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Quantification of CO_2 emission reductions from energy efficiency actions and solar photovoltaic generation at the Federal Institute of Education, Science, and Technology of Goiás.

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Abstract

The Federal Institute of Education, Science, and Technology of Goiás has approved the research project, entitled "Energy efficiency and mini generation at the Federal Institute of Education, Science, and Technology - IFG." The project consists of implementing energy efficiency actions and installing photovoltaic distributed generation (mini generation) in twelve of the fourteen IFG campuses. The main objective of this work is to quantify the CO2 emission reductions from the project through the methodologies used by the United Nations Framework Climate Change Convention for projects under the Clean Development Mechanism. The emission reductions over the project lifetime was estimated at approximately 37,400 tCO_2 equivalent, evidencing the environmental benefit to be provided by the referred project.

1. INTRODUCTION

- IFG participated in ANEEL Public Call Nº 001/2016 entitled "Priority project of energy efficiency and strategic R&D: energy efficiency and mini generation in public higher education institutions" [1].
- The project entitled "Energy efficiency and mini generation at the Federal Institute of Education, Science and Technology of Goiás - IFG" [2] was approved and executed between April 2018 and May 2019 on the 12 campuses of IFG located in the cities of Goiás state, as illustrated in figure 1.
- The energy efficiency action implemented in the project was the replacement of the lighting system consisting of fluorescent lamps and sodium vapor for lighting system with LED lamps. The project also included the installation of PV systems distributed in cities, totaling approximately 1.255 MWp of installed capacity.

Fig. 1. Location of IFG campuses contemplated with the project.

2. METHODOLOGY

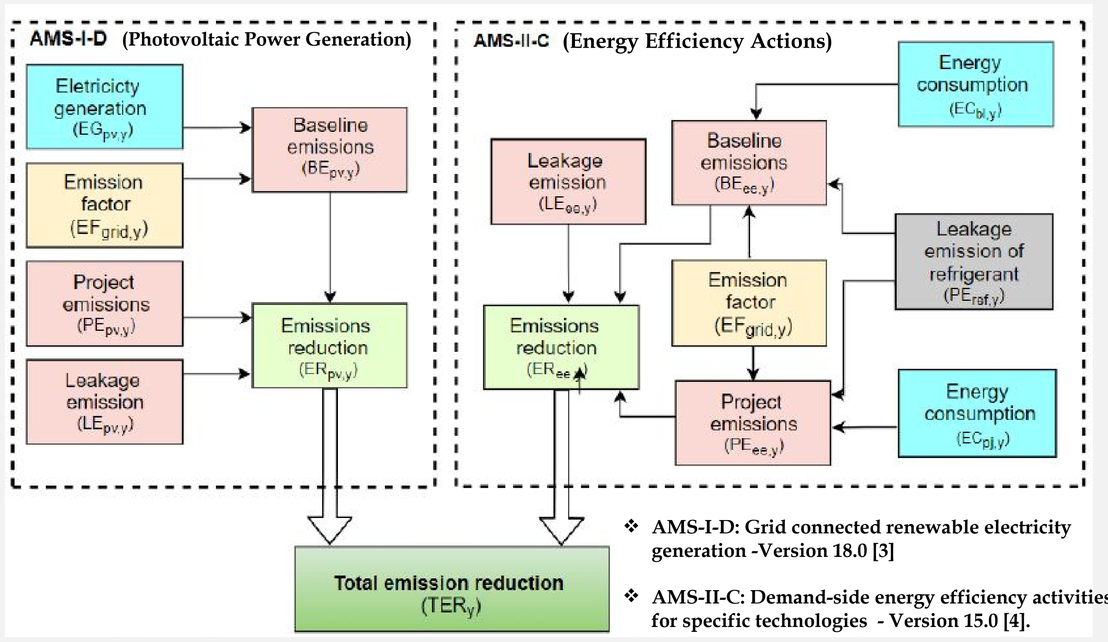

Fig. 2. Flowchart of the methodology used to quantify the reduction of CO2e emissions from the project

- The total emission reductions: $TERy = ERpv,y + EReey$
- Emission reductions from energy efficiency: $EReey = BEeey - PEeey - LEeey$
- Emission reductions from photovoltaic generation: $ERpv,y = BEpv,y - PEpv,y - LEpv,y$
- Baseline emissions from the PV project: $BEpv,y = EGpv,y \times EFy$
- Emission factor of the electrical system: $EFy = EFmo,y \times Wmo + EFmc,y \times Wmc$
- Baseline emissions (project of energy efficiency): $BEee,y = ECbl,y \times EFy + PEref,y$
- Baseline energy consumption: $ECbl,y = \sum(nipihi)/(1-ly)$
- Project emissions consumption: $PEee,y = ECpj,y \times EFy + PEref,y$
- Energy consumption after the implementation of energy efficiency: $ECpj,y = \sum(nipihi)/(1-ly)$
- Project emissions from the physical leakage of refrigerants $PEref,y = Qref,y \times GWPref,y$

3. RESULTS

- The methodology was applied to all IFG campuses, which are shown in Figure (1). The installation was made on the roof of the selected campus buildings.
- A scenario was designed for the Emission Factor forecast using the average value from 2012 to 2018, that is, the fixed value of 0.4811 tCO_2/MWh, which will be used over the 25 years of the project's lifetime.
- The energy efficiency action was the replacement of the lighting system consisting of fluorescent lamps and sodium vapor for lighting system with LED lamps.
- 3,850 photovoltaic modules of the polycrystalline type of 315 Wp and efficiency of 16.68%.

➢ ***Emission reductions from PVDG***

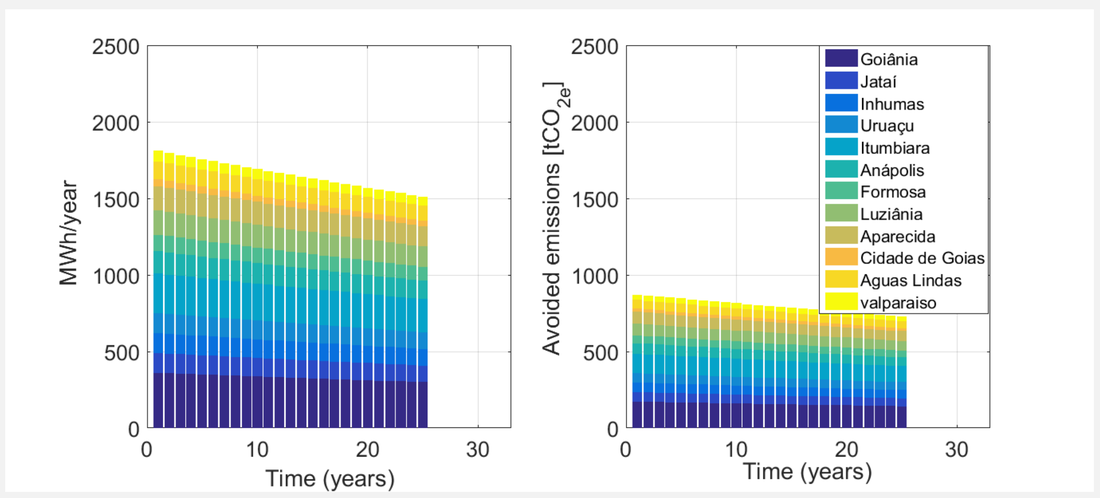

Fig. 3. Power generation of PV system in IFG .

Fig. 4. Avoided CO_{2e} emissions of PV system in IFG

- **It is expected that the PV projects generate around 41,350 MWh and avoid the emission to atmosphere about 19.900 tCO_{2e} over the project lifetime.**

➢ ***Emission reductions from energy efficiency actions***

Type of lamp	Quantity	Unit power [W]	OT [h/y]	EC [kWh/y]
Metal steam lamp	122	400	4,015	195,932.00
Metal steam lamp	125	250	4,015	125,468.75
Fluorescent lamp	6468	40	2,592	670,602.24
Fluorescent lamp	17228	32	2,592	1,428,969.60
Fluorescent lamp	1088	20	1,971	42,888.96
Fluorescent lamp	700	16	1,971	22,075.20
Compact lamp	670	20	4,015	53,801,00
Total				**2,539,737.75**

Table I - Total existing lighting system of the campus

Type of lamp	Quantity	Unit power [W]	OT [h/y]	EC [kWh/y]
LED outdoor Spotlight	122	70	4,015	34,288.10
LED outdoor Spotlight	125	70	4,015	35,131.25
LED Tubular Light	6468	18	2,592	301,760.64
LED Tubular Light	17228	18	2,592	803,779.20
LED tube light	1088	11	1,971	23,592.87
LED tube light	700	11	1,971	12,417.30
LED Bulb	670	9	4,015	24,210.45
Total				**1,235,179.81**

Table II. - Proposed lighting system for the campus

- **With the change of the lighting system, the electricity consumed decreased from 2,539.97 MWh/year to 1,235.17 MWh/year, which corresponds to a consumption reduction of approximately 52%, maintaining the same amount of light lamps.**
- **The annual avoided emissions were approximately 700 tCO_{2e}, and over the project lifetime about 17,500 tCO_{2e}.***

➢ ***Emission reductions from the project (PVDG + energy efficiency actions):***

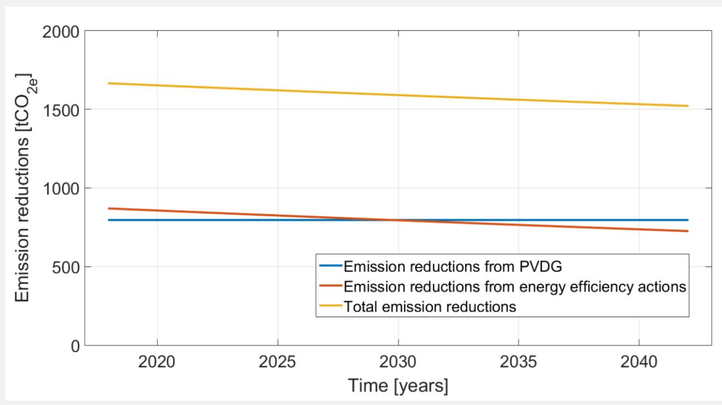

Fig. 5. Project emission reductions

Over the project lifetime:

- **Total emission reductions ranged from 1,666 to 1,522 tCO_{2e}, over the project lifetime;**
- **Total reduction estimated of 39,796 tCO_{2e}.**

4. CONCLUSION

- **The project included the replacement of the existing lighting system and the installation of PV systems totaling 1.255 MWp.**
- **The results presented in this article show the environmental benefit of CO_2 emissions that are no longer released into the atmosphere.**
- **It is possible to cease to release approximately 39,796 tCO_{2e} into the atmosphere, with 19,905 tCO_{2e} due to the implementation of energy efficiency actions and 19,891 tCO_{2e} due to the installation of photovoltaic plants.**
- **Reduced emissions over the years can be converted into CERs (carbon credits), which can be traded in specialized markets, contributing to the economic viability of these kind of projects.**

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* Considering the lamp ballast, the avoided emissions can increase to 19,900 tCO_{2e}