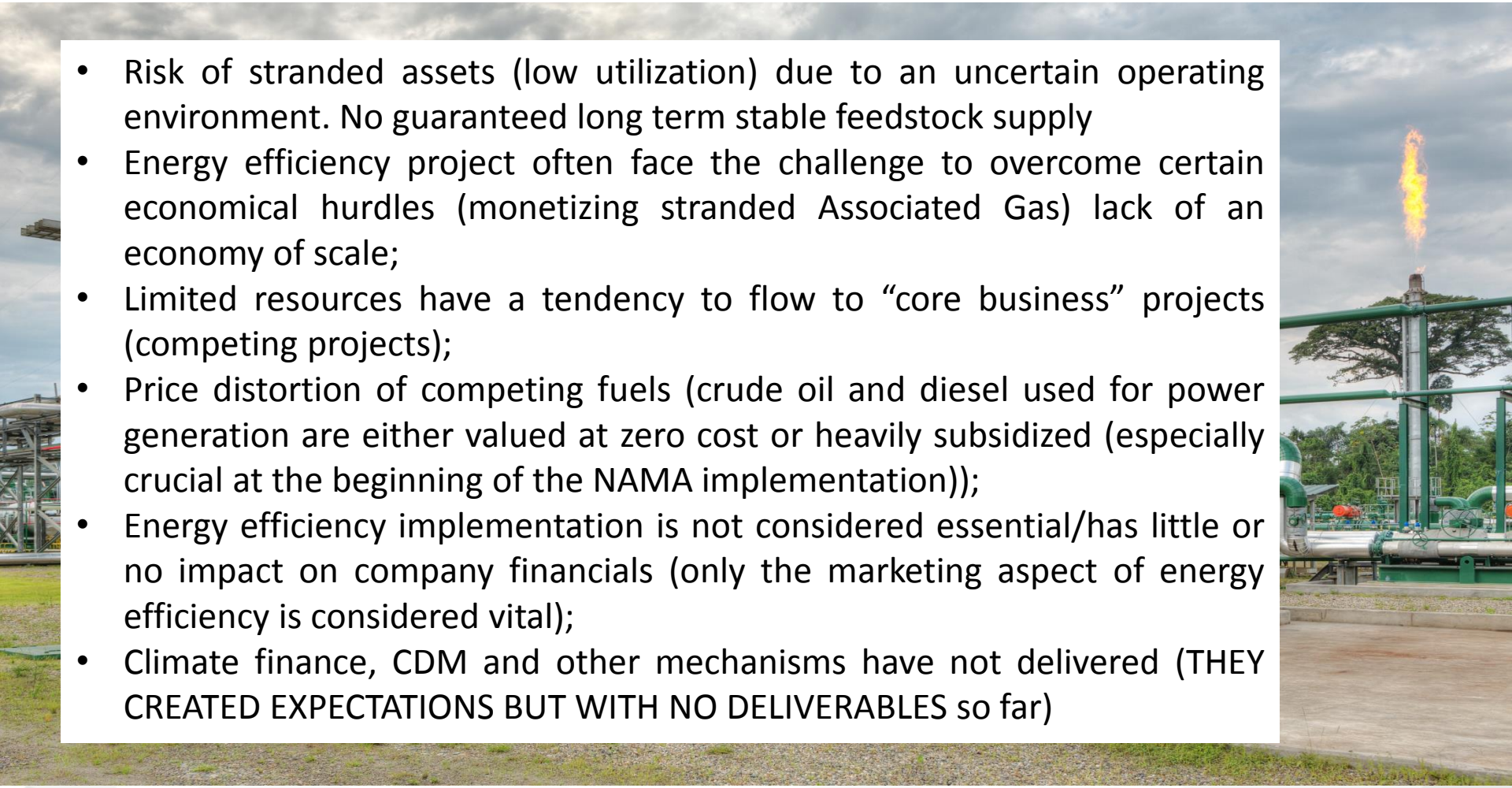
1. Instability and uncertainty of associated gas in terms of volume, composition and trend.
2. Moving target: One solution does NOT fit all requirements given the fact that gas composition and volumes vary constantly.
3. Storing associated gas (to mitigate batches) comes with significant technical/economical challenges.
4. Transporting associated gas requires significant infrastructure with the risk of ending up as a stranded asset.
5. Limited fuel range (in terms of fuel composition) and fuel flexibility (ability to burn lowest cost and environmental impact available fuel) of most available power generation technologies generates a risk of ending up with a stranded asset in the event of fuel composition variations and or fuel volume restrictions.
6. It is very challenging (technically / economically) to optimize associated gas peaks (see charts).







NAMA OGE&EE
Economical Barriers



- Risk of stranded assets (low utilization) due to an uncertain operating environment. No guaranteed long term stable feedstock supply
- Energy efficiency project often face the challenge to overcome certain economical hurdles (monetizing stranded Associated Gas) lack of an economy of scale;
- Limited resources have a tendency to flow to “core business” projects (competing projects);
- Price distortion of competing fuels (crude oil and diesel used for power generation are either valued at zero cost or heavily subsidized (especially crucial at the beginning of the NAMA implementation));
- Energy efficiency implementation is not considered essential/has little or no impact on company financials (only the marketing aspect of energy efficiency is considered vital);
- Climate finance, CDM and other mechanisms have not delivered (THEY CREATED EXPECTATIONS BUT WITH NO DELIVERABLES so far)

Ministerio del Ambiente

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

NAMA OGE&EE Scope (WHAT)

1. **Optimize** up to 70 – 80 mmscfpd of Associated Gas for LPG production and power generation.

2. **NAMA boundaries:** NOT limited to one oil field and/or one operator but covers a national petroleum sector (multiple fields and operators – both state owned and private).

3. **NAMA key infrastructure:**
   - Associated Gas capture and Associated Gas handling facilities
   - Associated Gas transportation infra-structure
   - Power Generation facilities
   - Substations and power distribution facilities

4. **NAMA scope:**
   - Over 45 substations
   - Over 1000 km of transmission / distribution lines
   - Over 31 power plants – over 17 oil blocks
   - (Associated Gas, Gas / Crude and Crude Power Plants)
   - Over 100 km of gas pipelines

NAMA OGE&EE
Scope / Research and Development (WHAT)

- **Fuel Flexibility:** Develop technology with the capability to burn either Crude Oil, Associated Gas and or Liquid Associated Gas (Condensates).
- **Waste Heat Recovery (WHR):** Optimize exhaust gases for process facilities.
- **Monetizing Stranded Associated Gas (MSAG):** Bring to market to monetize remote/limited volume of Associated Gas.

NAMA OGE&EE) Challenges (HOW)

- Develop small scale standardized/modular/redeployable (skid mounted / containerized) “plug and play” modules which can be fit together to form “phased in”/”phased out”/tailor made solutions.
- Building Block/LEGO solutions.

NAMA OGE&EE

A Robust Transmission and Distribution System (HOW)

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

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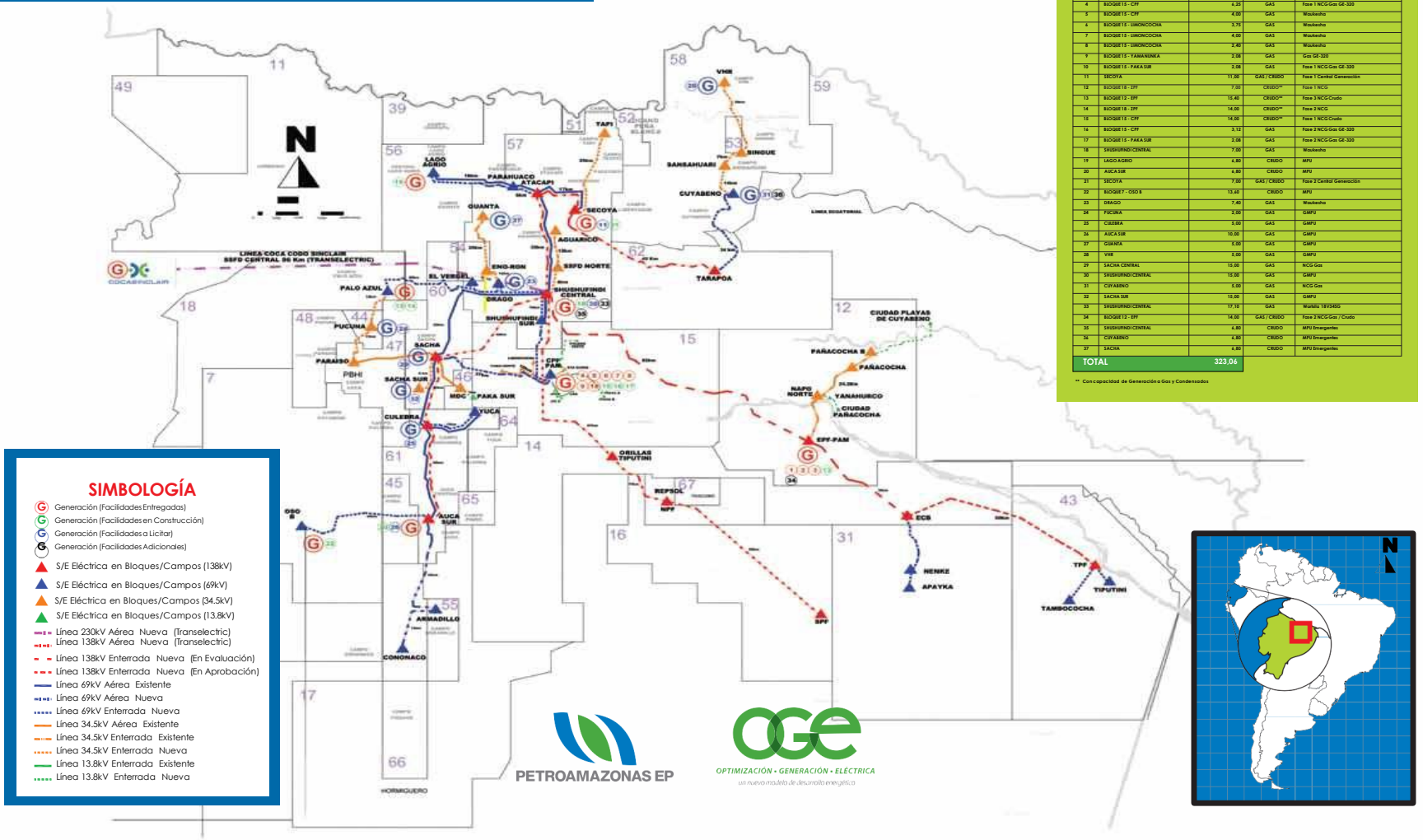
SISTEMA ELÉCTRICO INTERCONECTADO PETROLERO EXTENDIDO (SEIP-E) 2012 - 2017



SIMBOLOGÍA

- Generación (Facilidades Entregadas)
- Generación (Facilidades en Construcción)
- Generación (Facilidades a Licitar)
- Generación (Facilidades Adicionales)
- S/E Eléctrica en Bloques/Campos (138kV)
- S/E Eléctrica en Bloques/Campos (69kV)
- S/E Eléctrica en Bloques/Campos (34.5kV)
- S/E Eléctrica en Bloques/Campos (13.8kV)
- Línea 230kV Aérea Nueva (Transelectric)
- Línea 138kV Aérea Nueva (Transelectric)
- Línea 138kV Enterrada Nueva (En Evaluación)
- Línea 138kV Enterrada Nueva (En Aprobación)
- Línea 69kV Aérea Existente
- Línea 69kV Aérea Nueva
- Línea 69kV Enterrada Nueva
- Línea 34.5kV Aérea Existente
- Línea 34.5kV Enterrada Existente
- Línea 34.5kV Enterrada Nueva
- Línea 13.8kV Enterrada Existente
- Línea 13.8kV Enterrada Nueva

FACILIDADES DE GENERACIÓN ENTREGADAS Y EN CONSTRUCCIÓN / FABRICACIÓN
OGE & EE

ITEM	ESTACIÓN	CAPACIDAD (MW)	COMBUSTIBLE	DETALLE
1	BLOQUE 12 - EPF	24.00	GAS / CRUDO	Fase 1 NCG Gas / Crudo
2	BLOQUE 12 - EPF	13.40	CRUDO**	Fase 1 NCG Crudo
3	BLOQUE 12 - EPF	13.40	CRUDO**	Fase 2 NCG Crudo
4	BLOQUE 15 - CPF	4.25	GAS	Fase 1 NCG Gas GE-320
5	BLOQUE 15 - CPF	4.00	GAS	Waukesha
6	BLOQUE 15 - LIMONCOCHA	3.75	GAS	Waukesha
7	BLOQUE 15 - LIMONCOCHA	4.00	GAS	Waukesha
8	BLOQUE 15 - LIMONCOCHA	2.40	GAS	Waukesha
9	BLOQUE 15 - YAMANUNKA	2.08	GAS	Gas GE-320
10	BLOQUE 15 - PAKA SUR	2.08	GAS	Fase 1 NCG Gas GE-320
11	SECOYA	11.00	GAS / CRUDO	Fase 1 Central Generación
12	BLOQUE 18 - ZPF	7.50	CRUDO**	Fase 1 NCG
13	BLOQUE 12 - EPF	13.40	CRUDO**	Fase 3 NCG Crudo
14	BLOQUE 18 - ZPF	14.00	CRUDO**	Fase 2 NCG
15	BLOQUE 15 - CPF	14.00	CRUDO**	Fase 1 NCG Crudo
16	BLOQUE 15 - CPF	3.12	GAS	Fase 2 NCG Gas GE-320
17	BLOQUE 15 - PAKA SUR	2.08	GAS	Fase 2 NCG Gas GE-320
18	SHUSHUFINDI CENTRAL	7.00	GAS	Waukesha
19	LAGO AGRIO	6.80	CRUDO	MFU
20	AUCA SUR	6.80	CRUDO	MFU
21	SECOYA	7.00	GAS / CRUDO	Fase 2 Central Generación
22	BLOQUE 7 - OSO B	13.60	CRUDO	MFU
23	DRAGO	7.40	GAS	Waukesha
24	PUCUNA	2.00	GAS	GMFU
25	CULEBRA	5.00	GAS	GMFU
26	AUCA SUR	10.00	GAS	GMFU
27	GUANTA	5.00	GAS	GMFU
28	VHR	5.00	GAS	GMFU
29	SACHA CENTRAL	15.00	GAS	NCG Gas
30	SHUSHUFINDI CENTRAL	15.00	GAS	GMFU
31	CUYABENO	5.00	GAS	NCG Gas
32	SACHA SUR	15.00	GAS	GMFU
33	SHUSHUFINDI CENTRAL	17.10	GAS	Waukes 18V34SG
34	BLOQUE 12 - EPF	14.00	GAS / CRUDO	Fase 2 NCG Gas / Crudo
35	SHUSHUFINDI CENTRAL	6.80	CRUDO	MFU Emergentes
36	CUYABENO	6.80	CRUDO	MFU Emergentes
37	SACHA	6.80	CRUDO	MFU Emergentes
TOTAL		323.06		

** Con capacidad de Generación a Gas y Condensados

PETROAMAZONAS EP

OGE
OPTIMIZACIÓN • GENERACIÓN • ELÉCTRICA
un nuevo modelo de desarrollo energético

NAMA OGE&EE
WHO?

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

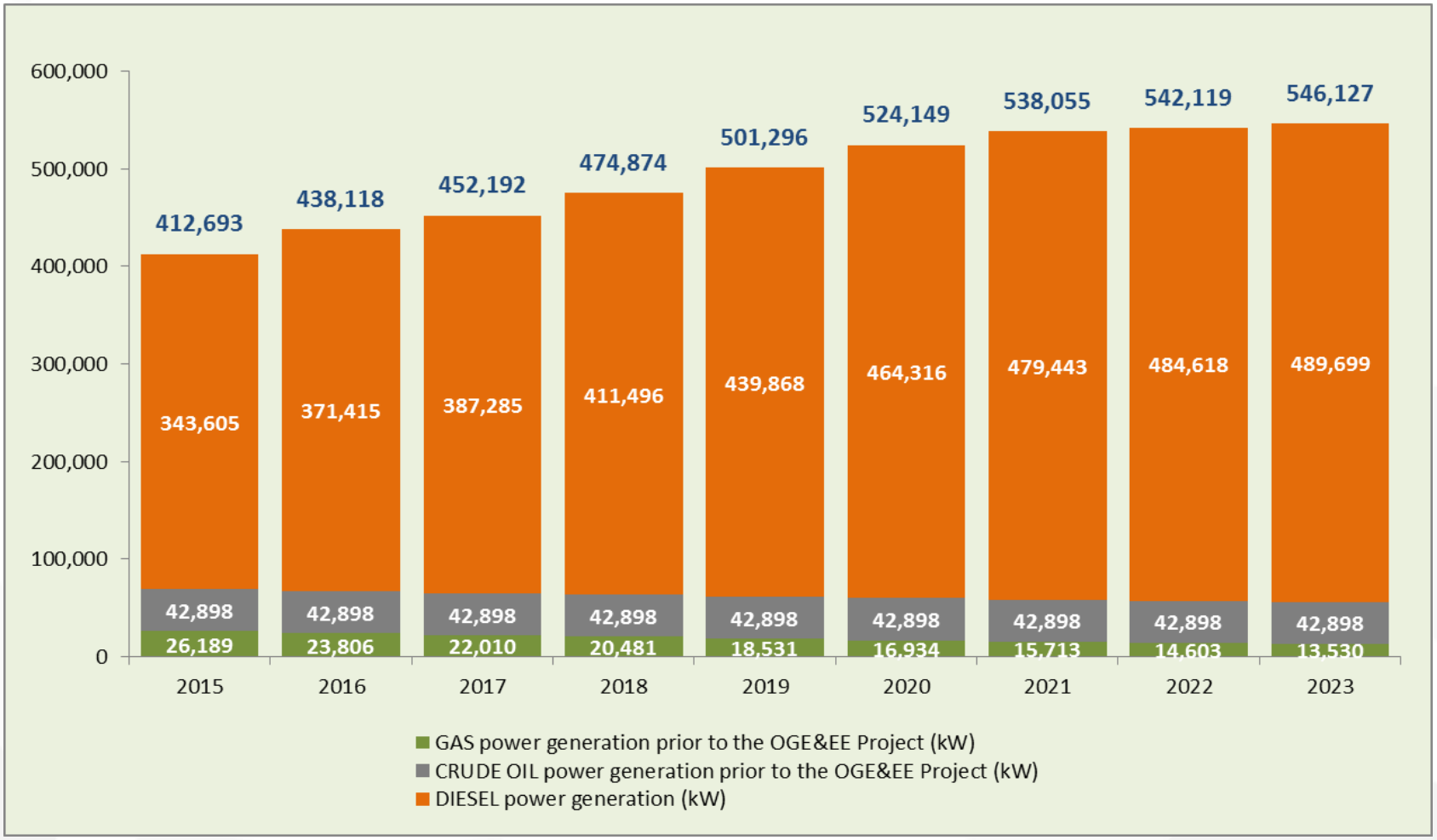
Ministerio del Ambiente

THE STATE OF ECUADOR HAS EMPOWERED TO PETROAMAZONAS EP TO DEVELOP THE OGE&EE PROGRAM

FLARE
(before the OGE&EE Program)

FLARE
(after the OGE&EE Program)

NAMA OGE&EE
Sector context: Baseline

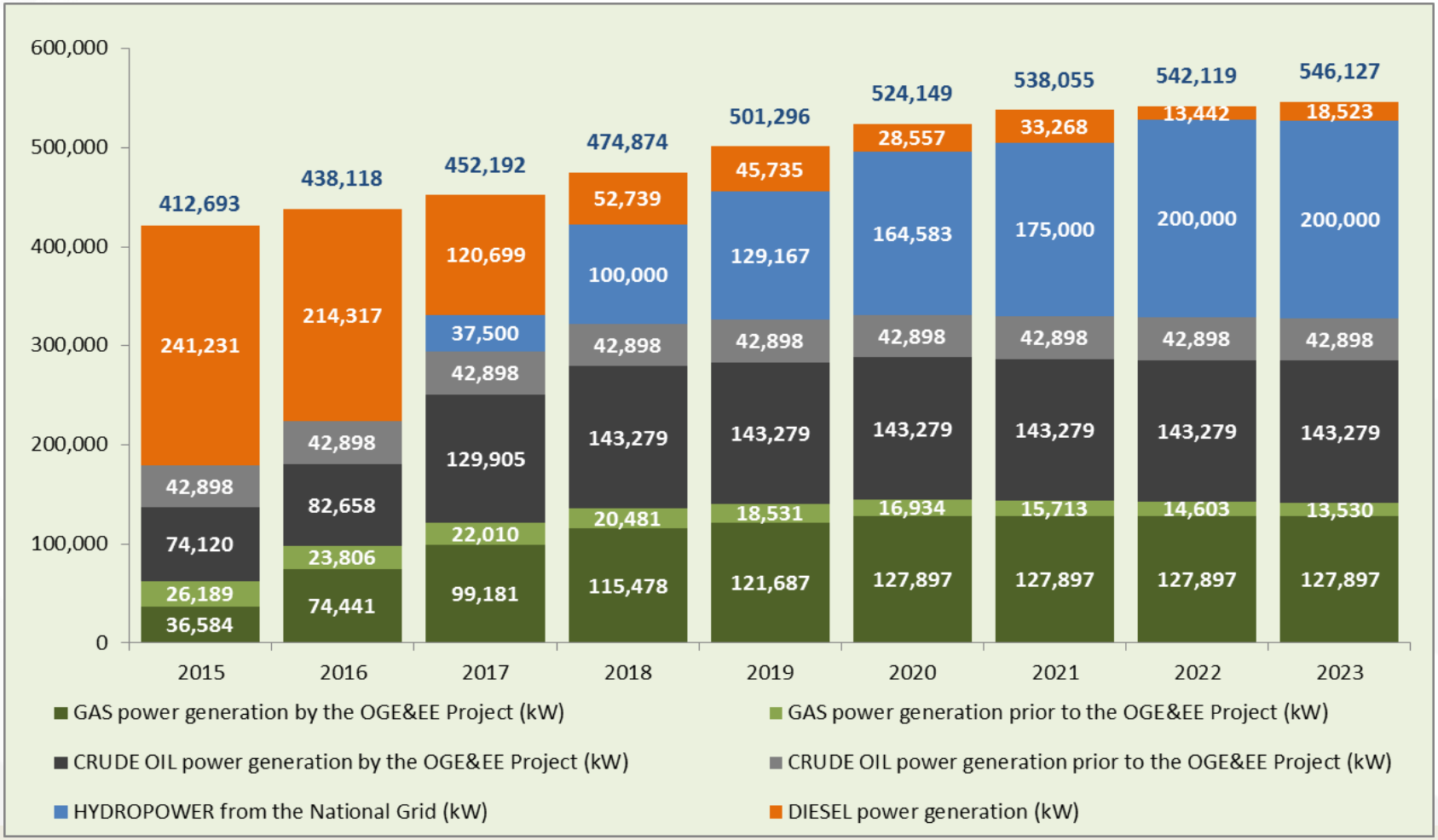


NOTES

1. The scenario "WITHOUT" the OGE&EE Project includes Gas and Crude Oil Power Generation Facilities installed by Private Oil Companies and Gas and Crude Oil Power Generation Facilities previously installed at Block 18 (Gas / Crude Oil vapor turbines and MAK Crude Oil power generator).
2. The power demand within the SEIP-E is based on the Scenario SHE 2014 which considers a peak volume of 570,000 bbl/d of crude oil more the projected power demand needed for private companies contracted by PETROAMAZONAS EP (incremental volume of 130,000 bbl/d of crude oil).
3. Power demand forecast based on the Scenario Secretaría de Hidrocarburos (SHE) 2014 is different from the Scenario Low Investment Wood Mckenzie - Ministerio de Recursos Naturales No Renovables (WM-MRNNR) due to: (i) The Scenario SHE 2014 includes ITT, the Scenario Low Investment WM-MRNNR does not, (ii) the Scenario SHE 2014 does not considers Improved Oil Recovery (IOR), the Scenario Low Investment WM-MRNNR does include IOR

NAMA OGE&EE
Expected Outcomes: Transformational Impact

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR



NOTES

1. The scenario "WITH" the OGE&EE Project assumes up to 200 MW of surplus Hydropower being imported from the National Grid as of 2017. According to CONELEC, for the SEIP-E has been considered a maximum of 100 MW on peak demand more an incremental power transfer depending on the hydrological conditions.
2. The scenario "WITH" the OGE&EE Project includes Gas and Crude Oil Power Generation Facilities installed by Private Oil Companies and Gas and Crude Oil Power Generation Facilities previously installed at Block 18 (Gas / Crude Oil vapor turbines and MAK Crude Oil power generator).
3. The power demand within the SEIP-E is based on the Scenario SHE 2014 which considers a peak volume of 570,000 bbl/d of crude oil more the projected power demand needed for private companies contracted by PETROAMAZONAS EP (incremental volume of 130,000 bbl/d of crude oil).
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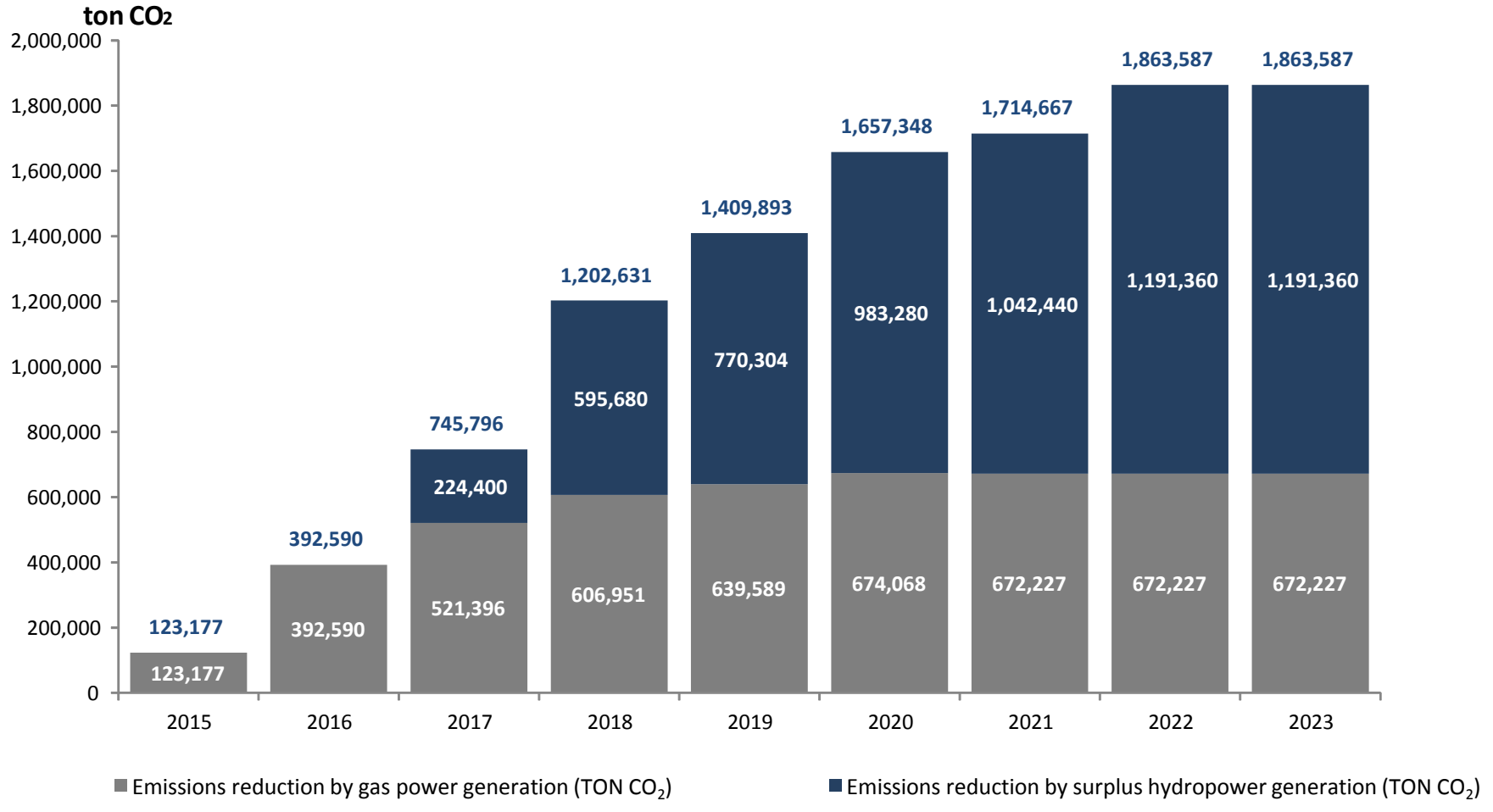
NAMA OGE&EE
Expected Outcomes: Environmental Benefits



NOTES

1. The emissions reduction within the SEIP-E is based on the Scenario of the Secretaría de Hidrocarburos (SHE) 2014.
2. The calculation includes CO2 emissions reduction due to fossil fuel displacement within the SEIP-E by surplus hydropower being imported from the National Grid.

NAMA OGE&EE
Ongoing Monitoring and Reporting

Ministerio del Ambiente

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

INPUT

- Power
- Investment
- Fuel Consumption
- Noise Level Measurement
- Fuel Cost
- CO2 Emission Factor
- Key Performance Indicators
- Black Carbon Emission Factor
- Energy Delivered to Communities

DATA PROCESSING

OUTPUT

Economic Indicators
- Economic Savings
- Savings vs. Investment

Energy Indicators
- Volume of Associated Gas Utilized
- Volume of Fuel Saved
- Power generated by fuel /source

Environmental Indicators
- CO2 Emission reductions
- Short-Lived Climate Pollutants Reduction

Social Indicators
- Energy for communities
- Noise Level Mitigation

The MRV System is so-called **the Energy Efficiency Indicators Management System or SGI-EE**

NAMA OGE&EE
MRV: Reporting

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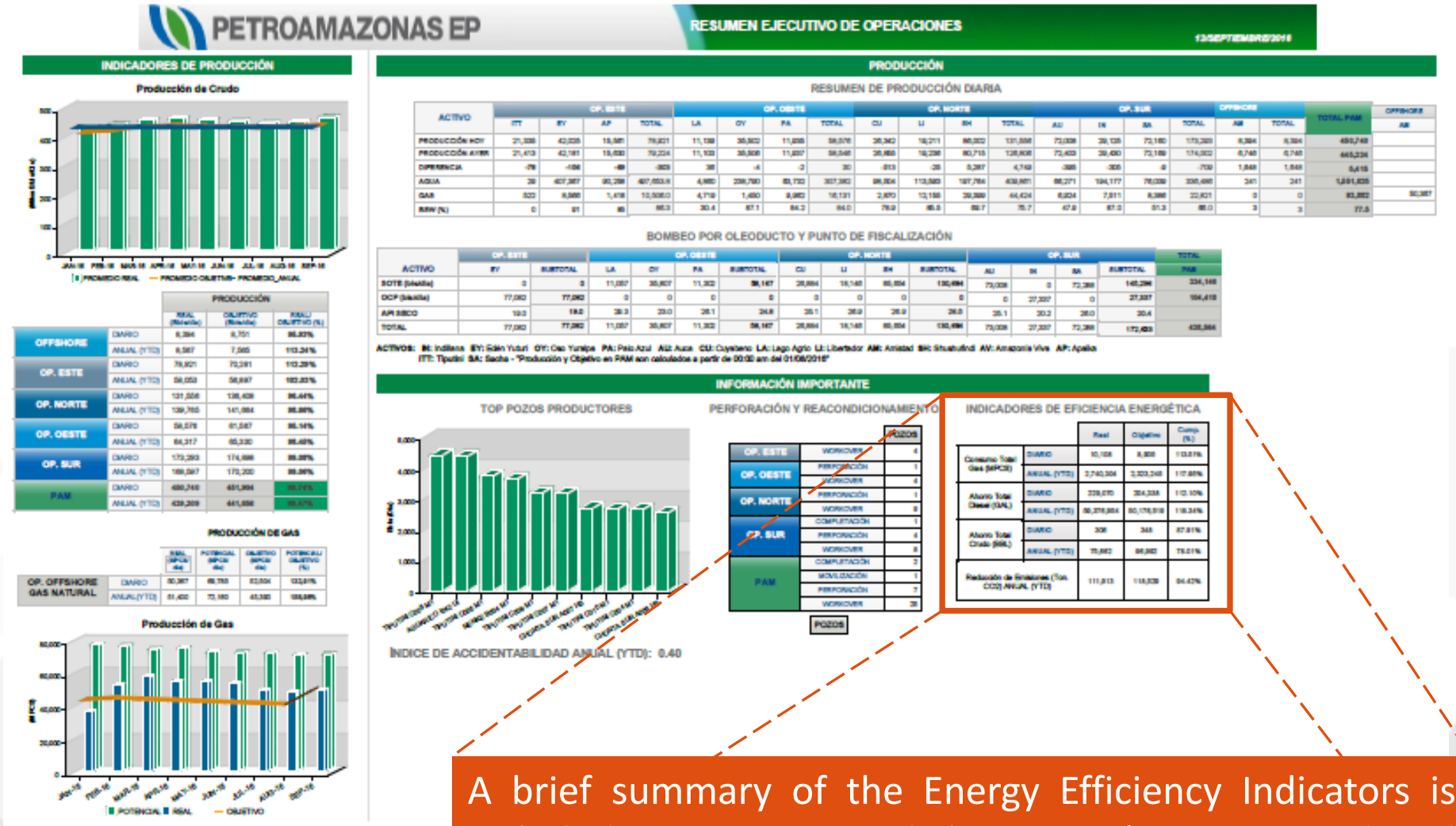
LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR



A brief summary of the Energy Efficiency Indicators is included in a company daily report (AG recovered and utilized, savings of diesel and CO_2 emission reductions).

NAMA OGE&EE
MRV: Reporting

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

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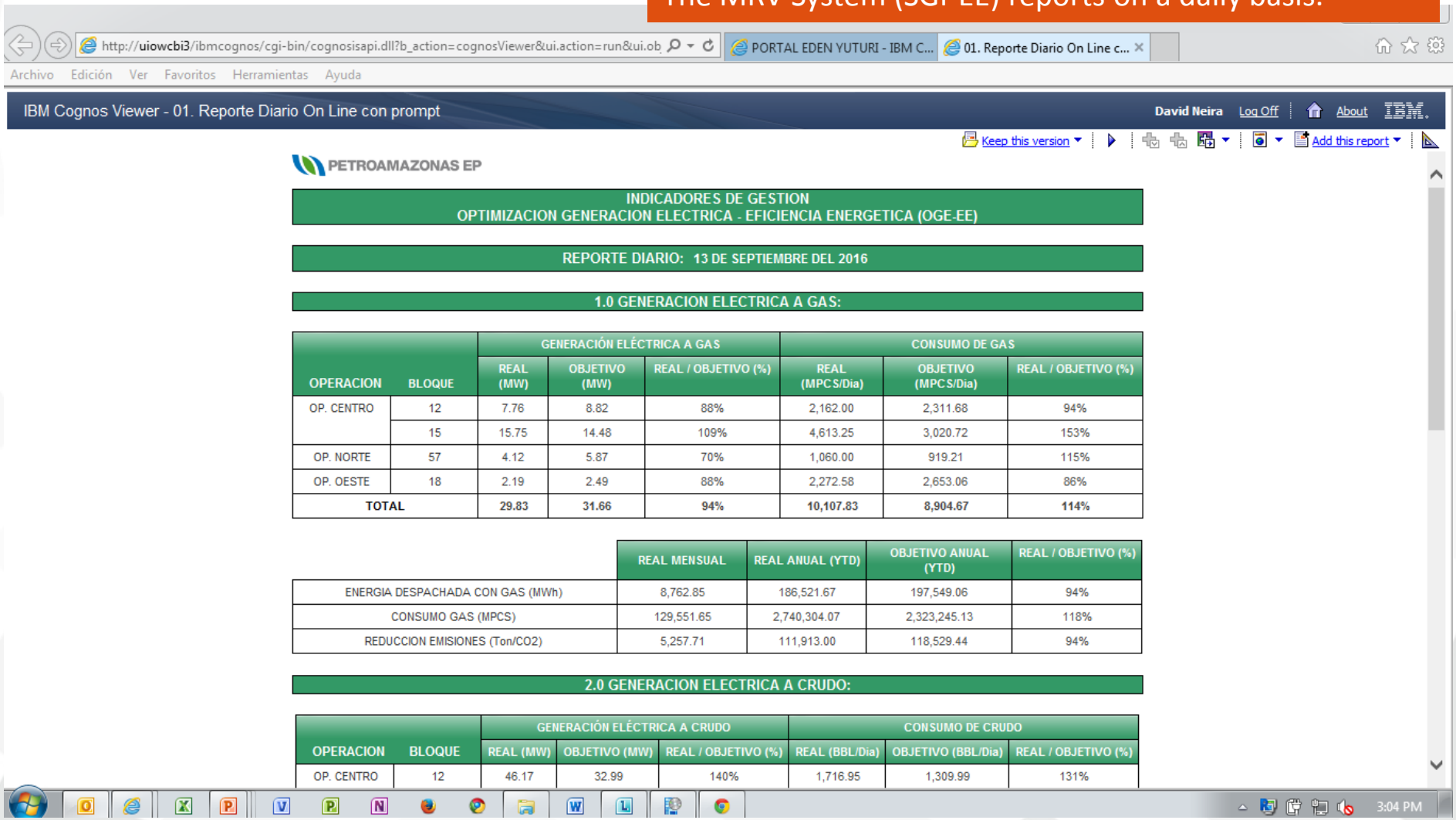
The MRV System (SGI-EE) reports on a daily basis.



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PETROAMAZONAS EP

INDICADORES DE GESTION
OPTIMIZACION GENERACION ELECTRICA - EFICIENCIA ENERGETICA (OGE-EE)

REPORTE DIARIO: 13 DE SEPTIEMBRE DEL 2016

1.0 GENERACION ELECTRICA A GAS:

OPERACION	BLOQUE	GENERACIÓN ELÉCTRICA A GAS			CONSUMO DE GAS		
		REAL (MW)	OBJETIVO (MW)	REAL / OBJETIVO (%)	REAL (MPCS/Dia)	OBJETIVO (MPCS/Dia)	REAL / OBJETIVO (%)
OP. CENTRO	12	7.76	8.82	88%	2,162.00	2,311.68	94%
	15	15.75	14.48	109%	4,613.25	3,020.72	153%
OP. NORTE	57	4.12	5.87	70%	1,060.00	919.21	115%
OP. OESTE	18	2.19	2.49	88%	2,272.58	2,653.06	86%
TOTAL		**29.83**	**31.66**	**94%**	**10,107.83**	**8,904.67**	**114%**

	REAL MENSUAL	REAL ANUAL (YTD)	OBJETIVO ANUAL (YTD)	REAL / OBJETIVO (%)
ENERGIA DESPACHADA CON GAS (MWh)	8,762.85	186,521.67	197,549.06	94%
CONSUMO GAS (MPCS)	129,551.65	2,740,304.07	2,323,245.13	118%
REDUCCION EMISIONES (Ton/CO2)	5,257.71	111,913.00	118,529.44	94%

2.0 GENERACION ELECTRICA A CRUDO:

OPERACION	BLOQUE	GENERACIÓN ELÉCTRICA A CRUDO			CONSUMO DE CRUDO		
		REAL (MW)	OBJETIVO (MW)	REAL / OBJETIVO (%)	REAL (BBL/Dia)	OBJETIVO (BBL/Dia)	REAL / OBJETIVO (%)
OP. CENTRO	12	46.17	32.99	140%	1,716.95	1,309.99	131%

3:04 PM

NAMA OGE&EE
NAMA Financing Status

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

Ministerio del Ambiente

OVERALL INVESTMENT *

USD 1,152,310,533

INVESTED UP TO JULY 2016

USD 654,226,589

*** According to the Plan de Desarrollo OGE&EE 2013 – 2017**

NAMA OGE&EE
Expected Climate Finance Support

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

Ministerio del Ambiente

Some projects that would contribute to recover more associated gas and reduce CO_2 emissions:

Category	Project	Estimated Budge
Gas recovery and transportation	CTGAS Transporte Drago -CIS	$ 10,869,010.12
Gas recovery and transportation	CTGAS Captacion y Transporte Yuca- Y	$ 12,258,847.64
Gas recovery and transportation	CTGAS Captacion y Transporte Yulebra- Y	$ 6,416,306.30
Power distribution facilities	SEIP Auca Sur - Rumiyacu (Armadillo)	$ 12,204,225.00
Power distribution facilities	SEIP Drago - Eno Ron 34.5KV	$ 6,418,627.08
Power distribution facilities	SEIP Drago - SSFD Central 69KV	$ 10,928,312.80
Power distribution facilities	SEIP SSFD Central - SSFD Sur 69KV	$ 7,982,794.67
Power distribution facilities	SEIP Secoya - Tapi (Tetete)	$ 9,888,662.15
Power distribution facilities	SEIP Tarapoa - Cuyabeno 69KV	$ 22,854,939.65
Power distribution facilities	SEIP Rumiyacu (Armadillo) - Cononaco	$ 6,186,417.00
Power distribution facilities	SEIP Cuyabeno - Sansahuari 34.5KV	$ 6,461,976.05
Power distribution facilities	SEIP ZPF - Pucuna 34.5KV	$ 8,831,916.00
Power distribution facilities	SEIP Sansahuari - Singue 34.5KV	$ 4,621,174.29
Power distribution facilities	SEIP Singue - VHR 34.5KV	$ 6,934,052.91
TOTAL		$ 132,857,261.66

NOTES

1. According to the Plan de Desarrollo OGE&EE 2013 - 2017.
2. The estimated budget could have slight changes based on updated KPIs.

NAMA OGE&EE
A Proposal of Financial Mechanism

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

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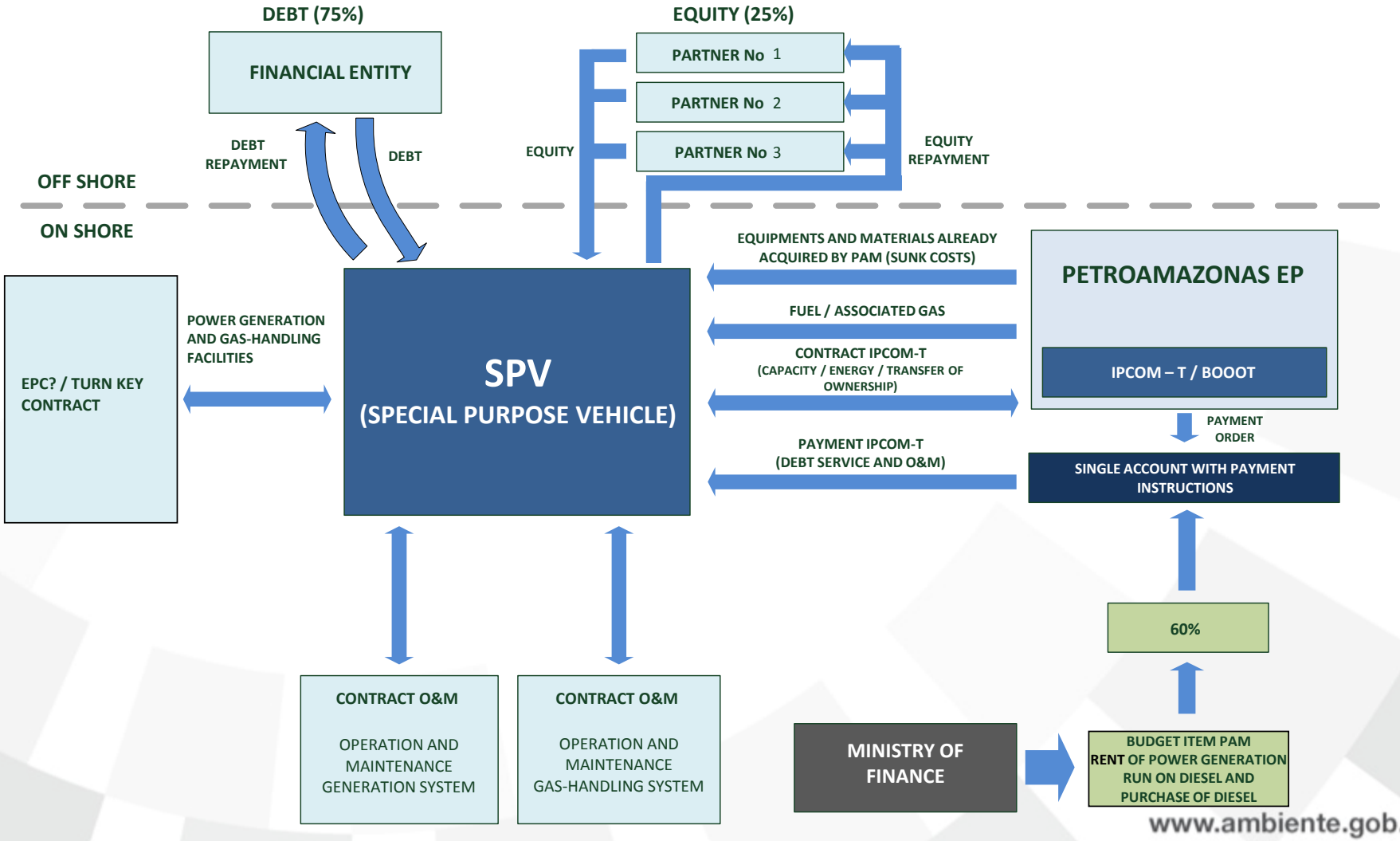
Based on the Project Finance Structure, a financial mechanism so-called IPCOM-T has been proposed for gas and gas/crude power generation facilities at first. At present, a first agreement applying this mechanism is under negotiation for 52,1 MW (USD 100 million aprox.) between Petroamazonas EP, Private Sponsors and the Private Branch of a Multilateral Bank.



Ministerio Coordinador de Sectores Estratégicos

Ministerio de Hidrocarburos

Ministerio del Ambiente

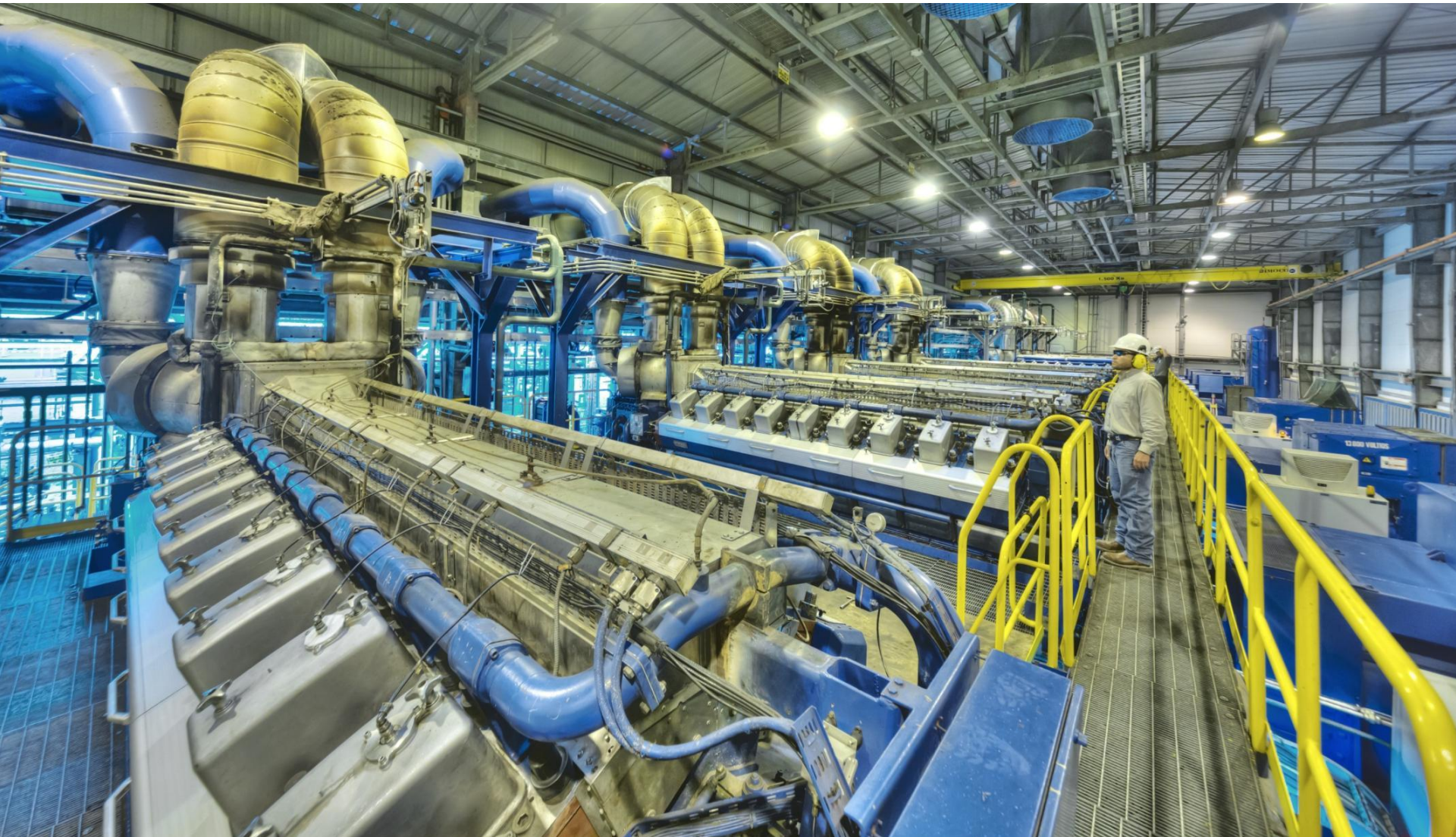
PETROAMAZONAS EP

Thank You

Questions?

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

SUPPORTING SLIDES



National Policy in Ecuador

CONSTITUTION 2008

buenvivir
PLAN NACIONAL

NATIONAL DEVELOPMENT PLAN 2013 - 2017

EXECUTIVE DECREES

NATIONAL ENVIRONMENTAL POLICY

Ministerio del Ambiente

MINISTERIAL LAW

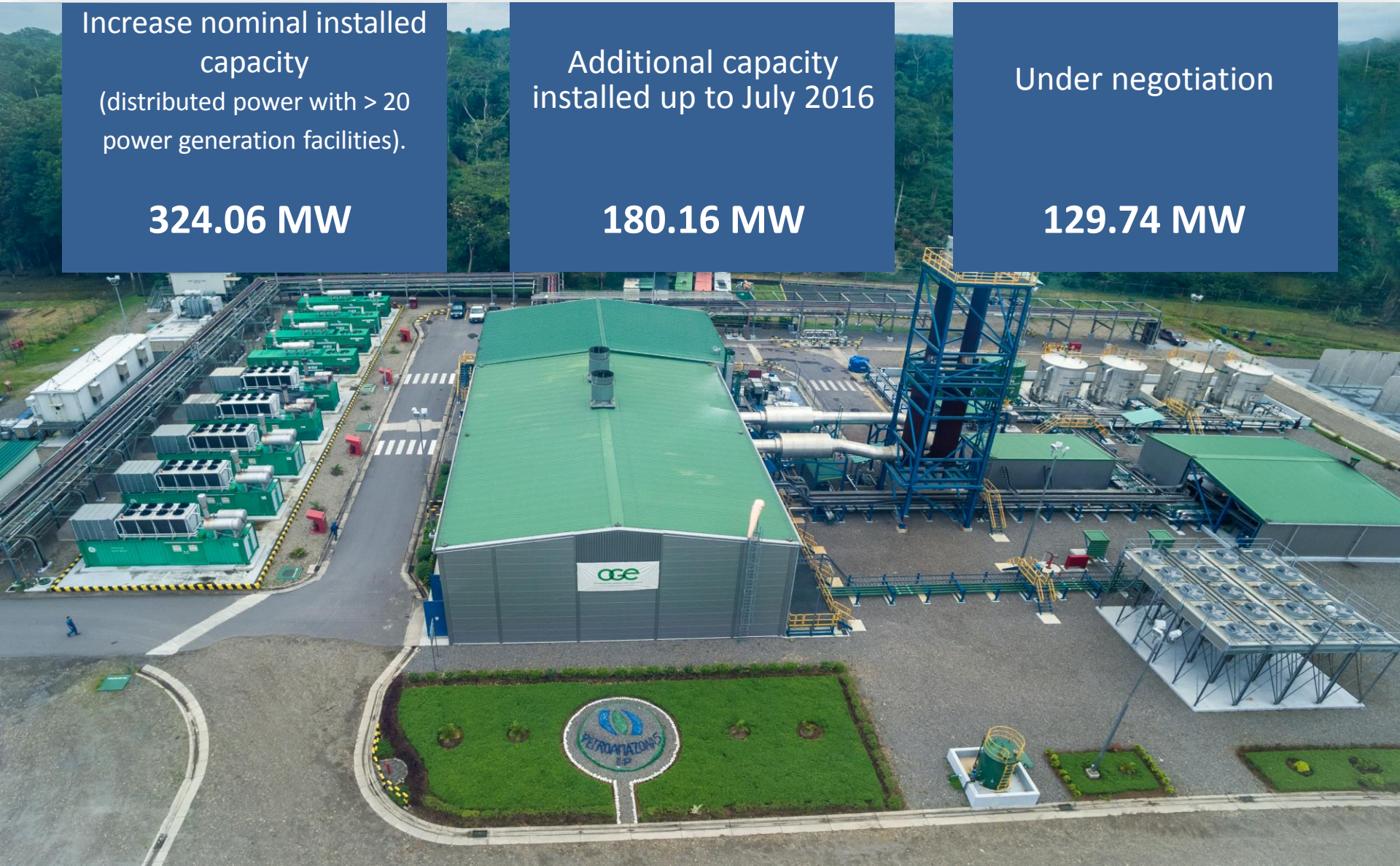
National Strategy on Climate Change (2012-2025)

The National Strategy on Climate Change (2012-2025) is a national policy that integrates de lines of action to fight climate changes up to 2025. This tool facilitates mainstreaming climate change in sector such as water resources, ecosystems, agriculture and energy. The current policy proposes the following approach:

1. ***Mitigation focuses in reducing emissions of greenhouse gases and increase carbon sinks in strategic sectors.***
2. ***Adaptation deals with strengthen the capacity of economic and environmental social systems to cope with the inevitable impacts of climate.***

NAMA OGE&EE
Outcomes: Power Generation

Increase nominal installed capacity (distributed power with > 20 power generation facilities).	Additional capacity installed up to July 2016	Under negotiation
324.06 MW	**180.16 MW**	**129.74 MW**



NAMA OGE&EE
Outcomes: Power Distribution

13.8 / 35 / 69 kV of Distribution System to be developed	13.8 / 35 / 69 kV of Distribution System built up to July 2016	138 kV Transmission System to be developed
519.7 km	**156.9 km**	**470 km**

NAMA OGE&EE
Outcomes: Gas Gathering and Transportation

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LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

Gas pipelines to be developed under OGE&EE

+ 100 km

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NAMA OGE&EE
Outcomes: Social Benefits

LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

800 Beneficiaries of this interconnection

79 Households in the community

In September 2014, the OGE&EE Program put into operation a first power interconnection between the Petroleum Power Grid (also known as SEIP-E) and the community in Block 12.

Petroamazonas EP deliver power to the community “Comunidad del Milenio Pañacocha” in the Amazon Rainforest through a 8.4 km. distribution power cable of 13.8 kV.

NAMA OGE&EE
Outcomes: Environmental Benefits

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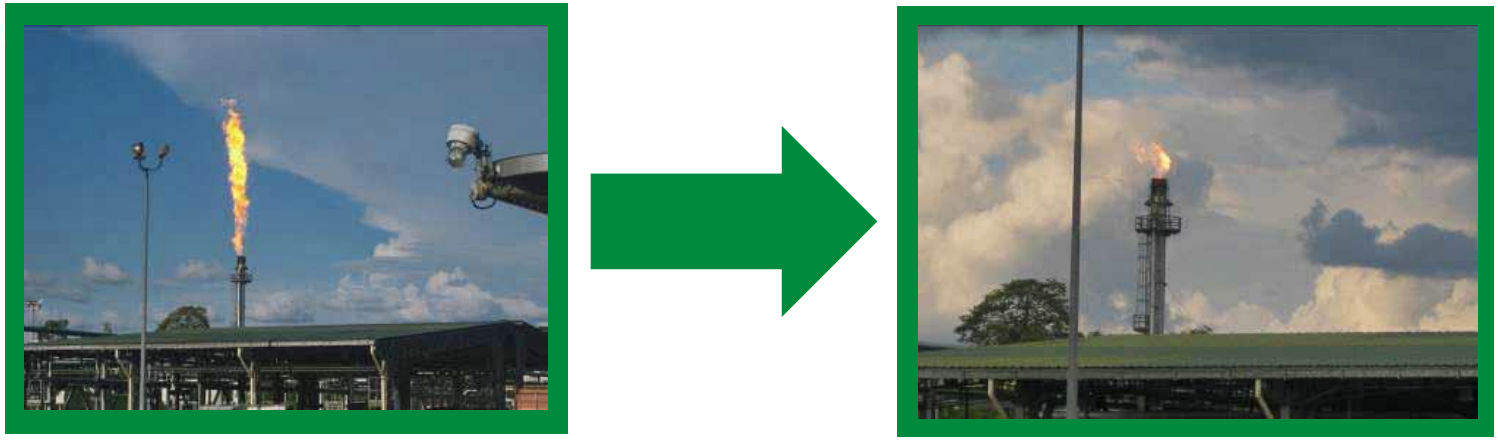
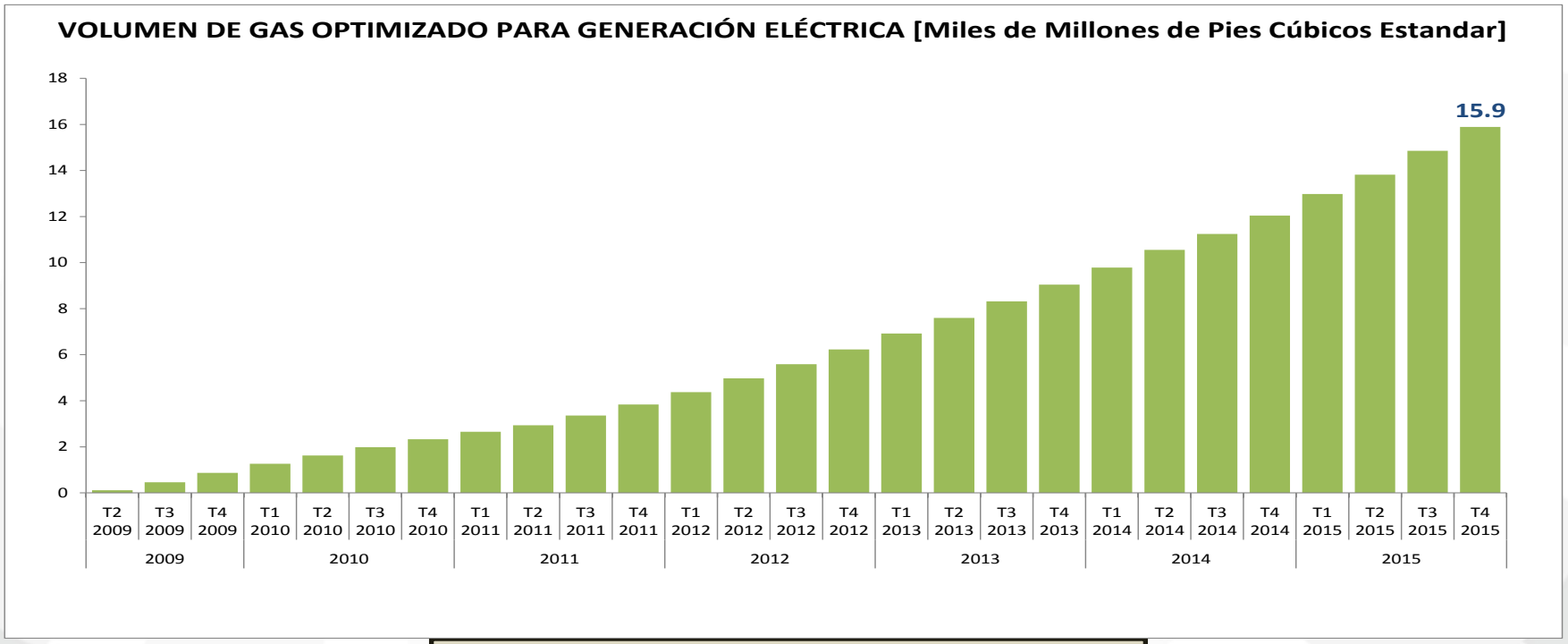
LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR





RESULT 2009 – 2015
VOLUME OF GAS RECOVERED: 15.9 thousand MMSCF

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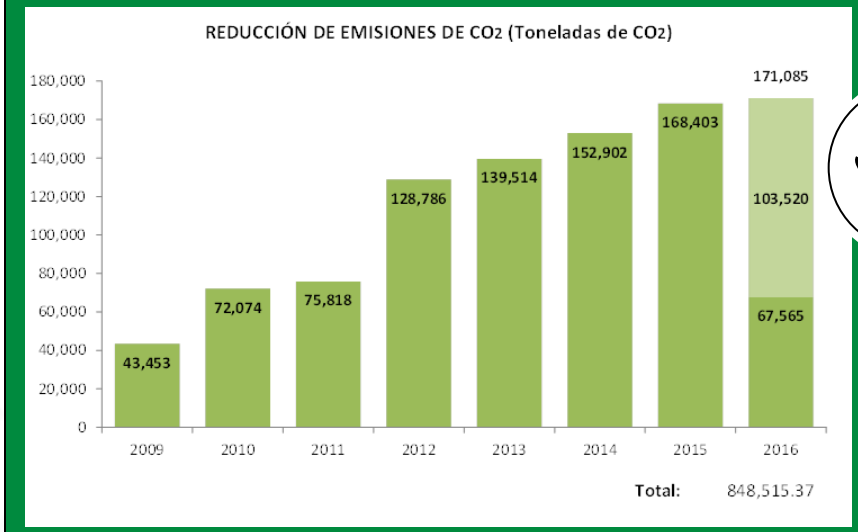
LOW EMISSION CAPACITY BUILDING PROJECT – ECUADOR

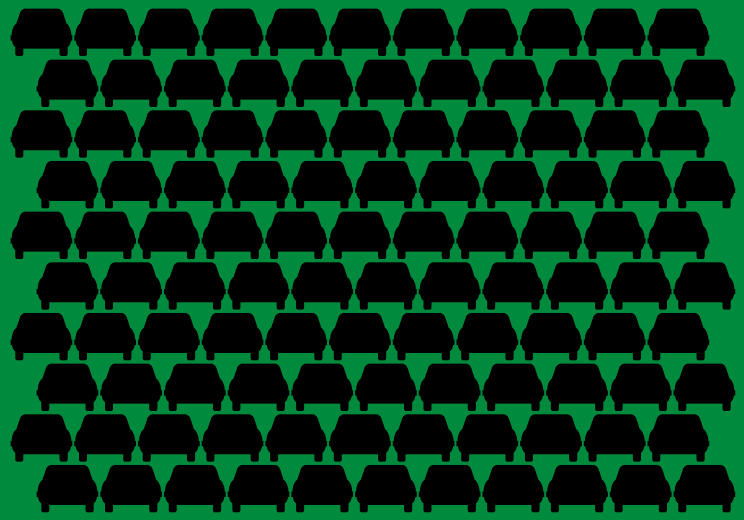
NAMA OGE&EE
Outcomes: Environmental Benefits

No Flaring ~ emission reductions



Associated gas recovery and utilization is national action included in the INDC of Ecuador.

CO_2 emissions



CO_2 emissions of 82,622 vehicles

RESULT 2009 – 2015
EMISSION REDUCTIONS: 848.5 thousand of ton CO_2