International Journal of Electrical and Power Engineering 4 (1): 1-7, 2010
ISSN: 1990-7958

Potential Impact of Greenhouse Gas Emission Reduction Scheme on Australia's Electricity Generation Sector

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Abstract: Australia electricity industry is currently operating under Mandatory Renewable Energy Target (MRET) scheme since April 2001 in order to cope with continuous greenhouse gas emission growth. This scheme is designed to increase the application of renewable energy in Australia' electricity supply. In this study Australia's generation sector, MRET scheme and RET scheme are discussed with the technique of Artificial Neural Networks (ANN) to forecast the trend of the electricity generation, greenhouse gas emission under MRET scheme, RET scheme and energy saving scenario. Finally, the results of simulation, the challenge for the Australian electricity generation sector, when tackling the issue of greenhouse gas emission reduction discussed in this research.

Key words: Emission reduction, MRET scheme, RET scheme, artificial neural network, forecasting

INTRODUCTION

Global warming is one of the very important issues being discussed in the world in recent years. Many countries have proposed policies trying to reduce greenhouse gas emissions. After Kyoto Climate Change Summit in 1997, the Australian Government has also started taking action to deal with the problem of greenhouse gas emissions. In April 2001, the Australia Government introduced the World's first legislated national renewable energy scheme, known as the Mandatory Renewable Energy Target (MRET scheme). The MRET scheme focuses on the electricity sector, which contributes approximately 30% of total greenhouse emission in Australia. Under the MRET scheme, the amount of electricity required to generate from renewable energy resources is defined for every year of the scheme. The target increases incrementally from 2000-2010, reaching 9500GWh in 2010. In order to encourage more renewable energy resource applications and enhancement of the current MRET content, the Australia Government had announced to introduce an Expanded Renewable Energy Target (RET) scheme in 2008. RET scheme is simply an extension of the MRET scheme. Instead of the constant value (9500GWh) after 2010 under the MRET scheme, the target of electricity generated by renewable energy resources will keep increasing and reach 45000GWh in 2020 (Mascher, 2006). This study described Australia's generation sector, MRET scheme and RET scheme in detail. Followed by introduced the technique of Artificial Neural Networks (ANN) to forecast the trend of the electricity generation, greenhouse gas emission under MRET scheme, RET scheme and energy saving scenario presented in this study. Finally, from the results of the simulation, the challenge for the Australian electricity generation sector when tackling the issue of greenhouse gas emission reduction will be analyzed in this research.

MATERIALS AND METHODS

Structure of electricity generation sector in Australia: The abundant coal resource of Australia results in its heavy reliance on coal-fired power for its electricity generation, with 75% of the total electricity generated from coal resource at present. Black coal is using extensively in the state of NSW, QLD, WA and brown coal in VIC and SA. On the other hand, hydro-power was one of the main electricity generation technologies in Australia during 80s and early 90s, with about 10-15% of electricity generated from hydro power during that period. The share of hydro power within total electricity supply was gradually decreasing in recent years due to a lack of suitable sites for development. In addition, the drought in Australia of recent years caused the share of hydro-power to fall to its current level of about 6% of total electricity generation. Despite this, hydro-power contributes 15% of total installation capacity. Gas-fired power is a much more

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environmentally friendly energy resource for use in electricity generation as it produces much less greenhouse gas compared to coal-fired power therefore, gas-fired power became a popular energy resource applied for electricity generation recently in Australia. In 1990, only 7% of total electricity generated was from gas-fired power however, the percentage increased rapidly and reached 16% by the end of 2007. Gas-fired power is expected to be one of the important energy resources for future electricity generation in Australia.

Finally, Australia has been considered as one of the countries, which have great potential for developing renewable energy technology in electricity generation. But under the rich coal resource circumstance with high investment cost on renewable energy technology, renewable energy technology will find it difficult to compete against traditional energy resource such as coal and gas. The development of renewable energy for electricity generation has been very slow in Australia and in 1990, <0.3% of electricity is generated from renewable energy resource.

Figure 1 hadn't changed until the Australian Government introduced MRET scheme in 2000. Under MRET scheme, a clear target of the amount of electricity, which must be generated from renewable energy resources has been set for the years 2000-2020. Due to the strong encouragement from Government and enforcement of MRET scheme, 2% of total electricity generated in 2007 was from renewable energy resources. The main renewable energy resources applied for electricity generation in Australia is wind, biogas and solar power (ABARE, 2006).

Mandatory Renewable Energy Target scheme (MRET): After Kyoto Climate Change Summit in 1997, Australia Government started taking action to deal the problem of global warming. In April 2001, the Australia Government introduced the World's first legislated national renewable energy scheme, known as the MRET scheme. The MRET scheme focuses on the electricity sector, which contributes for approximately 30% of total greenhouse gas emission in Australia. The MRET scheme began to operate in 2000 and will conclude the operation in 2020. Its main objective is to encourage more electricity generated by renewable energy resources; leading to the reduction of greenhouse gas emission in Australia. Under the MRET scheme, the amount of electricity required to be generated from renewable energy resources is defined in every year of the scheme. The detail of the target increases incrementally from 2000-2010, reaching 9500GWh in 2010. This amount is then kept constant

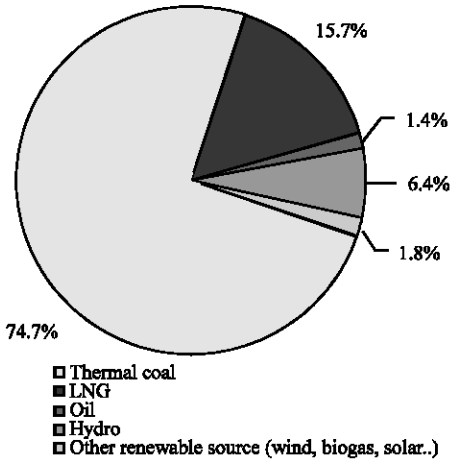

Fig. 1: Share of energy resource for electricity generation in Australia

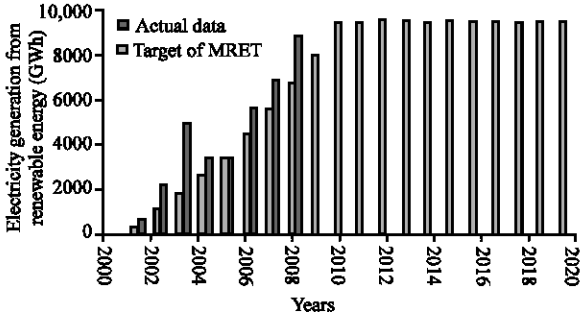

Fig. 2: Target of MRET scheme and performance

through to 2020, where the MRET scheme will conclude. The target in each year of MRET scheme is shown in Fig. 2. Under the MRET scheme, the renewable energy market has also been established in Australia. Electricity retailers and large buyers also known as liable entity will be legally required to purchase certain amount of electricity, which is generated by renewable energy resource. In the electricity market, Power Companies (also known as Eligible Source) creates Renewable Energy Certificate (REC) from the electricity generated by renewable energy resource. REC is a form of electronic currency, each representing one Megawatt Hour (MWh) of renewable energy generation. Then in each year of the scheme, liable entity is required to purchase certain amount of REC from an Eligible Source. The amount of REC required for a liable entity to purchase is calculated by Renewable Power Percentage (RPP).

If a liable entity fails to achieve the target, they will be penalized by paying the penalty fee for each REC, it falls below its target (Mascher, 2006). Australia's electricity generation sector is on track and has achieved

a great result under the current MRET scheme. Under the current trend, Australia's electricity generation sector expects to achieve the target without any difficulty. From the Fig. 2, it shows the Australian electricity generation sector generated 37108 units of REC in the operation of the first 8 years of MRET scheme. This not only cleared the target as defined under this period of MRET scheme (26100 units of REC), it actually generated much more than expected. The surplus of these REC units can be reserved and use to compensate the shortage that may happen in the latter part of the MRET scheme (OREG, 2009).

Renewable Energy Target scheme (RET): Recently, Australia Government conducted the review on MRET scheme. From the review, it indicates Australia is on track and will achieve the target without much difficulty. But the Australian Government believes the reduction of greenhouse gas emission in Australia will not receive much benefit by applying the current MRET scheme, also Government believes Australia has much more potential then the target defined in MRET scheme. Therefore, in 2008, the Australian Government suggested new greenhouse emission reduction scheme, known as Renewable Energy Target (RET) scheme, which is simply an extension of the MRET. Instead of the constant value (9500GWh) after 2010 under MRET scheme, the target of electricity generated by renewable energy resources will keep increasing and reach 45000GWh in 2020. This amount will keep constant through to 2030, where the RET scheme will conclude. The detail of the target in each year of RET scheme is given in Fig. 3. RET scheme is currently under review in Parliament and is scheduled for legislation this year (ADCC, 2009).

Artificial Neural Network (ANN): An Artificial Neural Network (ANN) is a very attractive technique in solving engineering problems, especially for the problem including complex non-linear characteristic. ANN has ability by learning from the relationship between input and output pattern to formularize the problem. This feature is especially useful, when solving problems in forecasting. The most commonly used architecture of ANN in power system is the feed forward Multi Layer Perception (MLP) with Back Propagation (BP) learning algorithm. This network architecture has been widely used for different power system applications, in particular load forecasting (Doulai and Cahill, 2001). Therefore, this type of ANN architecture been applied to forecast the electricity generation in Australia during 2008-2020 in this research. Furthermore, based on the forecasting result of the electricity generation, we then analyze the trend of greenhouse gas emissions in Australia under the MRET

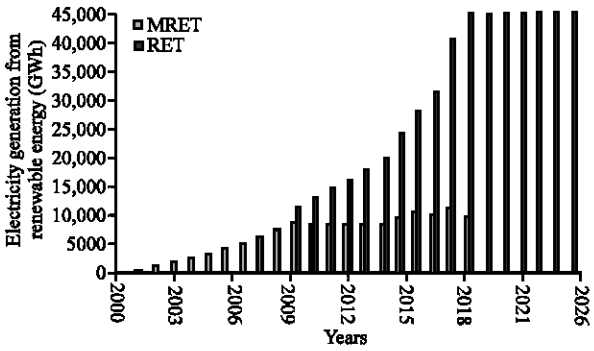

Fig. 3: Target of MRET and RET scheme

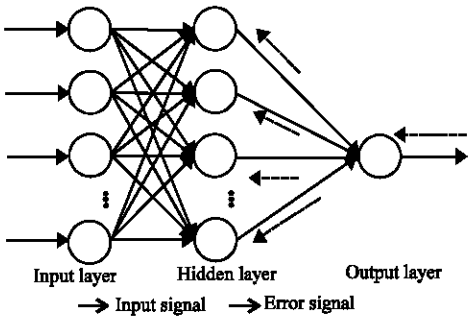

Fig. 4: Flow of signal of ANN with BP Algorithm

and RET scheme. The structure of an ANN with BP learning algorithm is shown in Fig. 4. This structure contains three layers: the input layer, hidden layer and output layer. The nodes within each layer are fully connected to the previous layer. For the BP algorithm, the input data is transmitted through the network, layer by layer until output is calculated. The calculated output is compared to the desired output value to generate the error signal, this error signal is then propagated backward through the hidden layers changing or adjusting the weight and biases in each layer in order to reduce the level of the error signal. The network will train continuously until the desired level of error will be achieved. Once the optimum result is achieved the network will be ready to apply for forecasting problem (Yi *et al*., 2008; Adepoju *et al*., 2007).

Model of ANN in this research: Training is the one of important processes for calibrating the neural network. By having a sufficient and relevant input data for neural network training, accuracy of the forecasting result can be improved significantly. From historical data, we established the elements GDP (Gross Domestic Product), Population, Household Number, Past Electricity Generation Data (total, maximum), Index of Industrial Movement and Weather Data to have a high correlation with the level of electricity generation in Australia, which

make them important factors when forecasting the level of electricity generation. In this research, we applied the historical data from 1980-2003 of the above mentioned elements to the input of the forecasting model. Then, proposed neural network models were trained and tested extensively using different numbers of hidden layers until the most accurate result achieved (Al-Mamum *et al*., 2004; NIEIR, 2008; ABARE, 2006).

RESULTS AND DISCUSSION

Forecasting of 2008-2020 electricity generation in Australia: The real market data of electricity generation during 2004-2007 applied as the testing data for measuring the accuracy of the created forecasting model in this research. The forecasting result was comparing to the actual market data and the result as given in Table 1. The error generated as shown in the Table 1 was small enough to be considered ready to apply for future forecasting problem (2008-2020).

According to the result of simulation, base on the strong growth in population and economic development, the electricity generation in Australia will expect to reach to 329280GWh in 2020 (22.9% increase in 2008-2020) (Fig. 5). Although, recent economic recession drag down the electricity generation, Australia electricity generation still consider as the key player of greenhouse gas emitter in overall.

Forecasting 2008-2020 greenhouse gas emission under MRET scheme: From the result of simulation, the greenhouse gas emissions generated by the electricity generation sector in Australia achieved a significant slow down since they began to adopt the MRET scheme in year 2000. The greenhouse gas emission has steadily increased during the 2000-2010 period.

It is expected to reach 240MT of CO_2 equivalent in year 2010 (Fig. 6). But unfortunately, the rate of emission will keep increase after 2010 since there is no further target on increasing renewable energy electricity under the MRET scheme. 269MT of CO_2 equivalent is expected to be generated by 2020, which is a 94 MT increase (53% increases) from year 2000. From the result of the simulation, we understand by keeping the constant target of renewable energy electricity after 2010 is leading to the problem. Without the efficient renewable energy target of reduction scheme, the greenhouse gas emission problem can not be solved.

Forecasting 2008-2020 greenhouse gas emission under RET scheme: The Australian Government is aware of the problem with MRET scheme, therefore Expanded Renewable Energy Target (RET) scheme was proposed

Table 1: Forecasts error 2004-2007

Parameters	2004	2005	2006	2007
Actual data (GWh)	225396	231235	237074	244223
Forecast result (GWh)	237548	241829	248322	259083
Error (%)	5.4	4.6	4.7	6.1

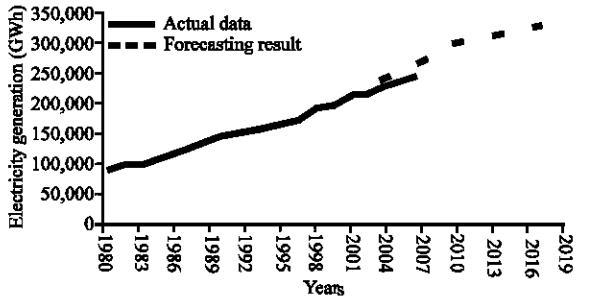

Fig. 5: Electricity generation forecasting 2008-2020

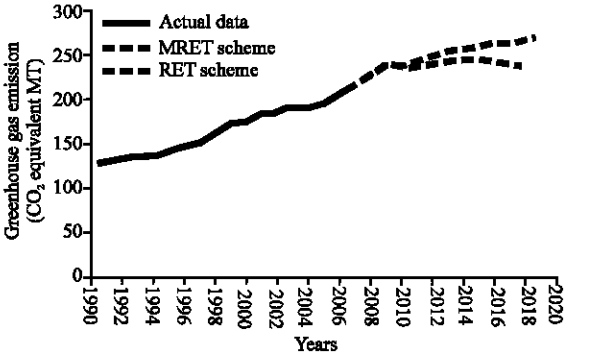

Fig. 6: Greenhouse gas emission generation forecasting under MRET, RET scheme

in 2008. RET scheme simply is an expansion of MRET scheme. The clear incremental target of electricity generate by renewable energy in the 2010-2020 period is defined under RET scheme.

Under the current RET proposal, 45000 GWh of electricity will be generated by renewable energy in year 2020, which is 4.7 times more then the current target under MRET scheme.

From the result of simulation, the rate of increase in greenhouse gas emission will achieve a significant slow down during the period 2010-2020 after adoption of the RET scheme (Fig. 6).

Especially after 2016, not only slow down the increasing rate but the greenhouse gas emission actually start to decrease to 237MT of CO2 equivalent in 2020, which is 32MT less compare to MRET scheme. Although, the great achievement on emission reduction expected under RET proposal, 4.7 times more amount of the target (9500GWh under MRET) becomes a great challenge. Whether the power system and electricity market in Australia can be sustainable will become a great challenge.

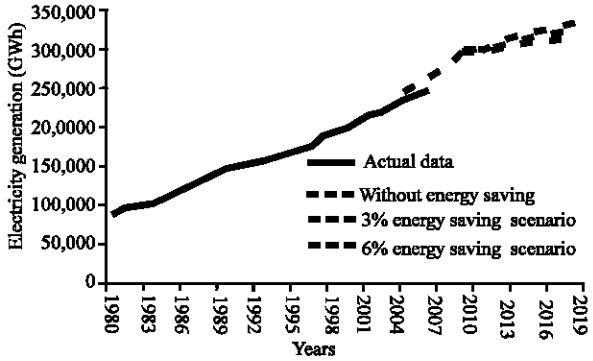

Fig. 7: Electricity generation forecasting under energy saving scenario

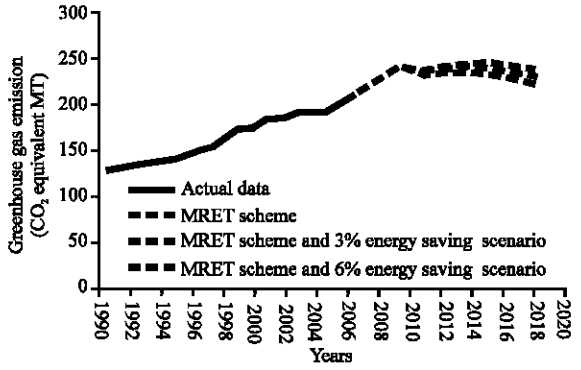

Fig. 8: Greenhouse gas emission forecasting under MRET scheme with energy saving scenario

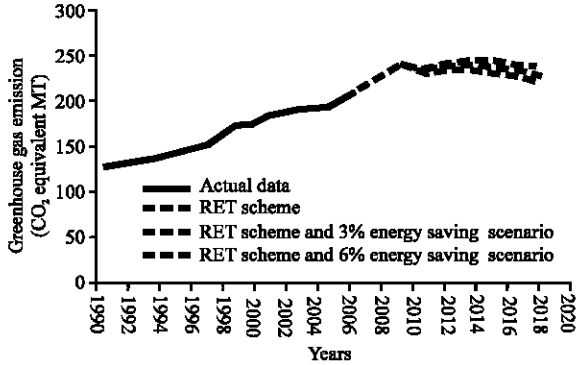

Fig. 9: Greenhouse gas emission forecasting under RET scheme with energy saving scenario

Forecasting 2010-2020 greenhouse gas emission under energy saving scenario: Apart from increasing renewable energy resources to reduce greenhouse gas emissions in electricity generation, decreasing electricity consumption (energy saving) can be an alternative solution for solving the problem of greenhouse gas emission reduction. In recently years, many countries proposed different policies to emphasize the serious problem of global warming to the general public and to encourage a reduction of electricity usage. Beside the MRET and RET scheme, we analyzed the performance of greenhouse gas emission reduction by including the scenario of energy saving in this research. Two scenarios were chosen in this research 3 and 5%, respectively. The 3% scenario represented a 3% increase in electricity generation between years 2010-2020. By the same token, the 5% scenario represented a 5% increase of electricity generation in the same future period. According to the previous forecasting result (Fig. 5), the electricity generation is expected to increase from 296291GWh to 329860GWh (11.3% increase) by 2020 without energy saving scenario applied. The level of electricity generation when energy saving scenario applied were given in Fig. 7. According to the simulation result, the reduction of greenhouse gas emission will be more effective by including the energy saving scenario into the electricity generation. About 3-9% reduction of emissions was achieved under different scenario combinations (Fig. 8 and 9).

The detail of greenhouse gas emission reduction under each scenario is summarized in the Table 2. According to the simulation result, since the target of renewable energy in the RET scheme (45000GWh) is 4.7 times larger than that under MRET scheme, an energy saving scenario of 11% is required in order to achieve the same emissions reduction under the RET scheme. From the result of the simulation, we understand besides the need for renewable energy resources, energy saving is also an important issue need to look at, when dealing with the greenhouse emissions reduction scheme.

Table 2: Greenhouse gas emission forecasting under different scheme and energy saving scenario

Schemes	2010 (MT)	2015 (MT)	2020 (MT)	2010-2020 (%)
MRET	243	256	269	+26MT (10.70)
RET	243	245	237	-6MT (-0.02)
Scenario 1	243	254	260	+17MT (7.00)
Scenario 2	243	245	251	+8MT (3.30)
Scenario 3	243	239	228	-15MT (-6.20)
Scenario 4	243	235	220	-23MT (-9.50)

Scenario 1: MRET scheme and 3% energy saving scenario; Scenario 2: MRET scheme and 6% energy saving scenario; Scenario 3: RET scheme and 3% energy saving scenario; Scenario 4: RET scheme and 6% energy saving scenario

Challenge for electricity industry under emission reduction scheme

Low electricity price remain: Since the Australian electricity industry reform began in 1996, the competition mechanism introduced into the generation and retail sectors of electricity industry lead the electricity price to decline substantially. The average price fall of about 20%

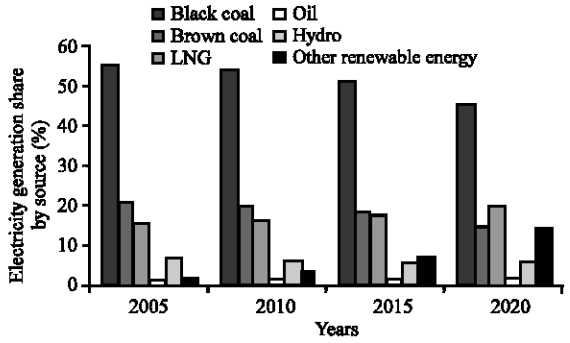

Fig. 10: Share of energy source in Australia electricity generation sector 2005-2020

lead Australia to have some of the lowest electricity prices among the International Agency (IEA) member countries. Currently Industrial and household electricity prices are 38 and 31% below the average, respectively across the IEA member countries (ERIG, 2007). But due to the high cost of investment to include renewable energy technology in the electricity generation sector, many people are asking will the electricity price remain in the low level? Will the renewable energy technology harm the economic growth in Australia? The Australian Govt. understands and is aware of the risk and is currently working on a new proposal to try and minimize the impact on the current electricity market. The economic aspect was not covered in this research. But in real world, electricity price is an important factor that needs to be considered when introducing renewable energy into the electricity market. The interaction between the environment and economic aspect of renewable energy resource in electricity generation will be studied by the researchers in coming research.

Construction of renewable energy technology remain keep in line with RET scheme: Under RET scheme, the target of electricity generated by renewable energy resource will reach 45000MWh in 2020, which is almost 5 times more then the target under the MRET scheme. Therefore, whether the constructions of renewable energy technology for electricity generation in Australia can keep in line with the target of RET scheme will become a great challenge.

Currently, there is 2.5% of total electricity generated by renewable energy technology in 2008 but the percentage will climb up to about 15% in 2020 according to the result of simulation (Fig. 10). With that big amount of electricity generated by renewable energy technology, whether the power supply in Australia remains stable is becoming the other great challenge.

CONCLUSION

Australia's electricity generation sector is on track and has achieved a great result under the current MRET scheme. The emissions generated by the electricity generation sector in Australia achieved a significant slow down since they began to adopt the MRET scheme in year 2000. But unfortunately, according to the forecasting result, the rate of emission will keep increasing after 2010 since there is no further target on increasing renewable energy electricity under the MRET scheme. The Australian Government is aware of the problems with MRET, therefore RET scheme was proposed. RET simply an expansion of MRET scheme, the current RET scheme proposal, 45000 GWh of electricity will be generated by renewable energy in year 2020. From the result of forecasting, the rate of increase in emission will achieve a significant slow down during the period 2010-2020 after adoption of the RET scheme. Especially after 2016, not only slow down the increasing rate but the emission actually start to decrease. Although, the great achievement on emission reduction expected under RET proposal, nearly 5 times more then the target of current MRET becomes a great challenge. Whether the power system and electricity market in Australia can be sustainable will become a great challenge. From the result of simulation, apart from increasing renewable energy resources to reduce greenhouse gas emissions in electricity generation, decreasing electricity consumption can be an alternative solution for solving the problem of greenhouse gas emission reduction.

Renewable energy is the important resource for tackling the greenhouse gas emission problem but how to address the transition process under renewable energy scheme is very important. Establishing the appropriate target of emission reduction scheme is a complex issue, not only consider from the engineering aspect, economic, commercial, society and government policy are all equally important and need to be consider.

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