MULTI-LEVEL FINANCIAL ANALYSIS OF RESIDENTIAL WATER AND WASTEWATER RATES AND RATE SETTING PRACTICES IN NORTH CAROLINA

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ABSTRACT

North Carolina utilities use many different rate structures and practices under an economic regulatory framework that has few rate setting standards. These different structures have financial impacts on utility revenue stability, customer expenditures, and water use behavior. Different rate strategies influence resource use differently and conversely efforts to impact resource use (for example, conservation) have unique revenue impacts depending on a utility’s type of rates and customer base. For example, for some rate structures, conservation leads to a disproportionately high drop in revenues. This paper presents the results of the first of a series of research tasks that will examine North Carolina water and wastewater utilities’ rates and rate setting in the context of the impact they have on utility financial health, customer financial capacity, and resource use. Rate schedules for 344 government-owned water and wastewater utilities were collected and entered into a computer model that automates the process of calculating the water or wastewater residential customer bill for different customer classes served by utilities throughout North Carolina, based on any quantity consumed by the customer. The development of the model represents a breakthrough in the methodology for carrying out large sample size utility rate surveys. Based on a sample of 283 municipal utilities, the median monthly-equivalent customer bill charged by utilities for “inside” customers for 6,000 gallons for water was $21.08 and $25.54 for wastewater in 2004. Between 2002 and 2004, 75% and 77% of municipalities increased their water and wastewater customer bills at 3,000 gallons of consumption, respectively. In subsequent phases of the research, information from the model will be combined with information from existing financial and environmental databases maintained by other organizations to compare the modeled customer billed amount to other indicators, such as the community median household income. Utility managers can use this information to gauge the impact their rates will have on households in their community. The research will eventually be used to identify key trends and causal relationships inherent in the state’s current rate practices. The models and analyses will be used to project the financial impacts – at the state, utility and household levels – of policy options currently being considered by local governments, state regulators, and funding agencies, such as statewide conservation efforts, or changing the eligibility criteria for different sources of funding.

KEYWORDS

Rates, rate structures, rate setting, revenues, household expenditures, financial planning, models

INTRODUCTION

North Carolina government-owned water and wastewater utilities collected more than $1.4 billion dollars from their customers in 2002\(^1\), yet utilities still report backlogs of funding needs with recent 20-year capital need estimates exceeding $11 billion dollars (North Carolina Rural Economic Development Center, 1998). North Carolina utilities use many different rate strategies and practices under an economic regulatory framework that has few rate setting standards (NCLM, 2002; Hughes, 2003). These different strategies and structures have financial impacts on revenue stability and customer expenditures. Different rate strategies influence resource use differently and, conversely, efforts to impact resource use (for example, conservation) have unique revenue impacts depending on a utility’s rate structure and customer base. Furthermore, different rate structures have a fundamental impact on how revenue requirements are

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\(^1\) Based on the authors’ calculations on data received from the Local Government Commission and a memorandum produced by the Commission (2004).
allocated among customer classes and customers with different usage patterns. An emerging issue for many utilities is how to mitigate the impacts of rates on low-income customers – a utility’s rate structure can play a major role in determining the amount low-income customers must pay to meet their basic needs.

Despite the importance of these relationships, little analytical work has been done to examine rates and rate setting in the context of the impact they have on utility financial health, customer expenditures, and resource use. This research begins to address that knowledge gap. This paper documents the early stages of an extended research project to study rate setting practices and the impact rates and rate setting practices have on household and utility finances in different parts of the state. The first phase focuses on inventorying current rate structures, particularly residential rate structures and developing a model that can be used to calculate residential water and wastewater bills as a function of consumption for utilities throughout the state. This paper documents the process of preparing this inventory and presents select summary findings using 2004 rates. In subsequent phases of the research, all of the rate data will be combined with information from existing financial and environmental databases maintained by other state agencies and organizations, to understand the driving forces behind rate setting in North Carolina and to assess the impact rate structures have on utility financial health and customer expenditures. Ultimately, models resulting from the research will be able to project the financial impacts – at the state, utility and household levels – of policy options currently being considered by local governments, state regulators, and funding agencies, such as statewide conservation efforts, or changing the eligibility criteria for different sources of funding.

**METHODOLOGY**

The first task of the research was to develop a model that calculates water/wastewater customer bills as a function of the quantity consumed, for all government-owned utilities in the state. To accomplish this goal, information from rate schedules from government owned utilities was collected and programmed into a household expenditure model.

In order to collect the necessary rate information, the Environmental Finance Center (EFC) collaborated with the consulting teams working on the Water 2030 initiative being carried out by the NC Rural Center. As part of the initiative, the consulting teams collected rate schedules for fiscal year 2004-2005 from the state’s government-owned utilities in November 2004. After several months of data collection, the consulting teams were able to collect, among other information, the rate schedules for approximately 225 utilities which they scanned and provided to the EFC.

The EFC examined dozens of the rate schedules and identified the key common variables needed to design the model. Key information included the water or wastewater variable rate, block ranges and rates, constant or meter-based fixed charges, quantity-based minimum charges and their corresponding quantities, and the billing period. A database was designed to differentiate the fields for water and wastewater, as well as for rates being charged for customers residing within the city limits (“inside customers”) or outside the limits (“outside customers”).

Following the design of the database, the EFC worked with staff members from the North Carolina League of Municipalities (NCLM) to examine the rate schedules and enter in necessary information from each rate schedule into the database. Initially, only data pertaining to rates charged to single-family residential customers were entered. In most cases, the information was clearly listed in the rate schedule, but in other cases the EFC and NCLM staff was required to make back-calculations or follow-up phone calls to interpret the rate schedules correctly and collect missing necessary information. Phone calls were also made to approximately 125 municipalities who had provided the NCLM with rate schedules in 2002, but whose current rate schedules were not provided by the Water 2030 consulting teams. These municipalities faxed their rate schedules, and the necessary information was entered into the database. In total, rate information from 283 municipal and 61 non-municipal utilities for fiscal year 2004-2005 was collected and used in the first part of the research.
A spreadsheet model was then developed to compute the water and/or wastewater monthly-equivalent bill using the data exported from the database and input variables such as the type of bill (water, wastewater or combined), the high or low season, bills for customers residing inside or outside the city limits, the meter size of the residential unit and the quantity of water billed per month for the household. Each input variable is categorical with a set of alternatives from which the user could make only one discrete choice, except for the quantity consumed which is set as a continuous variable. After the user enters in the consumption amount and descriptive variables, the model generates results in output tables for all 344 utilities. The program hence automates the process of reading and understanding the rate structure for each utility and computing the residential customer bill for any quantity of water consumed for all utilities in the database. The use of a model to automate household expenditures for rate surveys has been discussed, but to date, the authors are unaware of any major rate survey that includes an automated household expenditure model.

Several important data cleaning steps were required for quality control. The first data cleaning step was included at the end of data entry into the database, using 62 queries, many of which contained several sub-queries, to check that data are entered only in the valid fields based on selections made in other fields. For example, there should not be any data in the fields for block rates if the utility has a uniform rate structure, and consequently the uniform rate must be greater than zero in this case. This step was important in detecting transcription errors as well as systematic errors based on the data entrant’s misunderstanding, for which additional training was implemented. The data cleaning step also helped in eliminating errors which would have caused the spreadsheet model to miscalculate the residential customer bills, since the model relies on the data in specific fields from the database in computing the bills. The quality check step included randomly selecting 20% of the utilities and manually computing their water and wastewater bills from their scanned rate schedules for four discrete quantities of water consumed per month (0 gallons, 3,000 gallons, 6,000 gallons and 12,000 gallons), for both inside and outside customers, and comparing the results with the output of the computer model. A 100% accuracy goal was targeted.

In order to understand the motives influencing water and wastewater utilities in setting their rates and rate structures, a survey was designed to collect information on rate setting practices from utilities. A review of literature on factors influencing utilities’ choices of rate structures revealed that very little research on the subject has been done (one example is Hewitt, 2000). However, other sources of information were used in determining utility-level characteristics that may be correlated with rate structures and high or low rates (Dziegielewski, Kiefer and Bik, 2004; Mississippi State University Extension Service, 2004; Raftelis, 2004a; Raftelis, 2004b; New Hampshire Public Utilities Commission, 2003). The survey was developed to collect first-hand accounts of the practices and the reasons for modifying the rate schedules, as well as utility-level characteristics that may implicitly influence practices.

In the second phase of the research, information on each utility’s rates and rate structures will be combined with the information captured by a rate setting practices survey as well as additional utility-level and community-level data available from other sources including the Environmental Protection Agency, the US Census Bureau, and the North Carolina Local Government Commission. Using data from all these sources, econometric models will be developed to explore relationships between utility-level characteristics and the use of specific rate structures or high or low rates for different utilities. Comparisons between neighboring utilities will be conducted using G.I.S. analyses, and simulation models will be used to model changes to utilities’ revenues and customer bills based on different policy objectives and scenarios, such as a continued decline in per-customer consumption of water.

RESULTS

The utilities that were inventoried and entered into the household expenditure model were divided into municipal and non-municipal utilities. Preliminary results for 283 municipal utilities were used for the analyses in this paper using fiscal year 2004-2005 rates. This set will be combined with the non-municipal utilities and updated using 2005-2006 rates in future publications. Some of these results were published in a memo to the NCLM member municipalities in collaboration with the authors (NCLM and EFC, 2005).
Water and Wastewater Rate Structures

Of the 283 municipal utilities analyzed, 276 utilities served water customers and 254 served wastewater customers, the majority of utilities serving both water and wastewater customers. Most of the utilities employed a uniform rate structure in 2004, while almost all of the other utilities employed an increasing block or decreasing block rate structure. A uniform rate structure is one in which the rate, or per-unit price, of water or wastewater at which the household is charged is constant for all quantities; for example, $3.00 for each 1,000 gallons of consumption. An increasing block rate structure increases the rate at which water and wastewater is charged based on the level of consumption, designed in a block format. For example, a utility may charge a block rate of $2.50 per 1,000 gallons of consumption for all quantities up to 5,000 gallons, and a greater block rate of $4.00 per 1,000 gallons for quantities consumed above and beyond 5,000 gallons. A decreasing block rate structure, conversely, is one in which the rate of water and wastewater is decreased as consumption is increased. Of the 276 water utilities, 155 used uniform rate structures, 70 used decreasing block rate structures, 49 used increasing block structures, and 2 water utilities used seasonal uniform rates (in which the uniform rate is higher during the summer months than in the winter months). Similarly, of the 254 wastewater utilities, 198 used uniform rate structures, 26 used increasing block rates, 25 used decreasing block rates and 5 used flat fees or tiered flat fees.

In addition to the variable rates, utilities often include non-variable charges, which are non-consumption based fixed charges and/or consumption-based minimum charges. Fixed charges are fees added directly to the water or wastewater bill. Minimum charges are constant fees charged for any quantity consumed within a small initial block; for example, a customer would be charged $12.00 if she uses any quantity between 0 and 2,000 gallons in a month, and all consumption above this quantity would be charged at the uniform or block rate, hence the customer would always be charged a “minimum” of $12.00, based on her level of consumption.

In North Carolina, fixed charges and minimum charges are higher for small water and wastewater utilities than for larger utilities. The utility-median fixed and minimum charges for inside water customers are shown in Table 1, and for wastewater customers in Table 2, based on the population size of the municipality the utility serves. Small utilities more frequently employed minimum charges than larger utilities, which more often added fixed charges.

### Table 1  Non-Variable Water Charges for 276 Municipalities, by Municipal Population

<table>
<thead>
<tr>
<th>Municipal Population</th>
<th>Number of Water Utilities</th>
<th>Utility-Median Fixed (Non-Consumption Based) Charge</th>
<th>Percent of Utilities with Fixed Charge</th>
<th>Utility-Median Minimum (Consumption-Included) Charge</th>
<th>Utility-Median Gallons Included</th>
<th>Percent of Utilities with Minimum Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1,000</td>
<td>75</td>
<td>$8.23</td>
<td>17%</td>
<td>$13.00</td>
<td>2,250</td>
<td>85%</td>
</tr>
<tr>
<td>1,000 - 2,499</td>
<td>66</td>
<td>$9.00</td>
<td>24%</td>
<td>$11.00</td>
<td>2,000</td>
<td>80%</td>
</tr>
<tr>
<td>2,500 - 4,999</td>
<td>48</td>
<td>$8.00</td>
<td>25%</td>
<td>$12.15</td>
<td>2,375</td>
<td>73%</td>
</tr>
<tr>
<td>5,000 - 9,999</td>
<td>34</td>
<td>$6.32</td>
<td>29%</td>
<td>$10.01</td>
<td>2,375</td>
<td>76%</td>
</tr>
<tr>
<td>10,000 - 24,999</td>
<td>29</td>
<td>$5.50</td>
<td>48%</td>
<td>$8.55</td>
<td>2,000</td>
<td>52%</td>
</tr>
<tr>
<td>25,000+</td>
<td>24</td>
<td>$4.67</td>
<td>92%</td>
<td>$4.73</td>
<td>2,125</td>
<td>8%</td>
</tr>
<tr>
<td>Number of Municipalities with Charge</td>
<td>195</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2  Non-Variable Wastewater Charges for 254 Municipalities, by Municipal Population

<table>
<thead>
<tr>
<th>Municipal Population</th>
<th>Number of Wastewater Utilities</th>
<th>Utility-Median Fixed (Non-Consumption Based) Charge</th>
<th>Percent of Utilities with Fixed Charge</th>
<th>Utility-Median Minimum (Consumption-Included) Charge</th>
<th>Utility-Median Gallons Included</th>
<th>Percent of Utilities with Minimum Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1,000</td>
<td>56</td>
<td>$10.35</td>
<td>25%</td>
<td>$14.00</td>
<td>2,000</td>
<td>70%</td>
</tr>
<tr>
<td>1,000 - 2,499</td>
<td>65</td>
<td>$11.00</td>
<td>29%</td>
<td>$12.25</td>
<td>2,000</td>
<td>69%</td>
</tr>
<tr>
<td>2,500 - 4,999</td>
<td>48</td>
<td>$8.29</td>
<td>46%</td>
<td>$12.15</td>
<td>2,500</td>
<td>52%</td>
</tr>
<tr>
<td>5,000 - 9,999</td>
<td>33</td>
<td>$8.00</td>
<td>39%</td>
<td>$13.12</td>
<td>2,750</td>
<td>55%</td>
</tr>
<tr>
<td>10,000 - 24,999</td>
<td>29</td>
<td>$6.16</td>
<td>62%</td>
<td>$8.85</td>
<td>2,000</td>
<td>38%</td>
</tr>
<tr>
<td>25,000+</td>
<td>23</td>
<td>$6.12</td>
<td>87%</td>
<td>$3.93</td>
<td>3,000</td>
<td>4%</td>
</tr>
<tr>
<td>Number of Municipalities with Charge</td>
<td>139</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Water and Wastewater Rates

Because of the common use of consumption-included minimum charges, the marginal price of water for the majority of utilities is low for small consumption levels, and increases after the consumption-included quantity is used up. Marginal price is defined in this paper as the rate at which the next additional 1,000 gallons are charged, calculated as the difference in the residential customer bill for the next 1,000 gallons reflecting both non-variable and variable rates. Figure 1 indicates that the median marginal price of water among North Carolina municipalities remained constant as consumption increased past the minimum consumption-included quantity. The utility-median marginal price of water for customers inside municipal limits was $2.50 per 1,000 gallons at 6,000 gallons, and $4.00 per 1,000 gallons for outside customers.

Fig. 1: Utility-Median Water Marginal Price per 1,000 Gallons at Various Consumption Levels for 276 Municipalities

![Utility-Median Water Marginal Price per 1,000 Gallons at Various Consumption Levels for 276 Municipalities](image)

The utility-median marginal price of wastewater for customers inside municipal limits was $3.10 per 1,000 gallons at 6,000 gallons, and $4.53 per 1,000 gallons for outside customers (see Figure 2).

Fig. 2: Utility-Median Wastewater Marginal Price per 1,000 Gallons at Various Consumption Levels for 254 Municipalities

![Utility-Median Wastewater Marginal Price per 1,000 Gallons at Various Consumption Levels for 254 Municipalities](image)

6,000 gallons is the typical level of monthly residential consumption.
Water and Wastewater Monthly-Equivalent Residential Customer Bills

The median utility monthly-equivalent residential customer bill for inside customers at 6,000 gallons for water was $21.08 for the 276 municipalities, and for wastewater was $25.54 for the 254 municipalities in fiscal year 2004-2005. The median monthly-equivalent bill at 6,000 gallons for outside customers was $32.85 for water and $38.39 for wastewater. For utilities that have different outside rates than inside rates, the median outside-to-inside water and wastewater bills ratios were almost 2:1. The difference between the median inside and the median outside bills at various consumption levels increased as the quantity increased (see Figures 3 and 4).

Fig. 3: Utility-Median Monthly-Equivalent Residential Customer Water Bill at Various Consumption Levels for 276 Municipalities

Fig. 4: Utility-Median Monthly-Equivalent Residential Customer Wastewater Bill at Various Consumption Levels for 254 Municipalities

Of the 283 municipalities in the database, the authors had billing information from 2002 for some consumption levels for 231 of these municipalities (NCLM, 2002). Each municipality’s customer billing amount in 2002 and in 2004 for each of the listed discrete quantities were compared, and statewide trends in municipal water and wastewater rates were determined.
Of the 226 municipalities that charged for water in both years, 185 (82%) had either increased or decreased their water rates between 2002 and 2004. There were 96 municipalities (42%) that increased their customer bills by more than 5% for all quantities of water for inside customers. Two utilities more than doubled their inside bill charges, while four utilities more than doubled their outside bill charges between 2002 and 2004. There were, however, nine municipalities (4%) that have decreased their rates for their inside customers, and 10% for outside. The utility-median percentage increase in bills and the percentage of municipalities that have increased their customer bills for water and wastewater for each of three discrete quantities are shown in Table 3.

Table 3  Median Percentage Increase and Percent of Municipalities that have Increased their Residential Customer Bill for Water and Wastewater Services Between 2002 and 2004

<table>
<thead>
<tr>
<th></th>
<th>Median Increase in Bill Amount</th>
<th>Percent of Municipalities that have Increased their Bills</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inside City Limits</td>
<td>Outside City Limits</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 gallons</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>3,000 gallons</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>10,000 gallons</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Wastewater</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 gallons</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>3,000 gallons</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>10,000 gallons</td>
<td>10%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Of the 201 municipalities that charged for wastewater in both years, 170 (85%) had changed their wastewater rates between 2002 and 2004. There were 85 municipalities (42%) that increased their customer bills by more than 5% for each quantity of wastewater for inside customers. Four utilities more than doubled their inside bill charges, while five utilities more than doubled their outside bill charges between 2002 and 2004. There were, however, 15 municipalities (7%) that have decreased their rates for their inside customers, and 10% for outside.

An inverse cumulative distribution function reveals that for a given consumption quantity, in this case 3,000 gallons, customer bills have increased for the vast majority of the 226 municipalities serving water (75%, see Figure 5), while there has also been a substantial number of municipalities that have increased their residential customer bills significantly. For instance, 10% of the municipalities increased their bill charges for 3,000 gallons of water by at least 60%. Similarly, 10% of the municipalities increased their bill charges for 3,000 gallons of wastewater by at least 60% (see Figure 6). Overall, a slightly greater percentage of municipalities increased their residential customer bills for 3,000 gallons of wastewater (77%) than for water.
Fig. 5: Increases in Customer Water Bills for 3,000 Gallons Among 226 Municipalities from 2002 to 2004

Fig. 6: Increases in Customer Wastewater Bills for 3,000 Gallons Among 201 Municipalities from 2002 to 2004

Multi-level Financial Analysis of Residential Water and Wastewater Rates and Rate Setting Practices in North Carolina
DISCUSSION

Strengths and Weaknesses in the Methodology

This research represents, to the authors’ knowledge, the first time an attempt has been made to standardize rate information across hundreds of utilities and automate the process of modeling the residential customer expenditures on water and wastewater based on a continuous quantity variable. In previous rate surveys (e.g.: Raftelis, 2002; NCLM, 2002), the common practice of computing the customer bills was to use one of two methods: requiring the respondent of a survey that is sent to the utility to specify what the customer bill is for a few (usually three or four) pre-selected quantities of consumption (e.g.: at 0 gallons, 3,000 gallons and 6,000 gallons), or requesting the rate schedule from a utility so that the researchers would themselves manually compute the customer bill for a few pre-selected quantities of consumption. Aside from the time-consuming nature of computing the customer bills by hand, both methods encounter the same fundamental flaw: due to the nature of rate structures, where rates are oftentimes not uniform between two consumption quantities, it is impossible to accurately determine the customer bill between the pre-selected quantities simply through interpolation of the results. Hence, it becomes difficult to compare different utilities’ residential customer bills at consumption quantities other than those pre-selected by design which, for most utilities, do not include their customers’ average consumption level. The main advantage of using a computer model to automate the process of computing the customer bills is the ability to almost instantaneously determine the bill for any quantity consumed. This allows for better and fairer comparisons across utilities’ bills based on each utility’s average consumption level.

In fact, during the quality check step to verify the accuracy of the output of the spreadsheet model, it was found that the vast majority of the differences between hand calculations and the automated calculations of customer bills were made during the manual calculation of the bill. Once the spreadsheet model was developed and corrected for modeling errors, the model itself produces results at a 100% accuracy level for the majority of utilities, much superior to the accuracy of hand calculations that researchers have been relying on. However, while the model can accurately compute residential customer bills for the majority of utilities, it cannot compute special variants to the main rate structures that are programmed in the model. For instance, a handful of utilities adjust their rates by a fixed charge that is actually a variable amount which is dependent on the total consumption quantity. Currently, the model recognizes only one fixed charge that is not based on consumption levels, and therefore the model output for customer bills at certain consumption levels will be inaccurate.

Interpreting the utilities’ rate schedules and entering the data accurately requires as much effort as collecting them from the utilities. The scanned rate schedules varied greatly in form and structure. Several of the rate schedules provided the information in a clear and concise format, specifying the rates and non-variable charges in easy-to-read typed informational sheets. However, many of the rate schedules were not formatted in the same way. Some rate schedules consisted of dozens of pages of tables with a long list of specific quantities of water consumed in one column and the corresponding residential customer bill in another, from which the EFC and NCLM were required to back-calculate the utility’s rates, which oftentimes changed at different consumption levels. Even more provided handwritten notes on the utility’s rates, with missing information or ineligible handwriting, requiring follow-up phone calls. Missing data was an issue for the majority of rate schedules, particularly in reporting the billing period which has direct effect on how non-variable fixed or minimum charges are computed at the monthly-equivalent level. The EFC and NCLM staff used approximately 600 man-hours to collect 125 additional rate schedules, read and interpret the full set of 344 rate schedules, enter the data into the database and correct for transcription errors detected in the data cleaning step.

CONCLUSIONS

The variations in rate structures throughout North Carolina have deterred past researchers from developing computerized customer bill models thereby limiting the types of analysis that can be done. Now that a model has been developed that instantly calculates the amount utilities from across the state...
charge their customers, it is possible to analyze the impacts of current rate structures and to model the impact of slight changes in the rate structures. Initial use of the model to develop an inventory of rate structures and the amount utilities charge their customers provide a detailed picture of how much residential customers from across the state are currently asked to pay for water and wastewater services. The data show that the amounts customers pay for a specific consumption amount has increased for the majority of utilities throughout the state. In general, many utilities charge customers that live outside their jurisdiction much more for water and wastewater services.

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REFERENCES


