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Full Length Research Paper

PSO-ANN's based suspended sediment concentration in Ksob basin, Algeria

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Suspended sediment concentration estimation has a major influence on river basin planning and management. Prediction of such parameter with artificial neural network (ANN) has shown its performance, because of this, Back Propagation Neural Network model trained with particle swarm optimization (PSO) is used to forecast the daily sediment concentration for Ksob river, Tebessa using 22 years data set from Morsott gauging station; the recorded daily suspended sediment concentrations and correspondent daily discharges were used to train the ANN model. PSO is used to allow ANN architecture to be easily optimized. Simulation of both ANN and PSO-ANN models has shown more accurate results compared with the traditional sediment rating curve.

Key words: Ksob basin, Algeria, sediment rating curve, neural networks, particle swarm optimization.

INTRODUCTION

The estimation of sediment yield is of crucial importance, especially to ensure the efficient operation of hydraulic structures management and also for environmental issues. For many years, suspended sediment concentrations have been collected in gauging stations and to estimate sediment concentrations during periods when samples are not collected, relations between sediment concentrations or load and stream flows are developed and known as sediment rating curve (SRC) (Asselman, 2000; Cohn et al., 1989; Horowitz, 2002). This technique has been use for a long time despite errors involved in using it (Walling, 1977).

Artificial neural network (ANN) is an alternative and complementary set of techniques to traditional models (Abrahart et al., 2005; Cigizoglu, 2008). They may be treated as an universal approximators (ASCE, 2000) and most of their attractive features are self-learning, self-adapting, good robustness and capability of dealing with non-linear problems (Dhar, 2010), without the physics being explicitly provided to them (Nagesh, 2004).

Among many successful bio-inspired Swarm Intelligence, the well known approach particle swarm optimization (PSO) which was inspired from the social behaviors of birds flocking or fish schooling and was developed by Kennedy and Eberhart (1995). It is similar to Genetic Algorithms (GA) in the sense that is a population-based search method.

Combining ANN and Swarm Intelligence has received much attention in several engineering issues in order to overcome single model deficiencies (Chen, 2014). In the present study, an hybrid model of a ANN combined with particle swarm optimizer (PSO) in order to improve ANN

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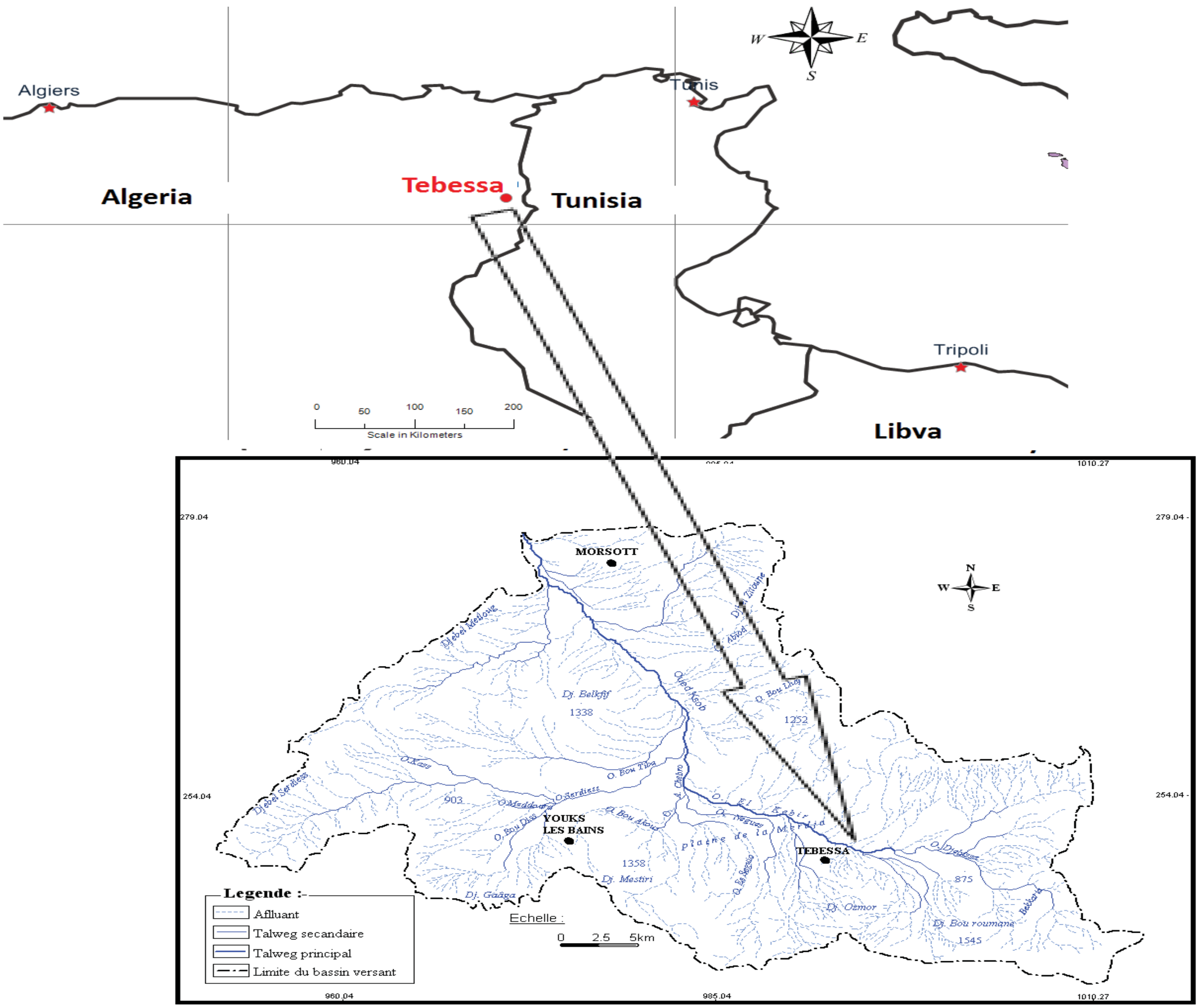

Figure 1. Ksob basin location map.

training for suspended sediment modelling of Morsott gauging station data in the Ksob basin of Tebessa town, Algeria.

Study area

The Ksob catchment (1304 km^2) is located in the extreme northeast of Algeria (Figure 1). It is a sub –basin of Wadi Medjerda, and a part of the Sahara Atlas. It is wedged between of 35° 21\` to 35° 43 N and longitude 7° 43\` to 8° 21\` E. The region is characterized by semi-arid climate with very hot and dry summer and very cold and wet winter. Inter annual average rainfall is about 339 mm. These rains are often in stormy form. The annual average temperature is around 16°C with a maximum in July (25.87°C) and a minimum in January (6.52°C).

Vegetation consists of forests, maquis and reforestation, the remaining area is divided between agricultural lands and wastelands. The development of agriculture is heavily compromised by soil characteristics, runoff, and intensity of human action. The basin consists mainly of old and recent alluvium, clay, sand stone and limestone gravel. These formations gave good soil permeability.

METHODS

Sediment rating curve

A sediment rating curve (SRC) is a relationship established between sediment concentration, *C*, and water discharge, *Q*, or

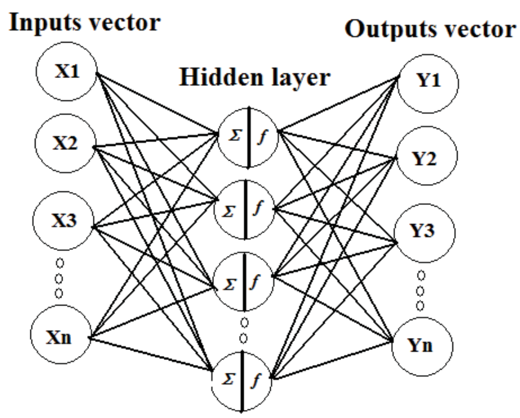

Figure 2. MLP architecture.

between sediment load Q_s, and discharge Q. It is a 'black box' type model not directly related to any physical parameters (Tebbi et al., 2012) and having a standard form of:

$$C = aQ^b \tag{1}$$

Or

$$Q_S = a'Q^{b'} \tag{2}$$

Coefficients *a*, *a'* and *b, b'* are empirically determined where *a* represents the sediment concentration for a discharge of 1.0 m^3s^{-1}, *a'* represents the sediment load for a discharge of 1.0 m^3s^{-1} and *b* and *b'* reflect load response to changes in discharge and typically fall in the range of 1 to 2 or possibly higher (Julien, 2010).

Large number of studies were conducted to estimate suspended sediment yields using SRC method in Algerian rivers (Achite and Ouillon, 2007; Khanchoul et al., 2010; Khanchoul and Jansson, 2008; Terfous et al., 2001; Touaibia et al., 2001). Most of these studies preferred the form of Equation (2) of the method ($Q_s=a'Q^{b'}$).

Artificial neural networks

Artificial neural networks (ANN) consist of layers of interconnected artificial neurons (Figure 2). A neuron (also called a "node" or "unit") is the basic unit of an artificial neural network, simulating a biological neuron. It performs a weighted sum of inputs and passes this to an activation function to produce the output of the neuron. A multi-layer perceptron is feedforward neural network that consists of neurons arranged in a distinct layered topology. The input layer nodes serve to introduce the values of the input variables. The hidden and output layer neurons are each connected to all of the units in the preceding layer.

For most applications fully-connected networks are better. There is usually some weight associated with every connection. Input layer represents the non processed information that is introduced into the network. The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input units and the hidden units. The behavior of the output units depends on the activity of the hidden units and the weights between the hidden units and output units (Sivanandam and Deepa, 2006). To adjust the weights, the most common learning algorithm is called Back Propagation.

ANN are being used alone or hybridized increasingly to predict and forecast water resources variables and have seen significant activity in various hydrology related areas such as rainfall-runoff (Kim, 2005), stream flow (Dolling and Varas, 2002), ground water (Daliakopoulos et al., 2005; Sreekanth et al., 2009), precipitation forecasting and water quality issues (Eslamian and Lavaei, 2009; Shamim et al., 2004), and for designing optimal strategies in reservoir operation (Chandramouli and Deka, 2005; Chaves and Chang, 2008; Hasebe and Nagayama, 2002). Also, ANN have been widely used for sediment transport modeling (Abrahart et al., 2008; Adib and Tagavifar, 2010; Chutachindakate, 2009; Cigizoglu and Alp, 2006; Cigizoglu and Kisi, 2006; Firat and Güngör, 2010; Kisi, 2007; Liu et al., 2013; Rajaee et al., 2011; Wang et al., 2008).

In Algeria, Boukhrissa et al. (2013) investigated the ability of ANN models to improve the accuracy of streamflow-suspended sediment relationships in daily and annual suspended sediment estimation for the El Kebir catchment and shown that the ANN models have the highest efficiency to reproduce the daily sediment load and the global annual sediment yields.

Kisi (2012) using daily stream-flow and suspended sediment concentration data from two stations on the Eel River in California, found that Least Square Support Vector Machine performs better than ANN models. Kisi et al. (2012a) applied Genetic Programming technique for estimating the daily suspended sediment load in two stations in Cumberland River in U.S.; results were comparecd with those of the Adaptive Neuro-Fuzzy Inference System, Artificial Neural Networks and Support Vector Machine, Genetic Programming give beter accuracy. Most of actual studies attempt to improve ANN models accuracy by hybridization with several evolutionary techniques.

Ramezani et al. (2014) used an ANN approach to predict sediment for Maroon River in Iran by optimizing the ANN connection weights with social based algorithm (SBA). Kisi et al. (2012b) compared neural networks with Artificial Bee Colony algorithm model with those of the Neural Differential Evolution, Adaptive Neuro-Fuzzy, Neural Networks and Rating Curve models using data from two stations, Rio Valenciano Station and Quebrada Blanca Station results showed that the ANN-ABC was able to produce better results than other models.

Kisi (2005) found that neuro-fuzzy gives better estimates than neural networks. Using 11-year data (1994 to 2004) of Doiraj River located in Iran, Kalteh (2013) applied both ANN and SVM models for predicting suspended sediment load and found that ANN models based on a quasi-Newton method named Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm has a better performance comparing with other models.

Particle swarm optimization

The basic particle swarm optimization (PSO) algorithm consists of three steps, namely, generating particle's positions and velocities, velocity update, and finally, position update. First, the positions, $X_{id}(k)$ and velocities, $V_{id}(k)$ of the initial swarm of particles are randomly generated.

The positions and velocities are given in a vector format for the i_{th} particle at time *k*. The second step is to update velocities of all particles at time *k +1* using the particles objective or fitness values, which are, function of the particles current positions in the design space at time *k*.

The fitness function value of a particle determines which particle has the best global value in the current swarm, P_{best}^{id}, and determines the best position of each particle over time, p_{id}, that is, in current and all previous moves.

The velocity update formula uses these two pieces of information for each particle in the swarm along with the effect of current motion, $v_{id}(k)$, to provide a search direction, $V_{id}(k+1)$, for the next iteration.

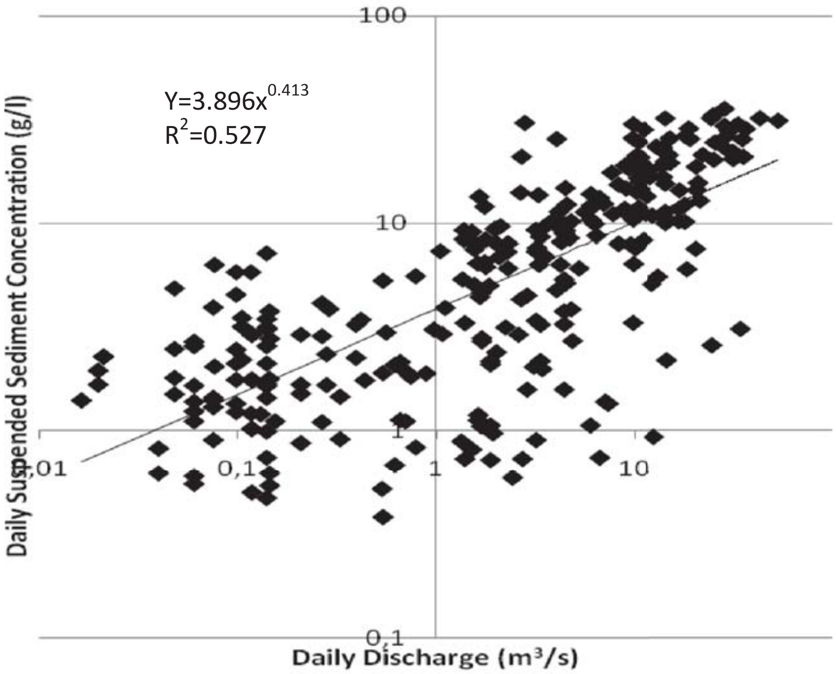

Figure 3. Sediment Rating Curve for Morsott station (1976-2002).

$$\vec{V}_{id}(k+1) = W \times \vec{V}_{id}(k) + C_1 \times \varphi_1 \times (P_{best}^{id} - P_{id}(k)) + C_2 \times \varphi_2 \times (G_{best}^{id} - P_{id}(k)) \quad (3)$$

Where i=1,2,…n . n is the number of particles. d=1,2,3,…m, m is the number of input variables to be optimized. W=weights trading off the impact of the local best and global best solutions' on the particle's total velocity. C_1, C_2 Position update is the last step in an iteration. φ_1, φ_2 samples a uniform random distribution [0,1].

$$X_{id}(k+1) = X_{id}(k) + V_{id}(k+1) \quad (4)$$

The three steps of velocity update, position update, and fitness calculations are repeated until a desired convergence criterion is met.

RESULTS AND DISCUSSION

Figure 3 is constructed using 294 data of both mean daily suspended sediment concentrations and mean daily discharges of Morsott gauging station in the period of 02/1975 to 10/2002. Goodness of sediment rating curve fit using Equation (1) is checked using coefficient of determination R^2. R^2 obtained for the best fit by a single curve is 0.527 and corresponding root mean square error is 6.0359 g l^{-1}.

ANN model

To be able to compare SRC method and other methods we used daily discharges (m^3/s) as the unique inputs in ANN_BP model. Matlab's neural network fitting tool creates a two-layer feed-forward with sigmoid hidden neurons and linear output neurons and it is trained with Levenberg-Marquardt backpropagation algorithm. Also training, validation and test sets are sampled respectively taking 70, 15 and 15%. Number of neurons in hidden layer is taken as 3. Figure 4 compares outputs of the ANN_BP model and observed suspended sediment concentrations.

PSO- ANNmodel

For combining particle swarm optimization algorithm and BP_ANN algorithm using a Matlab® code, the first step is initialization of random particles that represents a set of weights, and then simulating neural network, then evaluate fitness value of initialized particles. Determination of optimal solution individual Pbest and global Gbest according to the fitness value of each particle, and updating the velocity and position of particles according to Formulas (3) and (2). Best particle of current particles is stored. Repeat iteration until maximum number of iteration is met (Figure 5).

Estimating suspended sediment concentration by SRC, ANN and PSO_ANN's respectively enable us to estimate suspended sediment concentrations in the Ksob basin. Figure 6 shows linear regression between observed and simulated concentration using different transfer functions and different training algorithms of PSO_ANN model for test period. We can observe that R^2 is improved about.

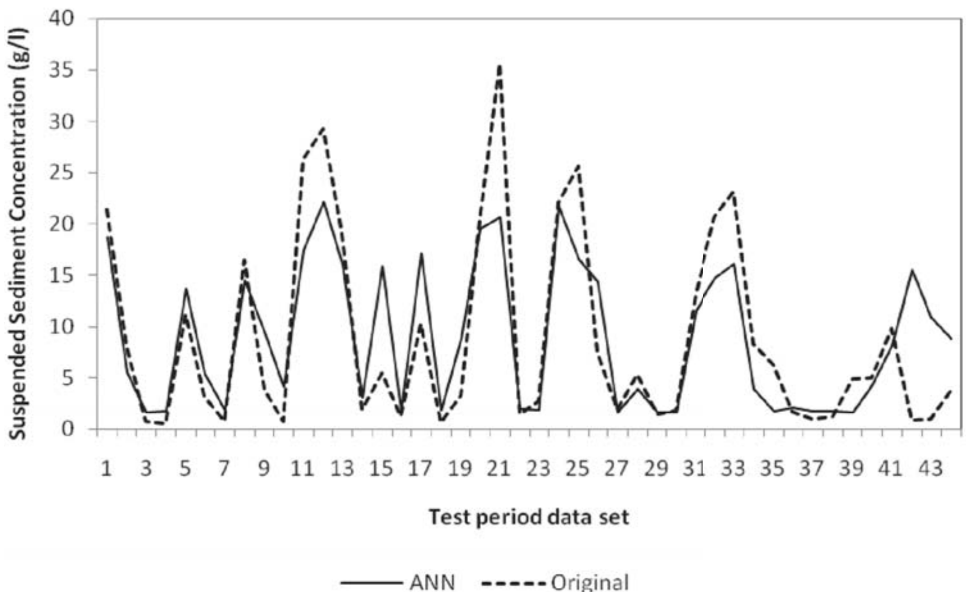

Figure 4. Simulated vs. observed mean daily suspended concentrations using ANN-BP model (Test period).

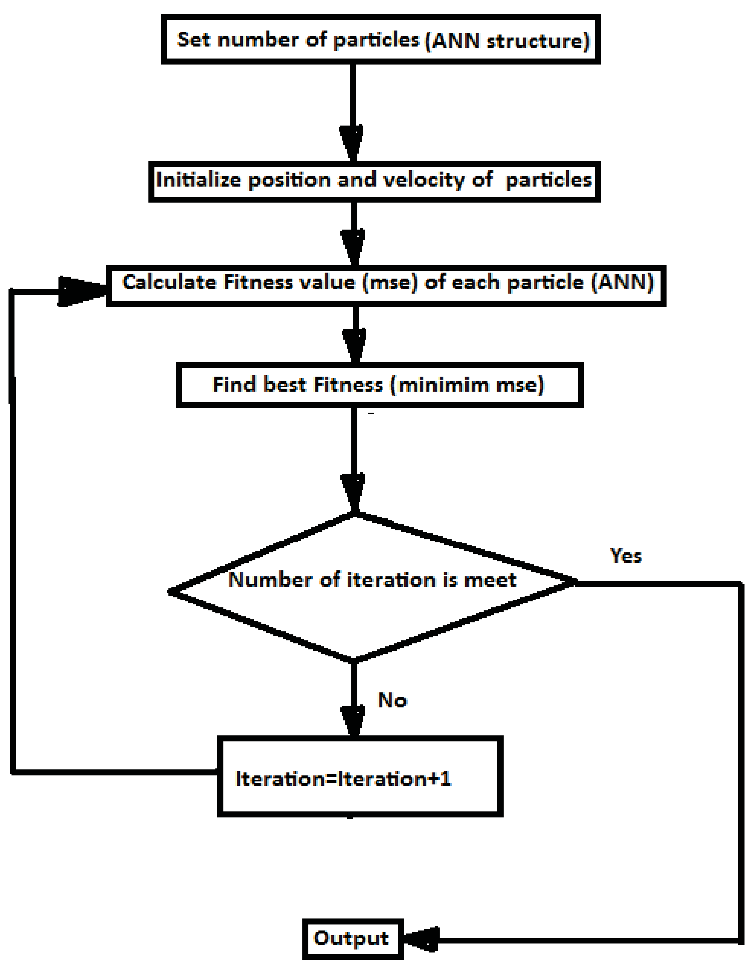

Figure 5. Flow chart of PSO-ANN's model.

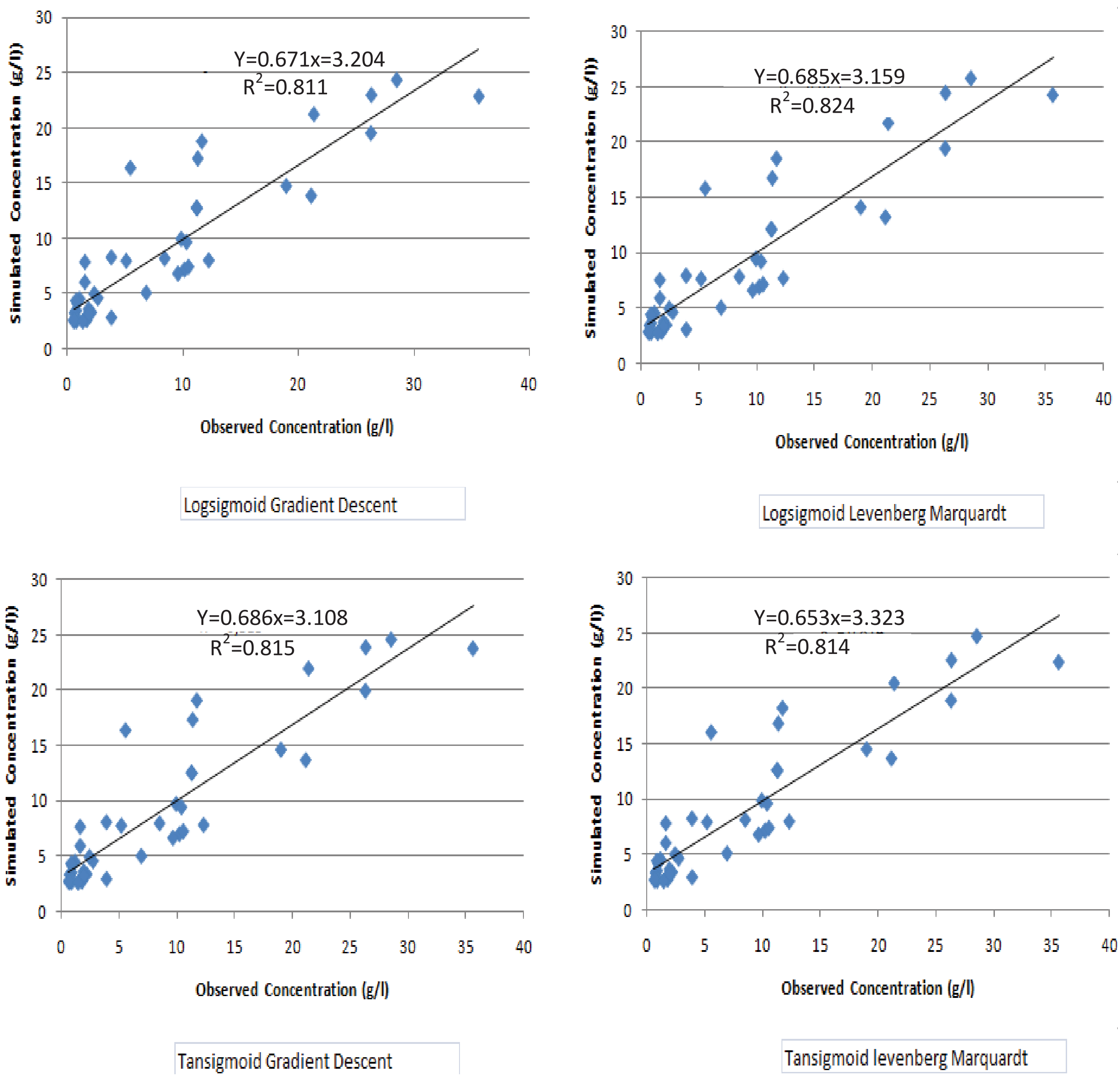

Figure 6. Simulated vs. observed suspended concentrations using PSO_ANN's model (test period).

Table 1. Models performances.

PSO-ANN (Test period)			ANN			SRC	
	RMSE	R^2		RMSE	R^2	RMSE	R^2
LOGGD	4.0962	0.8118					
LOGLM	3.9737	0.8247	Train	5.375	0.602	6.036	0. 527
TANGD	4.0264	0.8158	Test	5.307	0.689		
TANLM	4.1422	0.8141	Validation	4.090	0.678		

Table 1 indicates models performances using R square coefficient and root mean square error and shows that using hybrid ANN_BP model with principal transfer functions in hidden layer and training algorithms at test period for same sample improves RMSE and R^2; results show that PSO-ANN's improves ANN's model at least RMSE 21% and R^2 18% and both ANN and PSO-ANN model are better than SRC model.

Conclusion

Sediment rating curve, neural networks back propagation and hybrid PSO based neural networks models were employed in this study in order to model suspended sediment concentrations in Ksob river using Morsott gauging station data. Compared with the ANN model, PSO-ANN' appears to be more suitable for suspended sediment concentration modeling. Due to the lack of data, multiple linear regression and recurrent ANN's models were not considered, the proposed model based on PSO can be further investigated with several improved PSO models also other models in future studies.

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Conflict of Interest

The authors have not declared any conflict of interest.

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Full Length Research Paper

Relocation of source of sporadic production using genetic algorithm in distribution network

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Today, due to the development of distribution systems and increase of demand and load, the use of the source of scattered production has developed. The establishment of the installation place and the size of the source of scattered production decrease network loss, lead to best action of network as well as the recovery of the voltage profile. In this article, we use the genetic algorithm for relocating and finding the best sources of scattered production with active power production and reactive power production by arranging and using them. Also in this article, in addition to decreased loss, balanced voltage, stabilization and recovery of profile have purpose function. The results show that the system of 33 bass is the power and effectiveness of the method.

Key words: Scattered production, optimization, genetic logs.

INTRODUCTION

The main shave of loss in one power system is related to the distribution system. The study shows that distribution system loses because of the high relation of R/X and high decrease of voltage in this system.

Today, increased demand and load leads to the development of the distribution system and its aspects; and this agent causes more loss of voltage and increases casualty. As a result, there is decreased voltage stability of knots and load imbalance.

Different methods created for determining the capacity of decomposed granite (DG) are presented in this work. Willis (2000) showed the famous legal 2/3 methods used for determining the optimum place of condenser, which in turn determines the optimum place of DG.

DG of 2/3 length lower than the post was installed. Kashem et al. (2008) offered a number of methods for determining the optimum size of DG based on the sensation of the loss of power. The method based on the minimum casualty power in the presence of DG was established. The methods chosen were tested on the practical network in Tasmania and Australia. Acharya et al. (2007) used the increasing change in casualty power related to the change of the sensation factor of the real power injected; it was developed by Elgerd (1970). The factor this article was used to determine the bass that caused the casualty at the time the DG was installed on it, by arranging the offered method based on factor sensation.

The problem of this method is the length used in determining the place of optimum installation of DG in

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distribution network. It was also the only place to optimize the DG, and the only way to install a DG in the distribution network is proposed. Kean and Omalley (2006) also solve the DG optimum size on one of the line program (LP) on the Ireland network. In the literature, Rosehart and Nowicki (2007) presented a new model to determine location of DGs for economical distribution system and voltage improvement.

The purpose function was solved by using interpolation method (IP). The later output is the other rank of bass for DG installation.

The size of the optimum DG in this installation is not studied in this investigation. Hedayati et al. (2009) presented the method of load distribution for bass that is sensitive to reversal. The sensitive bass in this article is an appropriate place for DG installation.

The repeated method used for determining the place of DG optimum installation was used at first for one of the distinct capacity of DG that connected to the network the program of load distribution and the casualty of real power; voltage profile and the capacity of passing power of line are calculated. In the literature, MIthulananthan et al. (2006) determined the decreased casualty of real power of distribution network by using genetic algorithm (GA) containing the size of DG without considering any condition.

NR was used to calculate the casualty. Only one DG is investigated in this work. In the literature, Nara et al. (2001) hypothesized clearly the place of DG installation and used the method of Taboo to determine the size of DGs for the purpose of designing system network casualty.

Load is the source of fixed current generated by the coefficient of fixed power. Golshan and Arefifar (2007) have propounded the Taboo method for the size recovery of DG, where the source of reactive power like condenser and reactor or both in the distribution system is considered.

The purpose function decreases the cost of the reactive power, line load and the cost of the added reactive source.

In this investigation, the place of DG and source of reactive are not optimal.

PURPOSE FUNCTION

The aim of this study is to recover the technical function of network formulated in the form of recovery of two terms of technical network that include casualty and arrangement of the voltage of network distribution. So the presented purpose function is introduced in the form of one of the two purpose functions. In addition, the problem has equal condition, protection and functional condition which will be introduced later.

Relation 1 is description of the presented purpose function.

$$\text{Min.} f = f_1 + k_1 f_2 \qquad (1)$$

The function f_1, f_2 is also introduced by the following arrangement,

$$\text{Min.} f_1 = \min \{ P_{loss}(P_{d1}, P_{d2}, \dots, P_{dn_{DG}}) \} \qquad (2)$$

P_{loss} in above relation is the casualty of real power. P_{di} is the amount of the power of distributed production source in bass i.

f_2 is related to the index of deviation voltage that is introduced in the following form,

$$\mathbf{f_2} = \sqrt{\frac{\sum_{1=1}^{N_n}(V_1 - V_{rated})^2}{N_n}} \qquad (3)$$

V_{rated} in Relation 3 is related to the bass voltage name, that is, one per unit. V_i the voltage of bass of system and N_n is the number of the bass of the network.

EQUAL CONDITIONS

The presentation of DG in the network should be in one way, in which all of the control and system variables in the equations of load distribution is applied. The active and reactive power based on the famous equation of load distribution in Relations 4 and 5 is shown thus (MIthulananthan et al., 2006),

$$P_{gi} - P_{di} - V_i \sum_{j=1}^{N} V_j Y_{ij} \cos(\delta_i - \delta_j - \theta_{ij}) = 0 \qquad (4)$$

$$Q_{gi} - Q_{di} - V_i \sum_{j=1}^{N} V_j Y_{ij} \sin(\delta_i - \delta_j - \theta_{ij}) = 0 \qquad (5)$$

In the above relation P_{ji} and Q_{gi} are related to the active and reactive power of load in shin i in arrangement. Also, δ_i, V_i are the angle and the size of the shins voltage in arrangement. θ_{ij} and Y_{ij} are the elements that are extracted from the admittance Matrix.

Operational and protective constraints

Voltage condition

For the purpose of the observation of the quality of delivery to consumer, the voltage of every shin in distribution network should be in the minimum and defined maximum limit.

So in every condition, in the DG installation, the condition of voltage in accordance to the Relation 6 should be checked until the voltage of the bass place is in their allowed field.

$$V_i^{min} < V_i < V_i^{max} \quad \text{I = 1…}N_n \tag{6}$$

In the relation above, V_i is the voltage as bass i, V_i^{min} is the minimum allowed voltage at bass i, V_i^{max} is the maximum allowed voltage in bass I and N_n is the amount of bass in the network.

The condition of passing power line in distribution

Systems use the conductor by different segment surfaces, where the limit of the passing power is different. So during the time of installing DG in the network, subsidiary feeder should be investigated, that the power of every angle according to Relation 7 should not be more than the allowed amount (that is based on the kind of connector used).

$$|S_i| \le |S_i^{max}| \quad \text{i=1…}N_b \tag{7}$$

In Relation 7, S_i is the passing power of branch i, S_i^{max} is the maximum passing power of branch i and N_b is the amount of the branch of the tested systems.

MODELING OF THE SPORADIC PRODUCTION

Source of sporadic production generally can be divided into four groups as follows:

1) The source of sporadic production that has the ability of producing real power (fotoveltaik). In recovery program, it is related to the limited power production, which in the form of DG, governs the condition on this kind of formulation.

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \tag{8}$$

The minimum powerp_{gi}^{min} and maximum power p_{gi}^{max} production of generator, and p_{gi} in Relation 8 are the outputs produced by generator.

2) Sporadic production source that only has the ability to produce of reactive power (synchronous condenser). Governing condition on this equation is written thus,

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max} \tag{9}$$

Q_{gi}^{min} and maximum power Q_{gi}^{max} are the reactive power of the generator; Q_{gi} in Relation 9 is the minimum reactive power of the generator.

3) Sporadic production source that produces active power and consumes reactive power (induction generator and winding turbin). DG is the governing condition of this kind,

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \tag{10}$$

$$Q_{DG_i} = -(.05 + .04P^2{}_{DG_i}) \tag{11}$$

4) Sporadic production source that is known as the synchronous generator as follows:

a) Has the ability of fixing reactive or any kind of pY
b) Sets voltage or any kind of pV

In this article, we use four kinds of DGs (Yanjun and Yun, 2008; Vinothkumar and Selvan, 2009).

GENETIC ALGORITHM (GA)

We can call the genetic algorithm as an explorer method. This is based on the specification and choosing of the children of sequential generation based on the principles of the best programmed genetic algorithm (from the answer to the problem in one step) This simulates the laws in genetic algorithm and their use leads to the production of children with the best quality.

In every generation, using appropriate choices in reproducing children, better approximated final answers are achieved. This process causes the new generation to be more compatible with the problem condition. This competition between generations, the victory of dominant generations and side tracking of beaten ones are effective methods for solving complex and hard problem (Golberg, 1989).

The methods of solving the problem GA are as follows,

Step 1: (the amount of first overall) we equal the counter to zero (t = 0) and produce the chromosome accidentally [$x_j(.)$, j = 1,…,n] where $x_j(.) = [x_{j1}(0), x_{j2}(0),…,x_{jm}(0)]$. $X_{jk}(0)$, in the form of accidental chromosome in the searching space, is produced.

Step 2: (evaluation) every chromosome in the first population is evaluated by the use of j purpose function, and to choose the best amount, we search for J_{BST} and arrange the chromosome that is proportional to the J_{BEST} for best amount of X_{BEST}.

Step 3 (change of counter) = in this step t=t+1

Step 4: (production of new population) = by repeating the following step, we the complete the new population.

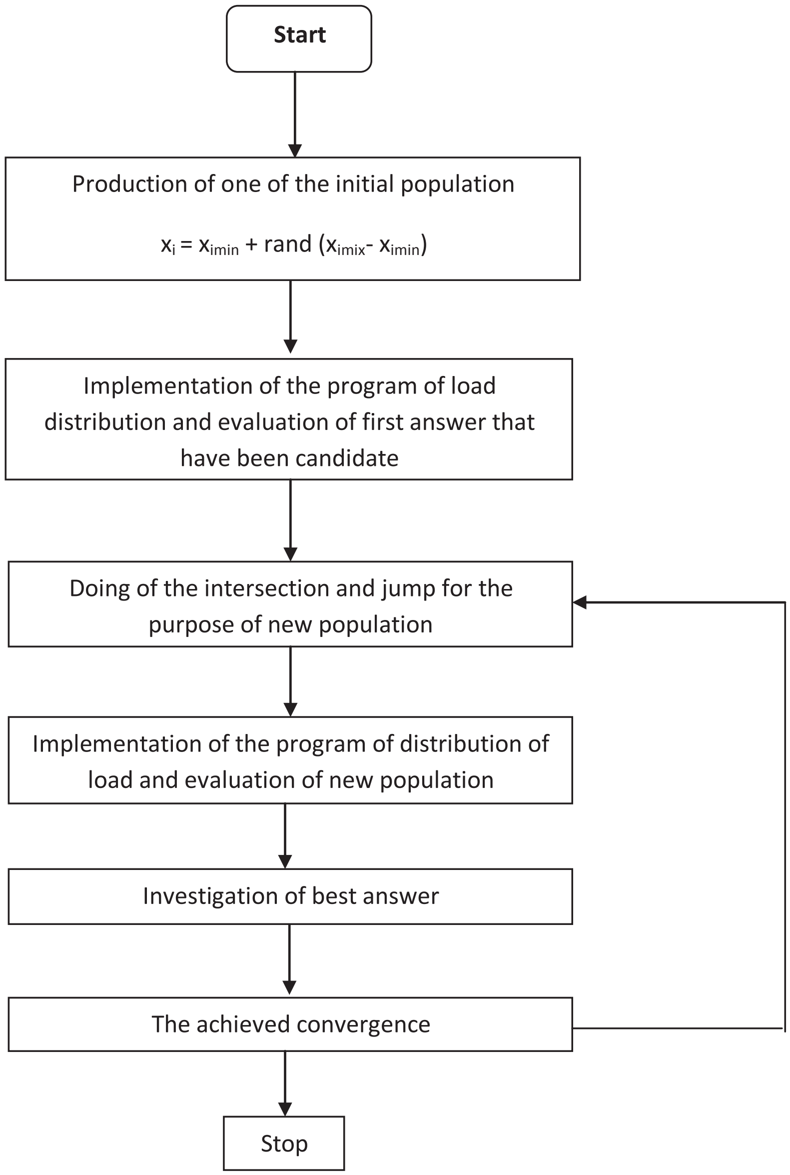

Figure 1. Flowchart of the relocation of decomposed granite (DG) sources production by genetic algorithm (GA).

a) Choice: We took an amount of parent chromosomes based on their suitability (the ones with better suitability have better chance of being chosen).
b) Intersection: By one probability, we apply the intersection operator on the chosen parent to produce the new children. If the intersection is not doing well, every branch of population is precisely copy as a parent.
c) Mutation = by one probability, we change every gene in one chromosome.
d) Acceptance = we put the new chromosome in the population.

Step 5: (replacement) = We used the new population produced to do the algorithm again.

Step 6: (stop) if the amounts of repeats are the distinct amounts needed, the program will stop, but if not, we will go to the next stop as shown in Figure 1.

NUMBER STUDY

The network includes one network of 12.66 radial KW. As shown in Figure 2, the whole active load is 3.2 MVAR and active casualty is about 210 KW before the installation of DG (Chakravorty and Das, 2001; Abu-mouti, 2010).

The appropriate initial population has direct effect on the speed of answer convergence and can directly affect

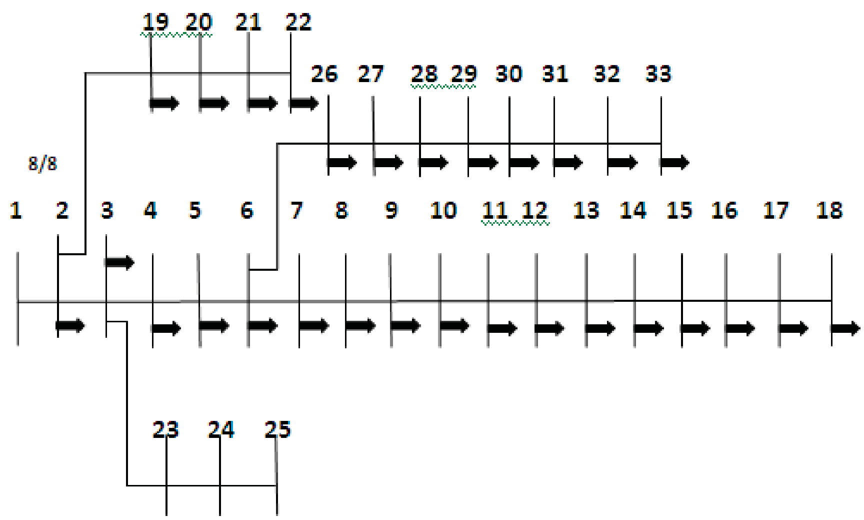

Figure 2. The study of the network by 33 bass.

Table 1. Genetic algorithm parameter.

Population	Method of choice	Intersection	Jump	End condition
300	Accidental	One point	Binary	100 repeated

Table 2. comparison between GA and PSO method for DG installation of type one.

Basic casualty of system				
210. 99 KW		143. 128 KVAR		
Kind of method	**Active casualty (KW)**	**Reactive casualty (KVAR)**	**Place**	**MW**
			13	0. 7571
GA	72. 9601	50. 7721	24	1. 0429
			30	1. 0429
			14	0. 7707
PSO (Li et al., 2005)	72. 8214	50. 6729	30	1. 0359
			24	1. 0966
Reload flow (EPRI, Palo Alto, CA, 2003)	116. 26	85. 42	12	2. 4939

the time of convergence.

The initial population DG created by 300 chromosomes and in every field shows the capacity and place of the installation of DG. Another information that is related to the genetic algorithm program is shown in Table 1.

In Table 2, there is a comparative between genetic method and movement algorithm of birds for installation of DG that has the ability to produce one active power.

In Table 2, the first column introduces the kinds of method, the second column introduces the casualty of the active power according to KW, the third column introduces the light reactive casualty according to KVAR, the fourth column shows the installation place of DG and the final column shows the capacity amount of DG installation on candidate bass. The place of DG installation in every three initial method is same; the only difference is in the DG capacity amount using the GA method in relation to the two other methods, which decrease the casualty a little more. Figure 3 shows the purpose function diagram.

Table 3 shows the comparison between the three methods used for DG installation, with the ability to

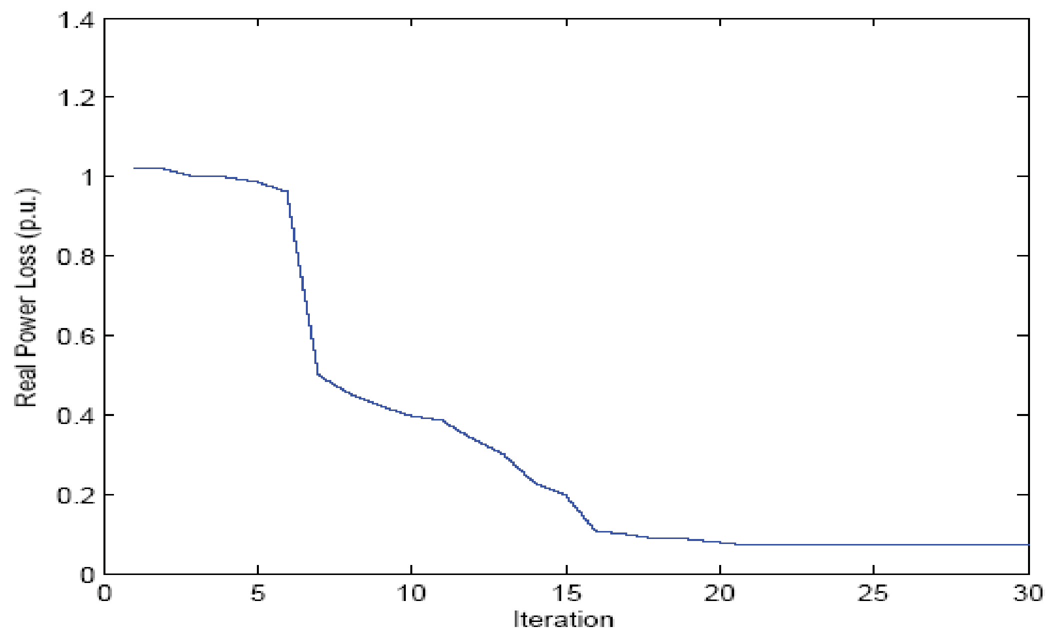

Figure 3. Minimum of the real power casualty by genetic algorithm (GA) method.

Table 3. Comparison between GA and PSO method of DG installation of type second.

Basic casualty of system				
210. 99 KW		143. 128 KVAR		
Kind of method	**Active casualty (KW)**	**Reactive casualty (KVAR)**	**Place**	**MVAR**
GA	140. 6558	95. 7170	10 24 30	0. 3201 0. 2143 1. 0714
PSO (Li et al., 2005)	139. 6957	95.2258	14 30 6	0.3092 0. 8938 0. 5691
Reload flow (EPRI, Palo Alto, CA, 2003)	158. 6782	108. 7812	22	1. 2092

produce reactive power only (type two).

Table 4 shows the comparison between the three methods used for DG installation, with the ability to produce active power and consume reactive power (type three).

Table 5 shows the comparison between every DG 3 method used for the installation of synchronous generator by stabilizing power (type four).

Looking at the charts and graphs of voltage profile presented in the previous section, the following points may be noted:

GA method presented to determine location and installed capacity of the four types of distributed generation sources has similar results with the GA and particle swarm optimization (PSO) methods, whose installation places are the same. The only difference could be found in installed DG capacity that causes less calculated loss in this method than the three other methods. The point is: As the search space and unknown parameters increase, GA method can be more useful. Looking at the calculated active and reactive power losses in the tables, we can conclude that, installed DG of fourth type, that is, synchronous generators have greater role in reducing losses than the other types of DG. After this type of DG, distributed generation sources from the type of photo voltaic systems, induction generator (active power generation and reactive power consumption) and the synchronous condensers decrease losses in distribution companies. Another point about the system voltage profile diagrams (Figures 4 to 7) on the

Table 4. Comparison between method GA, PSO for decomposed granite (DG) installation of type 3.

Basic casualty of system				
210. 99 KW		143. 128 KVAR		
Kind of method	**Active casualty (KW)**	**Reactive casualty (KVAR)**	**Place**	**MVA**
			12	0. 8746
GA	90. 1837	62. 2631	24	1.04701
			30	1. 04701
			13	0. 7899
PSO (Li et al., 2005)	90. 029	95.2258	24	1. 0759
			30	1. 0193
Reload flow (EPRI, Palo Alto, CA, 2003)	148. 18	105. 61	12	2. 4494

Table 5. Comparison between DA and PSO for installation of DG kind 4.

Basic casualty of system					
210. 99 KW		143. 128 KVAR			
Kind of method	**Active casualty (KW)**	**Reactive casualty (KVAR)**	**Place**	**MW**	**MVAR**
			14	0.7371	0.3485
GA	11.914	9.876	24	0.9872	0.4889
			30	1.0714	1.0369
			30	1.0687	0.9956
PSO (Li et al., 2005)	11.8411	9.8065	24	1.01268	0.5273
			13	0.7982	0.3960
Reload flow (EPRI, Palo Alto, CA, 2003)	71.396	57.431	12	2.5013	1.5822

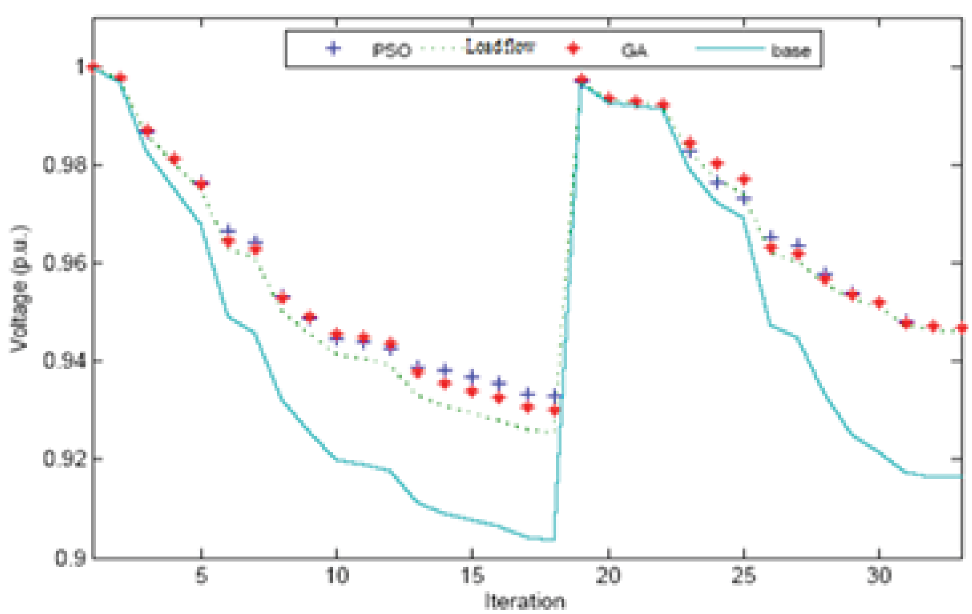

Figure 4. 33-Bus system voltage profile after installation of decomposed granites (DGs) type 2.

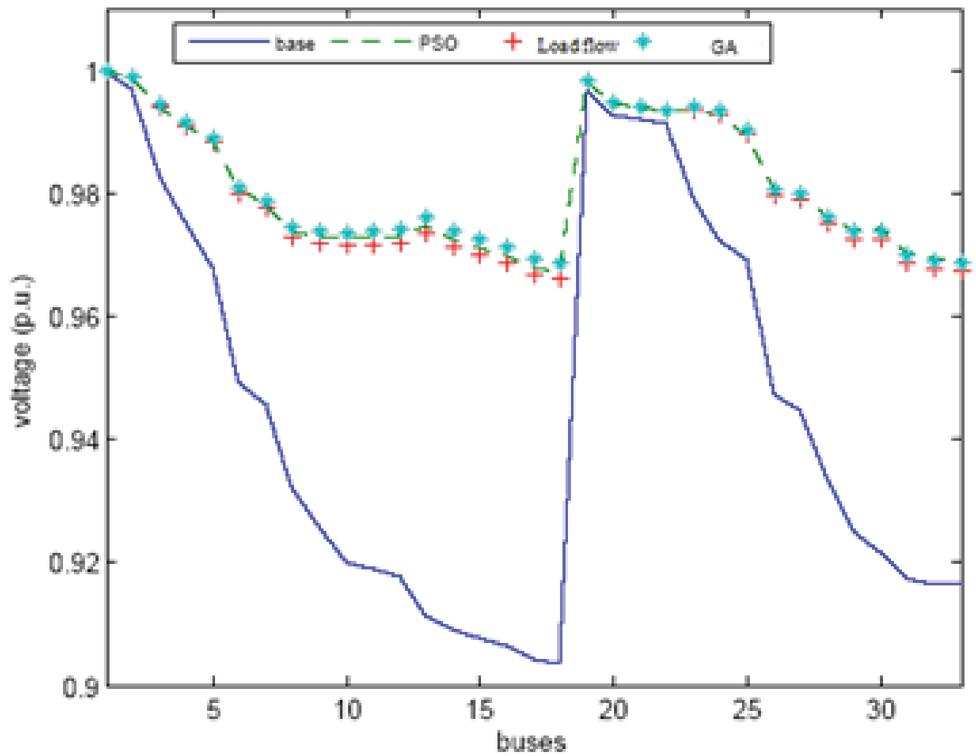

Figure 5. 33-Bus system voltage profile after installation of decomposed granites (DGs) type 2.

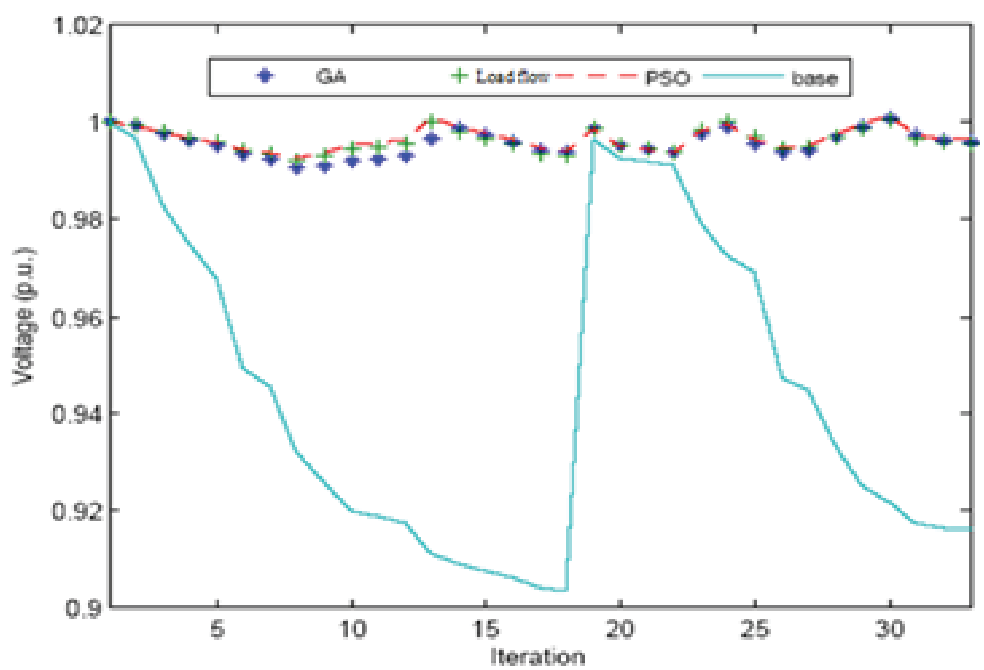

Figure 6. 33-Bus system voltage profile after installation of decomposed granites (DGs) type 4.

bass 33 system after installation of DG is that changes in bus voltage magnitude can be seen at the bass 33 system. As seen, the DG of the synchronous generator (PV), photo voltaic systems (P), induction generator and

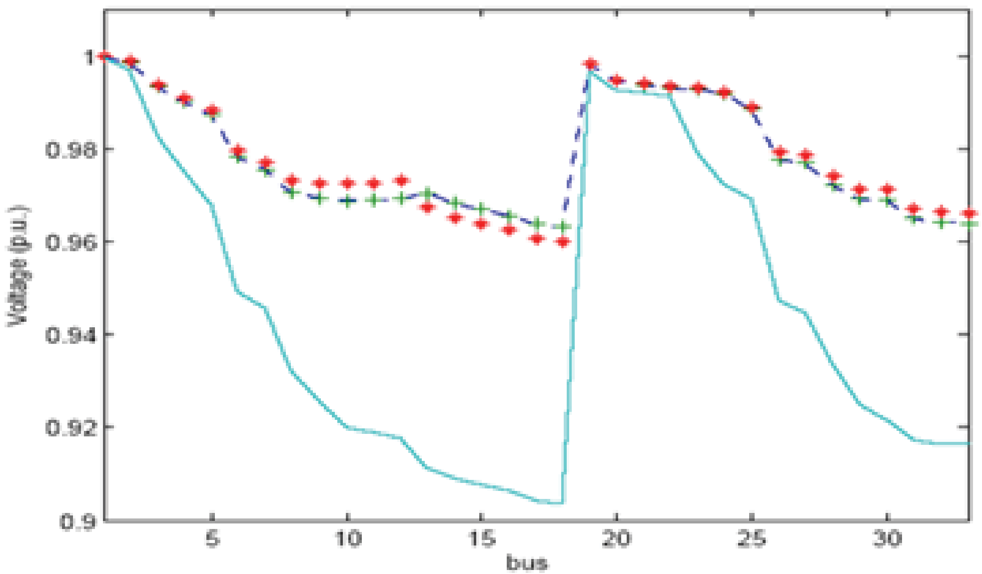

Figure 7. 33-Bus system voltage profile after installation of decomposed granites (DGs) type 3.

synchronous condenser ultimately are effective in improving network profiles.

Conclusion

GA approach was formulated to solve the problem of determining the size and location of DG and in this method, the location and capacity was nominated by GA. in spite of that, object function has two terms that improve Network voltage losses and profile. Also, DG impact of four models in the 33 bus network is evaluated and it could be seen that type of distributed generation sources will have a better impact to generate active and reactive power to reduce losses in the distribution network. Also, after installing the four types of distributed generation sources, loses reduced and the network voltage profile has been improved significantly.

Conflict of Interest

The author(s) have not declared any conflict of interest.

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Review

Geothermal Energy

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The term Geothermal originates from two Greek words 'GEO' and 'THERM'. The Greek word 'geo' means the earth whilst their word for 'therm' means heat from the earth. Geothermal energy is energy derived from the heat of the earth. The earth's centre is a distance of approximately 4000 miles and is so hot that it is molten. Temperatures are understood to be at least 5000°C. Heat from the centre of the earth conducts outwards and heats up the outer layers of rock called the mantle. When this type of rock melts and becomes molten it is called magma. Magma can reach just below the earths surface. Rain water sometimes seeps down through geological fault lines and cracks becoming super heated by the hot rocks below. Some of this superheated water rises back to the surface of the earth where it emerges as hot springs or even geysers. Sometimes the hot water becomes trapped below the surface as a geothermal reservoir. One way of producing electricity from geothermal energy is by drilling wells into the geothermal reservoirs. The hot water that rises emerges at the surface as steam. The steam is used to drive turbines producing electricity. If the water is not hot enough to produce steam, it can still be used to heat homes and businesses, saving gas/electricity. Geothermal energy is the heat from the Earth. It is clean and sustainable. Resources of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma.

Key words: Geothermal, energy, geothermal electricity, geothermal water, energy harnessed.

INTRODUCTION

History says that the first use of geothermal energy occurred more than 10,000 years ago in North America by American Paleo-Indians. People used water from hot springs for cooking, bathing and cleaning. The first industrial use of geothermal energy began near Pisa, Italy in late 18th century. Steam coming from natural vents (and from drilled holes) was used to extract boric acid from the hot pools that are now known as the Larderello fields. In 1904, Italian scientist Piero Ginori Conti invented the first geothermal electric power plant in which steam was used to generate the power. With the above experiment, the first geothermal plant in USA started in 1922 with a capacity of 250 kilowatts. It produced little output and due to technical glitch had to be shut down. However, in 1946 first ground-source geothermal heat pump installed at Commonwealth Building in Portland, Oregon During the 1960's, pacific gas and electric began operation of first large scale

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geothermal power plant in San Francisco, producing 11 megawatts. Today there are more than 60 geothermal power plants operating in USA at 18 sites across the country. In 1973, when oil crisis began many countries began looking for renewable energy sources and by 1980's geothermal heat pumps (GHP) started gaining popularity in order to reduce heating and cooling costs. As effect of climate change started showing results, governments of various countries joined hands to fight against it, for which Kyoto Protocol was signed in Japan in 1997, laid out emission targets for rich countries and required that they transfer funds and technology to developing countries, 184 countries have ratified it. Geothermal power today supplies less than 1% of the world's energy in 2009 needs but it is expected to supply 10 to 20% of world's energy requirement by 2050. Geothermal power plants today are operating in about 20 countries which are actively visited by earthquakes and volcanoes.

Geothermal energy is the energy stored in the form of heat below the earth's surface. Its potential is limitless in human terms and its energy is comparable to the sun. Geothermal heat and water have been used for thousands of years. The Romans, Chinese and Native Americans used hot mineral springs for bathing, cooking and for therapeutic purposes.Today geothermal water is used in many applications such as district heating, systems which provide steam or hot water to multiple units, as well as for heating and cooling of individual buildings, including offices, shops and residential houses, by using geothermal heat pumps. Moreover, it has industrial potential for raising plants in greenhouses, drying crops, heating water at fish farms and other industrial processes.For close to 100 years geothermal energy has also been used for electricity generation. Today, so called Enhanced Geothermal Systems (EGS, also known as Hot Dry Rock), enable the exploitation of the Earth's heat for producing electricity without having natural water resources. To extract energy from hot impermeable rock, water is injected from the surface into boreholes in order to widen them and create some fractures in the hot rock. Flowing through these holes, the water heats up and, when it returns to the surface, it is used for generating electricity. Clean, renewable, constant and available worldwide, geothermal energy is already being used in a large number of thermal and electric power plants (http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=research-geothermal).

The International Geothermal Association (IGA) has reported that 10,715 megawatts (MW) of geothermal power in 24 countries is online, which was expected to generate 67,246 GWh of electricity in 2010 (Erkan et al., 2008). This represents a 20% increase in online capacity since 2005. IGA projects growth to 18,500 MW by 2015, due to the projects presently under consideration, often in areas previously assumed to have little exploitable resource (Erkan et al., 2008).

In 2010, the United States led the world in geothermal electricity production with 3,086 MW of installed capacity from 77 power plants (Lay et al., 2008). The largest group of geothermal power plants in the world is located at The Geysers, a geothermal field in California (Khan and Ali, 2007). The Philippines is the second highest producer, with 1,904 MW of capacity online. Geothermal power makes up approximately 27% of Philippine electricity generation (Lay et al., 2008) (Table 1).

Geothermal electric plants were traditionally built exclusively on the edges of tectonic plates where high temperature geothermal resources are available near the surface. The development of binary cycle power plants and improvements in drilling and extraction technology enable enhanced geothermal systems over a much greater geographical range (Holm, 2010). Demonstration projects are operational in Landau-Pfalz, Germany, and Soultz-sous-Forêts, France, while an earlier effort in Basel, Switzerland was shut down after it triggered earthquakes. Other demonstration projects are under construction in Australia, the United Kingdom, and the United States of America (Tester et al., 2006)

The thermal efficiency of geothermal electric plants is low, around 10 to 23%, because geothermal fluids do not reach the high temperatures of steam from boilers. The laws of thermodynamics limits the efficiency of heat engines in extracting useful energy. Exhaust heat is wasted, unless it can be used directly and locally, for example in greenhouses, timber mills, and district heating. System efficiency does not materially affect operational costs as it would for plants that use fuel, but it does affect return on the capital used to build the plant. In order to produce more energy than the pumps consume, electricity generation requires relatively hot fields and specialized heat cycles. Because geothermal power does not rely on variable sources of energy, unlike, for example, wind or solar, its capacity factor can be quite large, up to 96% has been demonstrated (Lund, 2003). The global average was 73% in 2005.

GEOTHERMAL SUSTAINABILITY GOALS

If possible, sustainable production should be the goal during geothermal utilization. However, in cases where excessive production is necessary (e.g. for electricity generation), a geothermal reservoir must be afforded a recovery period. Such recovery periods should be on a timescale acceptable to society and the use of other geothermal reservoirs should be possible in the meantime. Resource management strategies should therefore consider a number of geothermal systems based around a central volcanic system.

Water usage for the power plant is compatible with other water usage needs in the hydrological catchment area of the geothermal resource.

Table 1. Installed geothermal electric capacity.

Country	Capacity (MW) 2007 (Bertani, 2009)	Capacity (MW) 2010 (Khan and Ali, 2007)	Percentage of national electricity production	Percentage of global geothermal production
United States	2687	3086	0.3	29
Philippines	1969.7	1904	27	18
Indonesia	992	1197	3.7	11
Mexico	953	958	3	9
Italy	810.5	843	1.5	8
New Zealand	471.6	628	10	6
Iceland	421.2	575	30	5
Japan	535.2	536	0.1	5
Iran	250	250		
El Salvador	204.2	204	25	
Kenya	128.8	167	11.2	
Costa Rica	162.5	166	14	
Nicaragua	87.4	88	10	
Russia	79	82		
Turkey	38	82		
Papua-New Guinea	56	56		
Guatemala	53	52		
Portugal	23	29		
China	27.8	24		
France	14.7	16		
Ethiopia	7.3	7.3		
Germany	8.4	6.6		
Austria	1.1	1.4		
Australia	0.2	1.1		
Thailand	0.3	0.3		
Total	9,981.9	10,959.7		

Efficiency

The geothermal resource is managed in such a way as to obtain the maximum use of all heat and energy produced and to minimise the waste of energy, by adequate forward planning and design of plants, the use of efficient technologies, reinjection where appropriate and cascaded energy uses.

Research and innovation

New technologies for the exploitation of previously untapped geothermal, or other energy resources, are actively researched or supported either directly or through links with university programmers or other research and development groups.

Environmental impacts

The geothermal resource is managed so as to minimize local and global environmental impacts through thorough resource and environmental impact assessment before development, appropriate reinjection management, usage of mitigation technologies and environmental management strategies during all phases of development.

Social aspects

The use of the geothermal resource generates net positive social impacts.

Energy security, accessibility, availability and diversity

The energy supplied by the geothermal resource is readily available, accessible and affordable.

The geothermal energy source is reliable and contributes to energy security for a nation or region.

Economic and financial viability

The geothermal energy project is cost-effective, financially viable and minimizes risk. The project should carry positive net national economic benefits.

The enterprise managing the geothermal resource practices corporate social responsibility.

Overarching issues: Information sharing/transparency

Knowledge and experience gained during the development of geothermal utilization projects should be accessible and transparent to the public and other interested groups.

ADVANTAGES OF GEOTHERMAL ELECTRICITY

1. Geothermal energy is relatively environmentally friendly. Pollution in the form of fumes are not produced although usually drilling of the earths surface takes place. The surrounding environment is not harmed with the exception of the land required for the power plant and transport links.
2. Unlike wind power, geothermal power can be relied on as it provides constant power.
3. The use of conventional polluting fuels such as oil and coal can be reduced if geothermal and other alternative energy forms are used (reducing pollution).
4. Geothermal power can take different forms. For instance, it can be used to produce electricity or the hot water can be used directly to heat homes and businesses.

Advantages and disadvantages of geothermal energy

Even though there is quite a number of arguments going on with regards to geothermal energy, but this one is still considered to be the most inexpensive and very affordable green energy solution that is very much available out there. Nevertheless, geothermal energy is truly effective all through any season and it can greatly help a lot when it comes to saving loads on energy costs. Aside from being less expensive compared to solar panel technology, it is also sustainable and completely clean.

First on the advantage list is with the fact that geothermal energy is surely environmental friendly. Since geothermal energy emerges from the natural that is being produced by the earth underground, so there are really no burned fossil fuels that were used along with the corresponding release of harmful and dreadful gases.

Another advantage is that the supply of this renewable energy is constant, as well as without limits. Put in mind that the earth is never going to stop producing heat energy and in theory, energy is abundant enough to supply all the needs of all mankind.

Third advantage is that when generating heat for a home system, it ensures you that it is really condensed. A standard geothermal heat pump is not larger compared to a small fridge.

The next advantage is that geothermal energy is considered low maintenance. It seems though these energy source do not really require regular servicing unlike many other standard heating systems out there. However, this just simply means that it can cost less, as well as hassle.

For the disadvantage, one would include the space that is needed for the piping system. For big scale operations, it would definitely require a massive amount of space in order to be able accommodate the maze of huge pipes.

Speaking of pipes, the repair, as well as the maintenance can also bring forth a big disadvantage since the maze of pipes located deep underground, maintenance work is definitely not an easy task to do.

This energy cannot be transferred over long distances. Unlike fuels such as coal, natural gas and petroleum, they can easily be hauled from the source to the user, even if it’s miles away.

Lastly, the hazard of geothermal gases can produce. Tapping onto this energy may bring forth release of potentially harmful and hazardous chemicals, as well as gases such as hydrogen sulfide. (http://topdiysolarpanels.net/advantages-and-disadvantages-of-geothermal-energy/)

Advantages of geothermal energy

1. It is a renewable source of energy.
2. By far, it is non-polluting and environment friendly.
3. There is no wastage or generation of by-products.
4. Geothermal energy can be used directly. In ancient times, people used this source of energy for heating homes, cooking, etc.
5. Maintenance cost of geothermal power plants is very less.
6. Geothermal power plants don't occupy too much space and thus help in protecting natural environment.
7. Unlike solar energy, it is not dependent on the weather conditions.

Disadvantages of geothermal energy

1. Only few sites have the potential of Geothermal Energy.
2. Most of the sites, where geothermal energy is produced, are far from markets or cities, where it needs to be consumed.
3. Total generation potential of this source is too small.
4. There is always a danger of eruption of volcano.
5. Installation cost of steam power plant is very high.
6. There is no guarantee that the amount of energy which is produced will justify the capital expenditure and operations costs.
7. It may release some harmful, poisonous gases that can escape through the holes drilled during construction.

HOW IS GEOTHERMAL ENERGY HARNESSED?

There are several different ways of harnessing the heat of the Earth for energy. We have outlined a few, below. Direct geothermal energy can be accessed in areas where hot springs/geothermal reservoirs are near the surface of the Earth. In these areas, hot water (pumped through a heat exchanger) can be directly piped in to heat homes or buildings. The “used” water is then returned to the reservoir for re-heating.

Geothermal heat pumps are another method for harnessing geothermal energy. These systems utilize a series of underground pipes, an electric compressor and a heat exchanger to absorb and transfer heat.

In the summer, the system removes heat from the house/building and returns it to the Earth. In the winter, the geothermal pump absorbs heat from the ground and transfers it into the house/building.

Geothermal power plants also harness the heat of the Earth through hot water and steam. In these plants, heat is used to generate electricity. There are three main types of geothermal power plants, including dry steam plants, flash steam plants, and binary cycle plants (http://www.justenergy.com/blog/beneath-our-feet-an-introduction-to-geothermal-energy/).

CONCLUDING REMARKS

Geothermal power requires no fuel (except for pumps), and is therefore immune to fuel cost fluctuations. However, capital costs are significant. Drilling accounts for over half the costs, and exploration of deep resources entails significant risks. A typical well doublet (extraction and injection wells) in Nevada can support 4.5 megawatts (MW) and costs about $10 million to drill, with a 20% failure rate (Geothermal Economics 101, 2009). In total, electrical plant construction and well drilling cost about €2 to 5 million per MW of electrical capacity, while the break–even price is 0.04 to 0.10 € per kWh. Enhanced geothermal systems tend to be on the high side of these ranges, with capital costs above $4 million per MW and break–even above $0.054 per kWh in 2007 (Sanyal et al., 2007). Direct heating applications can use much shallower wells with lower temperatures, so smaller systems with lower costs and risks are feasible. Residential geothermal heat pumps with a capacity of 10 kilowatt (kW) are routinely installed for around $1 to 3,000 per kilowatt. Geothermal resource extraction is independent of seasonal, diurnal and meteorological factors. It is essentially a base load electricity supply. There are no fuel costs other than the cost of identifying and maintaining the resource. Geothermal resource developments are well suited to development of complimentary applications such as space and process heating assuming that the resource is reasonably convenient to a market for the heat. Development of a geothermal resource is entirely dependent upon a successful exploration program which could take years depending upon factors such as funding, the level of effort and compliance with regulatory provisions. Actual plant construction, however, is straightforward and, depending on the size of the plant, construction may be expected to take two to three years once the resource has been quantified. Geothermal plants are being constructed and operated throughout the world. The technology, while innovative in some respects, is not radical. Accordingly, the completion risk is expected to be on par with that for any other energy project. Geothermal energy is very “green”, that is, no or minimal emissions, no combustion, small pant footprint. Insome areas, however, extraction of water from geothermal reservoirs have been linked to seismicity. This has been an issue in densely populated regions such as in Europe. Geothermal electricity would be expected to qualify for carbon credits.

Conflict of Interest

The authors have not declared any conflict of interest.

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