Energy Saving Technology Analysis for Commercial, Industrial, Social, and Public Sectors to Support Regional Energy Policy: Case Study in Daerah Istimewa Yogyakarta

by Tony K Hariadi

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Energy Saving Technology Analysis for Commercial, Industrial, Social, and Public Sectors to Support Regional Energy Policy: Case Study in Daerah Istimewa Yogyakarta

Tony K. Hariadi[1,4], P.Jutta Prahara[2,4], Surya B. Lesmana[3,4] and Raouf Saidi[5]

[1] *Departement of Electrical Engineering, Universitas Muhammadiyah Yogyakarta, jl. Lingkar Barat Tamantirta Yogyakarta, 55162, Indonesia.*

[2] *Departement of Electrical Engineering, University of Nebraska - Lincoln, 209N Scott Engineering Center, Lincoln, Nebraska, 68588-0511, USA.*

[3] *Departement of Civil Engineering, Universitas MuhammadiyahYogyakarta, jl. Lingkar Barat Tamantirta Yogyakarta, 55162, Indonesia.*

[4] *Center for Regional Energi Management, Universitas Muhammadiyah Yogyakarta, jl. Lingkar Barat Tamantirta Yogyakarta, 55162, Indonesia.*

[5] *Energy Research Center of the Netherlands, Westerduinweg 3, 1755 LE Petten, Netherlands*

[1,2,3] *Orcid: 0000-0001-6581-5903, 0000-0002-3526-7456, 0000-0001-8817-7051*

Abstract

Energy efficiency has been an issue in Yogyakarta since the province did not establish policy and regulation for the region. Household sector dominated the energy usage, however non-household sector also contributed significantly for energy consumption. Non-household sectors SME, Hotels (stars and non stars), and public (hospital and government building), also gave significant contribution for energy efficiency measure program. Random survey was conducted to collect key data, further analysis using Net Present Value, indicated feasible investment scenario for the proposed energy efficiency implementation. The result then simulated using several key data and assumptions collected from local institution were done to compare financial energy policy. Significant energy saving and finance saving can be made with low cost investment and financial support from government.

Keyword: Energy efficiency technology, energy policy, regional energy modeling, energy policy Yogyakarta

INTRODUCTION

Daerah Istimewa Yogyakarta (DIY) is a small province without big industry, as a city in a developing country, energy supply depends on non-renewable energy sources such as oil, natural gas and coal [1]. As a small region, Yogyakarta was interconnected with JAMALI (Jawa Madura Bali) system to fulfill its electrical energy needs, therefore Yogyakarta did not have its own electrical generator system. Energy consumption in Yogyakarta was dominated by household sector with around 54.94% user, followed by commercial/business with 33.38% and social/government with 11.68% [2]. Industries were reluctant to make medium to high cost energy efficiency investment, however energy efficiency and conservation program could increase their competitiveness [3][4]. As of the survey, air conditioner, television and desktop PC were the main energy consumer in household sector, while in non-household sectors, air conditioner and motors were the main energy consumers [5].

Average energy demand growth in Indonesia is 7%, and has to be faced by strategic measures. Daerah Istimewa Yogyakarta (DIY) faces the same problem with more burdens since DIY depends on energy supply from other region. Energy policy in Yogyakarta was adopted from National Energy Policy due to the lack of energy policy master plan in the province. Government of Indonesia has developed energy policy framework as recommended from IEA in 2008 [6]. Identification of strategic energy policy and measures is very important to assist all sectors to conserve energy. Energy conservation program would be feasible with energy labeling, tax reduction or even increasing energy price. Financial assistance plan and community education should also be considered as an energy conservation campaign program.

The objective of this project was to simulate the energy efficiency action plan, and analyze the impact of the simulation for non households sectors, and furthermore to:

- Utilize the energy efficiently and rationally,
- Using the energy as needed optimally, so that will reduce the cost incurred.
- Setting up the policy of technology selection on the energy source, and therefore will maintain the sustainability of natural resources.

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Some countries have failed in increasing energy access due to the lack of robust national energy strategy and implementation program [7]. Technology has to be selected with some consideration; availability, low cost, and willingness of the energy user, so that the proposed policy will be feasible and meaningful. Several technologies that are available:

- Variable Speed Drive (VSD), an electronic device that control speed and torque that is necessary for the work being done (Aditya, 2013). VSD can reduce as much as 50% of energy with only 20% performance reduction [8].
- Hydrocarbon Retrofit, selecting hydrocarbon refrigerant to match the operating condition and increase efficiency, this process can reduce power consumption by 20% [9].
- Unbalance Voltage, a condition where loads in three phase system are not balance between phases. An expert or consultant is needed to audit load distribution and to make a solution.

METHODOLOGY

Energy usage in industries, business, and social sector in Yogyakarta, was dominated by AC and motors. Therefore, this electrical equipment was the main energy efficiency target. Energy policy, such as price increase, taxation, and regulation can encourage energy efficiency in a region. Different policies will contribute to energy and climate policies [10]. To obtain the data on the usage of electrical devices, a random survey was conducted and the data collected clustered into key data as follows:

- The most common used of electrical devices
- Investment cost
- Energy consumption
- Electricity rating

Due to the lack of regulations and policies on energy conservation/energy efficiency in DIY, it is assumed to refer to the national regulations. The use of key data includes:

- the value of equipment investment cost,
- the energy consumption of equipment,
- the amount of electrical energy can be saved by more efficient electrical equipment, or through the changes in behavior in using the equipment,
- the price of electrical energy, and
- how long the investment cost can be returned if the use of the equipment is more efficient.

Data retrieval method used on this research project was random sampled survey on commercial (non-star motel/hotel), micro and small industry, social and public sectors. Assumption was also done using external factors, local assumption and other key data. Key data included the value of equipment investment costs, energy consumption of equipment, the amount of electrical energy can be saved by more efficient electrical equipment or through changes in behavior in using the equipment, the price of electric energy, and how long the investment cost can be returned if the use of equipment more efficient. Calculation of Net Present Value (NPV) was used to determine the energy saving projection. Although NPV calculation was less efficient, it still effective to make quantitative calculation for decision making. NPV could create meaningful potential investment by calculating cost and saving and also be able to take price increase and cost of investment into account [11][12].

National Energy conservation program was put as external factor:

1. Building public awareness on energy conservation,
2. Education and training,
3. opens a center for information about energy conservation activities,
4. Building a joint program of energy conservation, competency certification program manager energy for buildings and industrial sectors, and
5. Labeling program of efficiency level of electric equipment.

Key data assumption for the NPV calculation is presented in Table 1 below, based on survey finding from stakeholders.

Table 1: General Assumption

Discount rates	12 % per year	
Implementing Variable Speed Drive	1,000,000 IDR/kWh equipments	Occurs on motors, split AC's and central AC's
Retrofitting Refrigerant	280,000 IDR per unit AC's	Occurs on commercial, social, and public with split AC's
Price of Electrical energy	Increase maximum 20 %	Political situation difficulties to establish regulation
Allowance of Subsidy Scenario	Limit to 50 %	
Equipment Technical lifetime	5 years	In line with ministry standard analysis

Data about hotels/lodging was obtained from PLN (National Electric Company), Badan Pusat Statistic (Statistics Indonesia), and government, are presented in table 2, 3, 4 and 5 as follows:

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Table 2: Commercial Sector Data

Electricity Price	Using Basic Electricity Tariff (TDL) 2010	Consist of 2 groups of customers: B-1/TR 2,200 – 5,500 VA B-2/TR 6,600 VA – 200 kVA Price is 900 IDR/kWh
Split AC's	Average 12 pieces per hotel	Applied by non star hotels
Commercial Sector Type	Star hotels: 38 non star hotels: 1030	Most of star hotels use central AC's in systems

Table 3.: Industrial Sector Data

Electricity Price	Using Basic Electricity Tariff (TDL) 2010	Price IDR 750/kWh for I-3/TM above 200kVA
Industry type	Small and micro industry	Leather: 20 industries Limestone: 49 industries Wood: 30 industries
Energy Saving Program	Improvement of imbalance voltage	Hiring energy consultant (IDR 25,000,000.-) Projected energy saving 15,500 kWh/year

Table 4: Social Sector Data

Electricity Price	Using Basic Electricity Tariff (TDL) 2010	IDR 750/kWh for S-2/TR 3500VA – 200 kVA
Social Sector Type	Hospital Type C and above	Total 63 hospitals

Table 5: Public Sector Data

Electricity Price	Using Basic Electricity Tariff (TDL) 2010	Customers groups: P-1/TR 2,200 – 5,500 VA P-2/TR 6,600 VA – 200 kVA Price: IDR 900/kWh
Public Sector Type	Government building	P-1/TR 270 buildings P-2/TR 146 buildings

Industrial, commercial, social and public sector mostly used air conditioner, to regulate climate in tropical country such as Indonesia. Motor was also commonly used in industrial sector. This research was focused on energy saving scenario for AC and motor with the following implementation:

1. Implementation of Variable Speed Drive (VSD)
2. Refrigerant retrofit
3. Improvement of imbalance voltage

NPV Analysis was done to calculate the implementation measure, barrier and policy analysis was also done.

RESULT

A. Implementation of Variable Speed Drive

Several data gathered during the project indicated that:

1. AC operation average was 8 hours/day
2. Motors operation 24 hours/day
3. Variable speed drive cost IDR 1,000,000.-/kW equipment
4. Cost of electricity IDR 1,300.- (normal time), IDR 1,500.- (peak time)

NPV analysis for implementation of VSD in all sectors indicated in fig 1 below

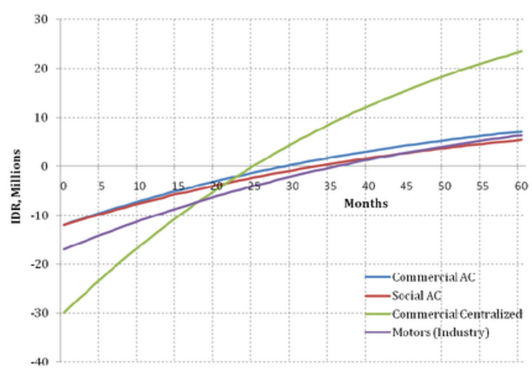

Figure. 1.: NPV Difference for Implementing VSD in Commercial, Industrial, and Social Sector

Fig 1 indicated that there are savings for implementing VSD at all sectors that being analyzed. The most interactive return of investment was in commercial sector. The return of investment was IDR 187,144 after 25 month for centralized AC's and of IDR 20,142 after 29 month for split AC. All sectors implementation scenario for VSD were feasible because payback period were less than 36 months [13] Large healthcare facilities were not analyzed due to its complexity, for air conditioning and other system in such facilities an energy manager was needed to set the efficiency measures [14].

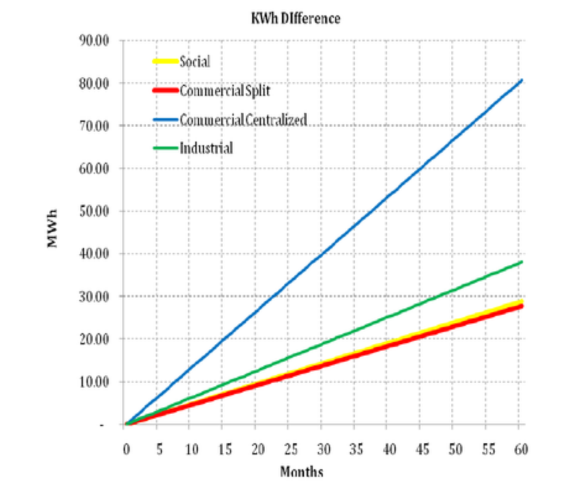

Figure 2: KWh Difference of Implementing VSD for Commercial, Industrial, and Social Sectors

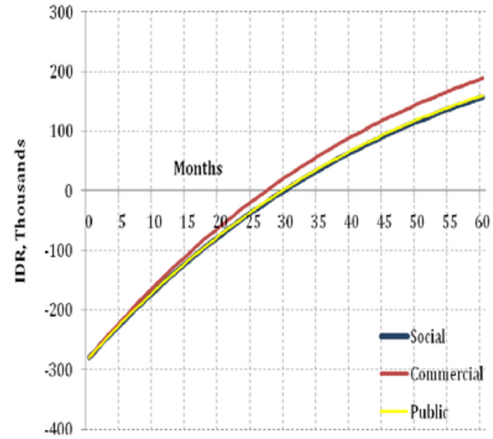

Figure. 3: NPV Difference for Refrigerant retrofit in Commercial, Social, and Public Sector

KWh calculation indicated largest total technical potential in commercial sector with a centralized AC, and the second potential is for industrial sector as shown in fig 2. This potential caused by the use of motor with large power capacity for their loads. Social sector and commercial sector indicated a similar KWh difference since both sector used split AC. Total energy savings potential was approximately 8.52 GWh in one year or 2.4% from total energy consumption, with assumption growth 6.75% per year. A research by Segreto concluded that combination of energy technology scenario can be used to increase energy efficiency as well as environment sustainability in industrial sector [15].

B. Refrigerant retrofit

Refrigerant retrofitting became necessary for economic and technical reasons, assuming that the refrigerant had as many similarities with the original as possible. The ban of some refrigerant had led the refrigerant retrofitting to become famous since 2010 [16]. This research project used hydrocarbon refrigerant as based calculation as it has had many advantages compared to other type of refrigerant. Data that we used for refrigerant retrofitting analysis was:

1. Split Air Conditioner operation average: 8 hours/day

2. Investment Cost IDR 280,000.-/hp

3. Cost of electricity IDR 1,300.- (normal time), IDR 1,500.- (peak time)

There was saving indicated from the NPV analysis in fig. 3., and this scenario was considered feasible, as the payback period was less than 30 months. Saving from this scenario was not high, however technical effort was also low. Therefor this scenario was worth considering to improve energy saving behavior. Energy saving potential is shown in fig. 4.

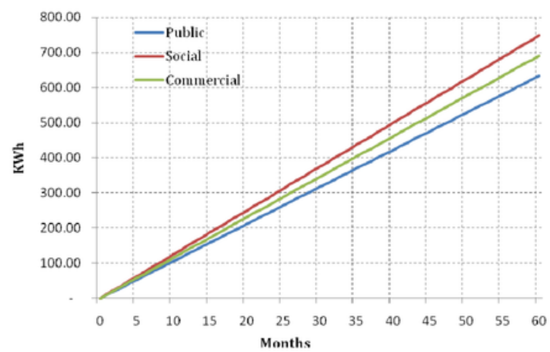

Figure. 4: KWh Difference for Refrigerant retrofit Commercial, Social, and Public Sector

C. Improving Imbalance Voltage

Imbalance voltage may occur in three-phase electricity sources. In three-phase system, electrical pulse were divided into three with 120º difference. However ideal condition may not be met, due to unbalance load and may reduce power quality [17]. Most industries were connected to the grid or used own generator with three-phase system. Perfectly balanced condition may never exist but should be minimized. Power quality improvement for three phase system needed a good evaluation and plan, therefore a consultant was needed

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for this scenario. Data and assumption that were used for this analysis:

1. Cost of consultant IDR 25.000.000,-
2. Energy saving potential 15,500 kWh/year

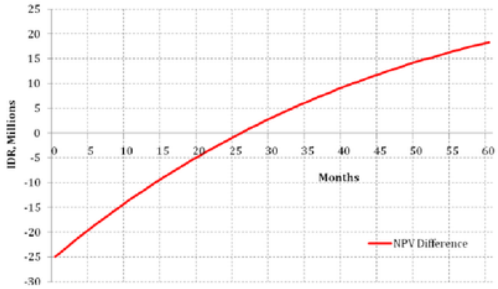

Figure 5: NPV Difference for Improvement of Unbalance Voltage in Industrial Sector

Pay back period for this scenario was less then 30 months, therefore it was considered feasible. Fig. 6. demonstrated energy saving was quite high, although the technical potential improvement was also high. Total energy saving was identified approximately 2.1 GW/year or 0.6% of total energy consumption with 6.75% growth per year. Energy saving potential is shown in fig. 6.

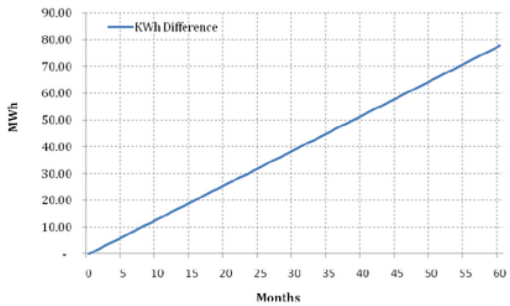

Figure. 6: KWh Difference for Improvement of Unbalance Voltage in Industrial Sector

D. Policy Scenario

Up-front with significantly high financial investment have been an issue in Yogyakarta and Indonesia in general. This condition was also worsening by the lack of financing scheme access, supporting investment and financing mechanisms were not available. Moreover integrated local policy to support incentive mechanism did not exist. Last but not least, lack of knowledge of the energy users about energy efficiency and conservation and low awareness on how to save energi [18]. The critical part of any energy management program is commitment to the saving of energy by the manager or owner that has not been a priority in most organizations in Indonesia. Policy options that was considered possible to help to increase financial capacity are:

1. Increasing financing by private/public financial institutions with improvement of portfolio lending such as revolving funds and guarantee funds.
2. Enhance private sector financing with two delivery instruments: leasing and energy service company performance contracts.
3. Promote trainings for managers in the respective sectors, and create a platform through regular seminars to exchange best practices.

Many methods of managing and conserving energy have been discussed in many researches. The critical part of any energy management program is commitment to the saving of energy by the manager or owner. These people must be convinced that energy management saves them money and is important for our energy resources. Managers and owners should always keep energy conservation in mind and develop realistic objectives for energy use. Direct link between business-friendly source and energy access was prerequisite for economic growth [19].

Table 6 a, b, c: Penetration Scenario for Commercial, Industrial, Social, and Public Sectors with different technology

(a)

Sector	Total Connection	Variable Speed Drive	
		Optimistic	Moderate
Commercial (Non-Star Hotel)	1030	40%	25%
Commercial (Hotel)	38	25%	15%
Industry	135	25%	15%
Social	63	40%	25%
Public	416		

(b)

Sector	Total Connection	Refrigerant Retrofit	
		Optimistic	Moderate
Commercial (Non-Star Hotel)	1030	35 %	25%
Commercial (Hotel)	38		
Industry	135		
Social	63	35 %	25%
Public	416	35%	20 %

(c)

Sector	Total Connection	Imbalance Voltage	
		Optimistic	Moderate
Commercial (Non-Star Hotel)	1030		
Commercial (Hotel)	38		
Industry	135	30%	20%
Social	63		
Public	416		

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Survey to access the willingness of all sector to apply the technology was presented in table 6, penetrating factor was assumed for optimistic and moderate based on the survey result. Further analysis was simulating the energy efficiency scenario with the penetrating factors. Table 6 indicated that non-star hotel was more optimistic to apply VSD technology than (Star) Hotel. Most star hotels used centralized AC that made high investment for VSD technology, while non-star hotels used split AC, with lower cost for VSD investment. The same condition was found for application of VSD in industry. VSD device must be installed in each motor in the industry, that increased investment cost. Hiring consultant to audit and recommend how to fix unbalance load was more interesting, that made higher penetrating factor. Social and public sectors had similar condition with non-star hotel. Public sector indicated that there was no interest in applying VSD due to the high investment cost.

Simulation result on implementing VSD, refrigerant retrofit and power quality improvement for imbalance voltage are shown for commercial, industrial, social and public sector:

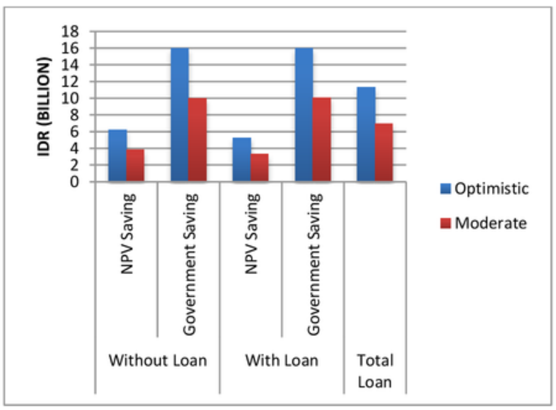

Figure. 7: Saving comparison for implementation of VSD

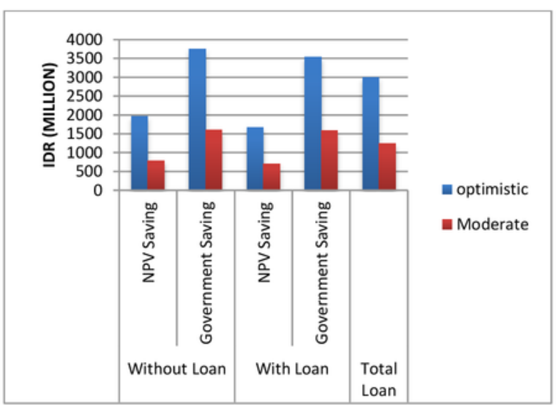

Figure. 8: Saving comparison for implementation of refrigerant retrofit

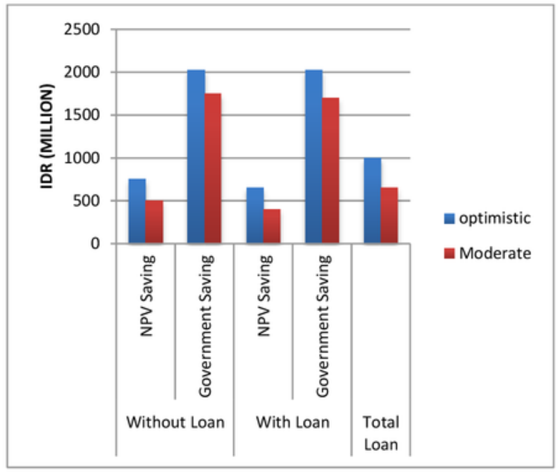

Figure. 9.: Saving comparison for imbalance voltage improvement

Saving existed in every sector as demonstrated in fig 7, fig 8 and fig 9, this was also accelerated by implementing energy efficiency equipment and policy. NPV saving decreased slightly between for loaned scenario, as a consequence of profit sharing to the fund supporting institution. However, this scenario was worth considering, for energy efficiency and conservation campaign. Government saving comparison only calculated the amount of subsidies (loan) to be borne but did not calculate saving from electricity tariffs increase.

There are several mechanism that were commonly available in DIY such as: principal investment.

1. Revolving Funds; use repaid loan funds are cycled back into the fund for relending for a new project. Money in the revolving fund is fully dedicated to energy efficiency lending. Revolving funds are typically publicly supported, through subsidized interest rates or through partial or full public funding of the principal investment.

2. Guarantee funds; help cover the credit risks associated with financing energy efficiency projects with a medium to long term. In such schemes, public or donor funding is pledged to guarantee some of the risk of principal repayment for these loans.

3. Lease; Energy-efficiency projects are frequently funded via capital leases, a financing structure under which an entity ("lessee") pays for equipment not at contract signing, but instead via scheduled installments to the capital provider ("lessor") over the term of the lease. One primary appeal of leasing as a means of funding is the flexibility leases afford in scheduling payments, which can be timed to coincide with projected energy cost savings from an Energy Performance Contracts (EPC).

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4. Energy Service Company (ESCO) Performance Contracts; In a case of performance contracting, the ESCO will perform an energy efficiency audit and develop recommendations and designs based on the audit. The ESCO will then secure financing for the project (upon agreement with the customer concerning recommendations). That financing typically will be based on the stream of energy cost savings that are expected as an outcome of implementing the recommended changes.

CONCLUDING ANALYSIS

Analysis indicated that energy efficiency and policy measures proposed in the project gave significant result. Two scenarios involving loan and without loan finance system also indicated an increase in energy saving, although financial saving decreased due to profit sharing. High risk transaction were common barrier for finance scenario from commercial banking system, moreover high equipment cost also played significant role in financing access to product and services. Following policy option were recommended to increase financial accessibility:

1. Government, related industry and organization must be involved to establish fund guarantee system.
2. Increase government intervention; establishing new financial institutions operating on preferential market terms, and introduce mechanisms to reduce the interest rate for commercial loan.
3. The main solutions to solving the problem of gaining the financial capital needed for implementation are to combine state guidance investment with social multi-channel investment.

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