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The Impact of Transmission Lines on Property Values: Coming to Terms with Stigma

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Abstract

The impact of power transmission lines on property values remains insufficiently explored and inconclusively theorised. This paper provides a platform for examining what appears to be a general phenomenon of price depreciation of land abutting power lines. A large scale international literature review is organised in terms of a thematic model as a prelude to a précis of key papers discussing the power line/property value nexus. Broadening the account, attention turns to the issue of stigma which has different manifestations from its normal context involving contaminated lands. In order to advance theoretical understanding, a speculative model is provided of the stigma apparently attaching to power lines and attendant installations.

Keywords: electricity industry; positioning; property; values

Introduction

Despite successive studies over the 1990s, the impact of high voltage overhead transmission lines (HVOTLs) on property values remains insufficiently explored and inconclusively theorised. Understanding the impact is important to electricity suppliers in planning routes and determining fair compensation in cases of full or partial resumption of private land. Those affected by the establishment or extension of transmission infrastructure also want greater certainty about the process and outcomes and how their economic or domestic operations are likely to be affected. Years of international practice in compensation raise the issue of the exact nature of the affliction created by power lines and equipment. Proceeding beyond the existing literature, we explore this question via some initial speculation as to the constituents of stigma, a theme not specifically addressed or categorised in previous investigations.

The scope of this paper is thus quite broad. It first sets out a conceptual framework including a generic model within which studies of power line impact can be assessed. Next, it undertakes a detailed international review of literature analysing from a real estate viewpoint the elements of power transmission. This step leads to an account of the relationship of HVOTLs and property values. Numerous instances of *ex-post* depreciation prompt the need for a clearer interpretation of stigma in the power line context. The final section handles this task.

The relevance of this work is evident in that it was undertaken as consulting for a major electricity supplier.

Conceptual framework

While one might occasionally see a sympathetic painting or an artistic photograph of power lines on sunlit plains, in reality the driver of research on electricity transmission lines and property is the issue of stigma. Power lines are popularly cast as a negative externality or a necessary evil. For property owners, they are invariably a NIMBY (not in my backyard) (Hopkins, 1999). Despite this apparent unanimity, sorting out the various connotations of power lines within the literature is no simple task. In order to encapsulate what has become a diverse body of knowledge, a model is required which is both robust and rigorous.

Studies of electricity lines as they influence property can be categorised as per the model shown in Figure 1. Initially, it proposes three causative domains: electromagnetic fields,

design and engineering. The interests here are respectively: health, visual impact, and noise and other possible outcomes.

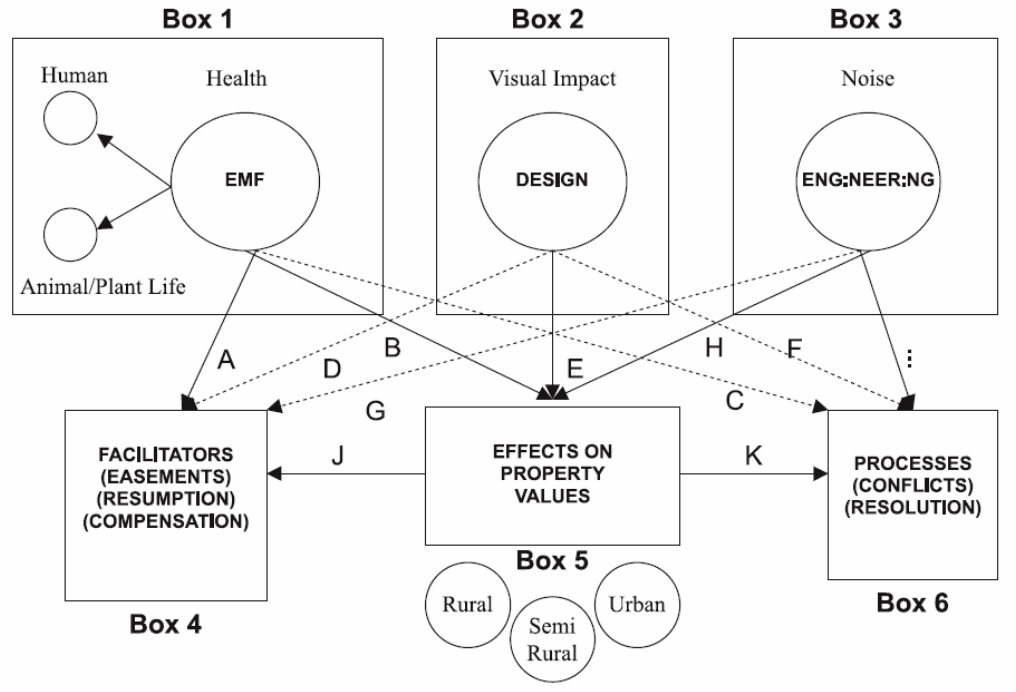

Figure 1. Conceptual model for property value studies

Sources

Box 1 - Florig (1992); Gorman (1992); Hayes (1990); Hopwood (1996); Pierobon (1993); Shulman (1990); Toburen (1996)
Box 2 - ERM McCotter and Mitchell (1998)
Box 3 - New Zealand (Ministry of Commerce) (1993)
Box 4 - Gregory and von Winterfield (1996); Hamilton and Schwann (1995)
Box 5 - Beasley (1991); Bond and Hopkins (2000); Jayne (2000); Millar and Hargreaves (1994); Priestley (1989)
Box 6 - Peyton (1999)
Link B - Rikon (1996)
Link F - Johnson (1998)
Link J - Bolton and Sick (1998); Furby *et al.* (1988)

Essentially, the model focusses on the effects of HVOTLs on property values in a number of geographical settings (Box 5). In a process sense, certain elements in Figure 1 (i.e. Boxes 1, 2 and 3) are cast as "causes" of the monetary or other property effects. However, as much as these causes are necessary determinants, they are not sufficient since other elements, such as community or individual attitudes, could influence property values or the ease of transactions. Related aspects taken into account in the model include "facilitators" such as easements, resumption and compensation (Box 4). Likewise, some authors have concerned themselves with processes of power line establishment or conflict resolution (community consultations, negotiations, legal proceedings and outcomes etc.) (Box 6).

Given the volume of prior research, references exist which consider links between many of the elements mentioned. For this reason, lines are drawn among boxes which indicate the possibility of relational enquiries, such as the effect of pylon design on property values, the relationship of health concerns to processes.

Once constructed, the model was applied to categorisation of the titles of some 200 international journal articles, books, monographs, technical reports and Internet sites. It proved adequate to the task.

The elements of power transmission

In order to appreciate the effect of power transmission elements, alone or collectively, on property prices, it is necessary to have some initial understanding of those individual elements. Informed by Figure 1, the following subsections address Boxes 1 to 4 and Box 6, along with the links viewed aggregately. References supporting these brief explanations can be found towards the end of this paper in the additional select bibliography. The various outlines act as a springboard to consideration of Box 5 (effects on property values) in the subsequent section.

Electromagnetic fields (Box 1)

The use of electricity produces two kinds of fields: electric and magnetic[1]. The former occurs when an electric charge or voltage is present and is a product of the force which electric charges exert on each other. Magnetic fields are produced by the flow of the electric current and are the basis of electromagnets and electric motors. Consequently, electric and magnetic fields (EMF) arise from anything which produces, carries or is powered by electricity. The strength of an electric field varies with the voltage of the transmission line, whereas that of the magnetic field relates to the current flowing in the conductor (Holland, 1997). The relativity of these effects appears in Table I.

Table I. Electromagnetic field strengths

Source	Specification	Electric field Kilovolts per metre KV/m	Magnetic field Milligauss (mG)
275kV HVOTL	Directly beneath	3.0	5-25
	Edge of easement	0.3	1-5
66kV HVOTL	Directly beneath	0.4	5-20
	Edge of easement	0.04	1-3
Electric blanket	Surface	2.0	10-30
Hairdryer	30cm distant	0.04	1-70
Iron	30cm distant	0.06	12-30

Sources: http://www.health.sa.goc.au/pehs/topics/topic-electromagnetic.htm (see also Holland, 1997)

Electromagnetic fields and the effect of differing kinds of radiation on humans are matters of mounting concern, abetted by recent dilemmas surrounding mobile telephones and their towers. The focal health outcome is, naturally, cancer and a fairly copious literature has emerged. Associated writing probes the effect of EMF on livestock, with obvious implications for rural property valuations near power lines. Still further studies have investigated impacts on plants, insects and wildlife.

While, overall, the literature about health effects is mixed, it is clear that potential litigation has producers of EMF erring on the side of caution. Key articles are referenced in the select bibliography and useful primers and résumés appear on several Internet sites[1,2]. Of course, the normal caveats about authenticity and reliability should be applied to non-refereed, on-line sources.

Design (Box 2)

Other than in straight engineering aspects, the literature on pylon and line designs and their visual impacts is comparatively underdeveloped. In advanced countries, virtually all

transmission as opposed to reticulation applications rely on steel rather than wooden pylons. At higher voltages involving double circuitry, only tubular steel or steel lattices are practical construction options[3]. Even so, there is little to suggest that alternative aesthetics have been tested on surrounding inhabitants, whether or not their land is directly impacted by line establishment. Similarly, if routing were considered an aspect of design, the best the literature offers is some textbook-type accounts of desirable locational and siting principles. Communities generally appear to be afforded little choice in the placement of lines.

Engineering (Box 3)

Interest of property professionals in power line engineering might relate to routing (i.e. cost differentials in land take-up) but more likely to negative physical outcomes. Lines and structures can act as a large antenna, radiating electric and magnetic noise fields. Nearby radio communications can be affected and so, occasionally, can television reception.

This segment of literature is not extensive, indicating that negative engineering externalities from power lines are constrained, at least as far as property practitioners are concerned. The military, however, is likely to have stringent requirements of line operators, so that their base operations are not affected by radio frequency interference[4].

Facilitators (Box 4)

Property professionals will likely be well acquainted with a general literature on easements and corridors, resumption and compensation. A small section of it concerns transmission lines. Easements protect the public and allow authorities access to conduct proper maintenance and servicing of infrastructure. While lower voltage distribution lines can be run underground without any major problems, burying lines of over 132kV requires heavy insulation and becomes prohibitively costly.

Easements vary in width depending on the voltage and design of the line. In New South Wales, Australia, for example, recommended widths are 45 metres for 132kV and 70 metres for 500kV lines. Trees, fences, buildings and motor vehicles provide shields from the electric field discharges of power lines but not the magnetic ones, a possible concern for surrounding land owners (Holland, 1997).

Little appears to have been written specifically about resumption for power line establishment. In many jurisdictions, compensation is codified by statutory provisions which usually allow some discretion to power authority or other valuers. These practical domains have not attracted much comment and no reference dealing with betterment was found.

Processes (Box 6)

Among property research, this facet of power line practice is poorly documented apart from scattered Internet commentaries. This fact could suggest that transmission lines are installed without undue dispute, though an examination of the literature on environmental management might indicate otherwise. It would be instructive to have more detail on situations which caused conflict and how it was resolved. It is difficult to believe that the methods used by engineers and valuers in approaching the public and those eligible for compensation could not be improved and some statement be put forward on best practice. The manner in which these functions are executed could form an important part of the corporate image of electricity suppliers.

Relational studies (all links)

The lettered links in Figure 1 have attracted varying degrees of attention. Link A (EMF and facilitators) is effectively unexplored although the fall off of electrical and magnetic radiation with distance is understood (Table I). Link B (EMF and property value effects) reflects an expanding literature dominated by discussion of stigma. By contrast, Link C (EMF and processes) appears all but non-existent.

The links of design and property outcomes are sparsely referenced. Link D between design and facilitators is not one likely to attract much attention. One Internet reference linking design and property effects (Link E) goes as far as to describe power lines as an "eyesore"[5], surely identifying visual elements as a cause of the stigma to be discussed below. Design and processes (Link F) is an interesting link which raises the issue of field management, namely, how design elements of power lines and their easements can attenuate EMF effects and thereby mitigate conflict with people impacted[6].

Engineering and property effect links are only lightly researched. For example, no electronic or published paper was found which related engineering to facilitators (Link G) or to land values (Link H). Link I (engineering and processes) is attended by a few Internet references which discuss the problem of amateur and other radio operators in dealing with RFI (radio frequency interference) emanating from power lines or other utilities. The onus is upon power authorities to handle such problems at source but sometimes public regulation and intervention might be required.

Within the property realm, good discussion attends Link J between facilitators and effects on property values, as a subset of the overall compensation literature. The message from Link K (values and processes) is obvious: future conflict can be avoided if new property structures are not built abutting power lines. Similarly, people purchasing property near corridors should understand the status quo and eschew complaint about existing infrastructure since they have accepted the benefit of discounted prices upon occupancy. In the absence of informal understanding, some type of covenant over land or additions might be the only sensible recourse.

HVOTLs and property values

Box 5 (rural, semi-rural and urban) and links J and K of the conceptual framework relate to the effects of the proximity of HVOTLs on real estate values (Figure 1). The literature relating to this part of the model can be broadly classified into:

- case studies based on regression models to estimate the impact of HVOTLs on real property value;
- appraisal or valuation-based case studies utilizing relatively small samples of properties which analyse the effect of HVOTLs on real property value; and
- case study surveys or attitudinal surveys which focus on the perceived effect of HVOTLs on real property value.
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Most of the case studies in the last 30 years have been conducted in the USA, although recent ones have emanated from New Zealand, Canada and the UK. It is understood that the way in which North Americans and Australians arrange their land holdings for the erection of power lines is similar in that the companies acquire right of way over private land. Other countries have different practices. For example, in New Zealand, lines are established on private land without rights of way and compulsory acquisition. Therefore some care is needed when interpreting the results of studies internationally.

Initially investigations were concerned with visual impact. More recently, research has been driven by health fears. Gregory and von Winterfeldt (1996) cite 1979 as the turning point with respect to health. That year marked the publication of the first study which linked EMF exposure to possible human health effects (Wertheimer and Leiper, 1979). Gallimore and Jayne (1999) argue that these fears have been especially prevalent in the past six years in the UK. The literature is now examined within the above classification in more detail.

Case study research based on regression analysis

An analysis of major case studies undertaken in the last 30 years is outlined in Table II.

From Table II, it will be noted that negative impacts on property values from HVOTLs range from 1 to 9 per cent, depending on proximity. However, care must be taken in interpretation. For example, distances at which the effects are observed vary from study to study with respect to central points or origin. Central points of measurement include centre of transmission line, edge of right of way, centre line of right of way and centre point of right of way. Also, factors such as the topography and nature of landscape will differ. It is also reported that only half of these studies produced results which were statistically significant (Gallimore and Jayne, 1999). Most focussed on residential precincts.

Table II: Refereed HVOTLs proximity studies using multiple regression

Study	Date of publication	Period/date of study	Location and sub market	Summary of effects i.e. percent decrease in price	Distance at which effects observed	Powerline capacity
1. Callanan and Hargreaves	1995	1983-1993	Newlands, Wellington New Zealand residential	27.3 9.1 2.7	10m 30m 100m	110kv
2. Colwell	1990	1968-1978	Illinois, USA residential	6.6 2.0	50ft (15m); 200ft (60m) >200ft insignificant	138KV on steel pylons
3. Colwell and Foley	1979	1963-1978	Illinois, USA residential	8.8 3.6	50ft (15m); 200ft (60m)	138KV on steel pylons
4. Hamilton and Carruthers	1993	1985-1991		5.0	120m	
5. Hamilton and Schwann	1995	1985-1991	Four residential suburbs in Vancouver	6.3 1.1	100m 200m	1-230kv on steel pylons 1 x 60 – 2 areas – 500kv
6. Ignelzi and Thomas	1991	1976-1989		1.0-9.0	300ft	
7. Kinnard	1967	1956-1965	Surburban town/areas in Hartford USA	3.0	200ft	
8. Kinnard *et al.*	1984	1973-1984	Orange county, New York	2.0	200ft	
9. Kinnard	1996	1990-1995		0.3	200ft	
10. Kinnard *et al.*	1997	1990-1996		0.2-4	200ft	

Source: Based on Gallimore and Jayne (1999)

Gregory and von Winterfeldt (1996) report that the Mountain West Research Foundation found that, of 27 pre-1979 studies they identified concerning the effects of HVOTLs on property values, only two were considered methodologically sound. One was the Colwell and Foley (1979) study noted in Table II. It predicted the selling price of 200 properties using multiple regression analysis based on ten characteristics of the housing stock, including proximity of a 138kV transmission line supported by four-legged, steel pylons. Sales represented more than a decade of transactions near a transmission line in two neighbourhoods. The line was within 130 metres of all properties in the sample. Easements had been in existence since 1926 and were acquired for the right to erect, maintain and

operate a line of steel pylons and wires with all necessary anchors. The easements were of varying width and only the centre line was identified.

The regression model relates selling price, the dependent variable, to ten independent or explanatory variables. These variables can be summarised as:

- proximity to transmission line;
- presence of a tower;
- nature of neighbourhood;
- size of property; and
- date of sale.

Unlike many studies prior to 1979, Colwell and Foley's work showed that the proximity to a line could be associated with diminished selling prices of some substance. "Although the transmission line appears to have little impact at distances beyond 200 feet, substantial differences in selling prices exist between 50 and 200 feet from the transmission line" (Colwell and Foley, 1979, p. 498).

Since 1979 other studies have been conducted. Colwell published a further paper in 1990 based on the foregoing study area and data set. One particular criticism of previous studies was that no account was taken of a possible enhancement in value arising from lots which are contiguous to the easement and therefore have "use" of the greenbelt as in an open view, gardens, swing sets etc. Colwell (1990) accordingly formulated the following hypotheses:

1. *H1*. Residential selling prices are related both to proximity to the lines and to the pylons. It was argued that lines and pylons have a large negative impact in close proximity but that any impact declines at a decreasing rate as distance increases. Additional distance beyond a few hundred feet might make very little difference.
2. *H2*. Any impact of the power line and pylons might be lessened through time.

In summary, the second study again established that the negative impact of power lines is large in close proximity, but declines as distance increases. Furthermore, the impact of the lines diminishes with time. There may be an additional negative value impact of proximity to pylons but this impact showed no significant signs of diminishing through time.

Among post-1979 studies, that of Hamilton and Schwann (1995) has been cited as one of the most reliable. It examined the effect of proximity to transmission lines in sale prices of 12,907 single detached dwellings in four Vancouver neighbourhoods over the period 1985-1991. The regression results showed that proximity to high voltage electric pylons was significant with respect to depreciation in property prices (Gregory and von Winterfeldt, 1996).

A particular aspect to note in this study was that the HVOTLs effects varied among the four neighbourhoods. The rights of way in two areas were 140 metres in width with two 500kV and one 230kV power lines on steel pylons; one with two transmission lines on steel pylons; and one area with a 60kV line on wooden poles. Distances were measured from the centre of the transmission line right of way.

There appear to have been few enquiries involving non-residential real estate. Fortunately, one (Boyer *et al*., 1978) is regarded as among the more rigorous and comprehensive. It found that "the per acre values from more than 1,000 agricultural property sales in Eastern Canada were 16-29 per cent lower for properties with easements for transmission lines than for similar properties without easements" (Gregory and von Winterfeldt, 1996, p. 207). The adverse effects of proximity were largest with smaller properties. The study examined the impacts of 230kV and a 500kV lines. The lines were of different age and physical size as well as voltage. The following points emerged:

- There were few differences in responses from the 230kV and 500kV study areas. The impacts of transmission corridors do not appear to be influenced by the age, voltage and physical size of the line.

- Hydro lines appear to meet with the strongest opposition during the planning and construction phases but, once in place, become neutral components of the landscape. The affected public's consciousness of their impact tends to diminish over time.
- In the past the affected public has adjusted and adapted to the impacts of hydro transmission facilities. It is suggested, however, that with the current level of public consciousness of the issues related to power generation and transmission, similar accommodation might not be expected to continue in the future.

Case study research based on valuation

The disadvantage of valuation-based studies is that they generally use small samples and can be subjective. They employ direct comparisons of groups of sales and a "paired sales analysis" approach. An impact area is defined and sales of properties within it are compared with sales of similar "competitive properties" in an area not traversed by HVOTLs. Any price differentials are noted, and patterns identified.

According to Kinnard (1995), the shortcomings of this approach are:

- identifying what constitutes a pair of virtually identical properties involves subjective judgement; and
- the generally small number of appropriate pairs identifiable in studies makes the results questionable in terms of representing the market.

Few of these types of studies are reported in journals. They are generally prepared for corporations and rarely made available.

Case study research based on attitudinal surveys

These studies focus on the perceived effects that transmission lines have on property values and are generally regarded as less sophisticated than regression-based research. There is a widely-held belief that they over-estimate the negative impacts of transmission lines (Kroll and Priestley, 1991). Moreover, they rely on the ready availability of market transaction data which does not apply in all countries. Key reports are outlined in Table III.

It should be noted that attitudinal research is fraught with potential difficulties with respect to quantifying likely market behaviour by potential buyers. They have been highlighted by Roddewig (1999) in a review of recent legal cases in the USA. The general conclusions were that practitioners should:

- be objective in the presentation of facts to survey participants; and
- avoid using surveys as the only basis for conclusions relating to the effect of stigma.

Stigma

Studies reviewed and others referenced in the reference list demonstrate the broadly negative impact of electricity lines on property values. What is presently missing from the power line literature is a dissection of the causes of the deprecatory effect: in other words, the genesis of stigma[7]. Yet, if stigma could be better understood, it might be possible for power authorities to "educate" property holders and thereby lessen their liability for compensation. This outcome might be achieved by appeals to the "social good", or through reassurances that popular fears about certain power line elements are not substantiated in research.

Elsewhere in property studies, stigma has been broadly defined as "a market imposed penalty that can affect a property that is known or suspected to be contaminated, property that was once contaminated but is now considered clean, or a never contaminated property located in proximity to a contaminated property" (Dybvig, 1992, p. 47). This definition relates to land which can be objectively shown to be contaminated in full or part. With power transmission, the situation is less clear cut. While the spatial incidence of EMF can be accurately gauged, its implications are still being debated. A lack of common perceptions will translate into varying attitudes and financial responses.

Unlike other forms of contamination of land, power lines do not represent (what becomes seen as) an historical accident. They are for the here and now and their influence remains only as long as they do. They do not represent a source of affliction which needs to be, or will someday be, "cleaned up". In some countries they can exist on private land while, in others, they are confined to public easements. Their influence has spatial spread and decays with distance: as a "contaminant", they are not punctiform or contained to some point source.

For these reasons, any stigma associated with transmission lines requires a different approach from that applying to other contaminated lands. Figure 2 presents a speculative model (). In any area, one would first question the existence of stigma (as expressed in property value data or in public attitudes to power lines (and/or power authorities)). Having determined the fact, the approach suggests several possible roots of the problem. They lie variously with individual property holders or with entire communities.

Table III. Comparison of data, refereed HVOTL proximity studies using survey research

Study	Period/ date of study	Location and sub market	Summary of effects i.e. percent decrease in price	Distance at which effects observed	Power line capacity	Type of study
1. Priestley and Evans	1990	Vallejo, California		Not applicable	Not specIfied	Opinion survey
2. Bond	1995	Residential	50 percent of valuers responding suggested up to 10 percent decrease 46 percent of agents 5-10 percent decrease 31 percent of agents 10-15 percent decrease	Not applicable	110kv	Opinion survey
3. Delaney and Timmons	1992	Memphis and Shelby, Tennessee residential	Mean value 10.2 percent decrease in price	Not applicable	Not specified	Opinion survey
4. Kung and Seagle	1992		28 percent of homeowners thought price affected 72 percent thought no effect on sale price	Not applicable	Not specified	Opinion survey

First, individuals could react to coercion itself, whether occasioned by a power company or any other private individual or public authority. Many people, particularly libertarians, would value being left alone without hassles to enjoy their freehold or other rights. Second, individuals could resent the intrusion of a power authority for fear of resumption or down-zoning of nearby tracts of land or of falling property values. Despite the creation of open space in a locality due to the establishment of the easement, such an attitude could be rational, given the results of prior studies.

Third, communities could express dissatisfaction with pylon design or line routing. Both matters could be negotiated by an electricity authority. Fourth, the community might

hold positive viewpoints about the environment or the "public good", which run contrary to the intent of the authority (a "green" consciousness, for example). Finally, both individuals and entire communities could be influenced by negative publicity surrounding the effects of EMF[8].

It is not clear where, among these or other possible causes, the roots of stigma lie or which factors might be the most influential. Indeed, their bearing could vary from setting to setting and country to country. There is extensive scope for further research into individual and community attitudes. It could simultaneously clarify the issue and specify an optimal approach of transmission authorities to property matters in power line establishment.

There is also much in the general property literature which could assist such investigations. Mundy (1992), for instance, has advanced a number of criteria to measure the incidence of stigma. Prospective explanation could be forthcoming from constructs such as the potential for disruption, prominence of the source, aesthetic effects, perpetrating agency, prognosis, degree of peril and level of individual or community fear. In this way, power line research should be able to draw on the wider, contemporary and quite vibrant work on contamination elsewhere in the real estate discipline.

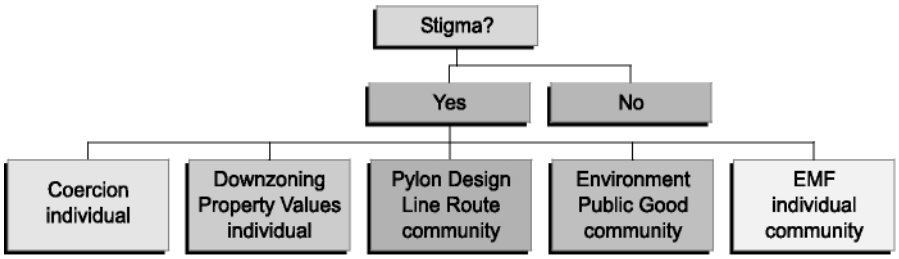

Figure 2. Scoping the nature of power line stigma

Summary and conclusions

This paper responds to ongoing concern in property circles about land uses which are perceived negatively and create stigma in the marketplace. For the case of electricity transmission, it has set out a conceptual model which dissects related facets of the association between power lines and real estate values. The contribution here has been a broad scale literature review which takes account of published and online sources.

The burden of this account is that the issues of stigma need greater understanding. For power lines, an exploratory schema has been developed which should guide future research and the approach of electricity authorities. However, this analysis has relevance beyond the immediate context to include airports, noxious and hazardous industries, freeways and so on. The need is to discern exactly what are the negative externalities to which people react and express displeasure in the form of depressed property values. Only then can cost-effective steps possibly be taken to counter the most obtrusive aspects of these land uses.

Notes

1. http://www.health.sa.gov.au/pehs/topics/topic-electromagnetic.htm (see Holland (1997)).
2. http://www.ortho.isumc.edu/Faculty/Marino/Powerline/PowerlineTOC.html; http://www.futuredynamicadvantage.com/learchives/powerline.html See recent major studies via British National Radiological Protection Board at www.nrpb.org.uk
3. According to the United States Department of Energy: http://nepa.eh.doe.gov/ea/ea0194b/EA_0194B_2.html
4. http://www.ee.uwa.edu.au/-esc/research_rfnoise.htm
5. http://www.newrivervalley.com/news/aep/aep673.html
6. http://www.emf-data.org/symposium98/syn-13.html A useful bibliography on field management is included.

7. Stigma, however, is recognised in other fields of property research such as contaminated lands: see, for example, Mundy (1992).
8. Given the current state of research, who can say what perceptions are actually held by the public? For example, the environmentally and health conscious segments of a community might not be indifferent between power transmitted from nuclear as opposed to coal-fired power station!

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