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Appraising infrastructure for new towns in Ireland

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Over a 20 year period 1996–2016, a new 223 ha town is being developed 10 miles west of Dublin's city centre on the south side of Lucan, County Dublin, in the Republic of Ireland (ROI). This €4 billion 'Adamstown' development is the first of four planning schemes in ROI to be approved as a strategic development zone – an integrated planning framework deemed suitable for creating sustainable neighbourhoods in sites of strategic economic or social importance to the state. The creation of sustainable neighbourhoods in ROI is facilitated through the implementation of a checklist of 60 indicators. This paper critically examines the attempts being made to consider sustainability within the development's overall infrastructure plan, specifically: transport, energy and water services, information technology and waste. Inadequacies in the existing development are linked to shortfalls in the sustainability checklist, by way of a comparison of infrastructure-related indicators from the ROI checklist with those derived for the UK and exemplar European projects (i.e. Bedzed, UK and Freiberg, Germany). The subsequent legacy for future residents of Adamstown is then considered in the context of 'what if' scenarios.

1. Introduction

Adamstown is the first new town to be built in the Republic of Ireland (ROI) for more than 20 years. The 223 ha development site lies to the south-west of Lucan (10 miles from Dublin's city centre) in close proximity to the main M50 motorway (Figure 1). Planned for development between 1996 and 2016, the population of the completed Adamstown is expected to exceed 30 000, making it as large as neighbouring towns of Drogheda and Dundalk. Moreover it will increase the population of the greater Lucan area to more than 50 000 – census figures already show Lucan to be the fastest growing town in ROI (CSO, 2006). It is an underlying ambition that Adamstown will be a 'sustainable residential development' and as a private initiative in a rural area it has many similarities with the eco-towns currently proposed for the UK. Therefore the lessons learned in Adamstown could be invaluable for sustainable development projects elsewhere.

At the early stages of development (i.e. visioning) the original sustainability concept within Adamstown was somewhat aspirational: for a 'sustainable' and 'vibrant' community centred on the railway station rather than an agglomerate of housing estates bolted on to the edge of Lucan (Mahoney, 2007). This vision was endorsed by all members of the development team and embedded within the decision-making process from the earliest stage.

At this time, sustainable development (SD) principles were moving from an 'unclearly defined' cornerstone of government policy to integration within the heart of the ROI planning system (Mahoney, 2007). These vitally important changes within the Irish planning system with regard to SD mirrored the development of clear strategies and guidelines for SD occurring in the UK in the same time period (Porter and Hunt, 2005). In 1997 in ROI these included publication of 'Sustainable development – a strategy for Ireland' (DoE, 1997) and in 1999 this was accompanied by 'The strategic planning guidelines for the Greater Dublin Area' (Martin *et al.*, 1999). In 2000 Acts of Parliament included the implementation of a SD agenda (e.g. The Planning and Development Act 2000 – Acts of the Oireachtais, 2000).

The Adamstown local area plan (LAP, SDCC, 2001) specified many details of the Adamstown development, including: the nature and extent of buildings and the uses permitted therein; the amenities and facilities required; and the services and infrastructure necessary to serve the now 'zoned' Adamstown lands (Johnson, 2001). The LAP aimed to 'create a sustainable

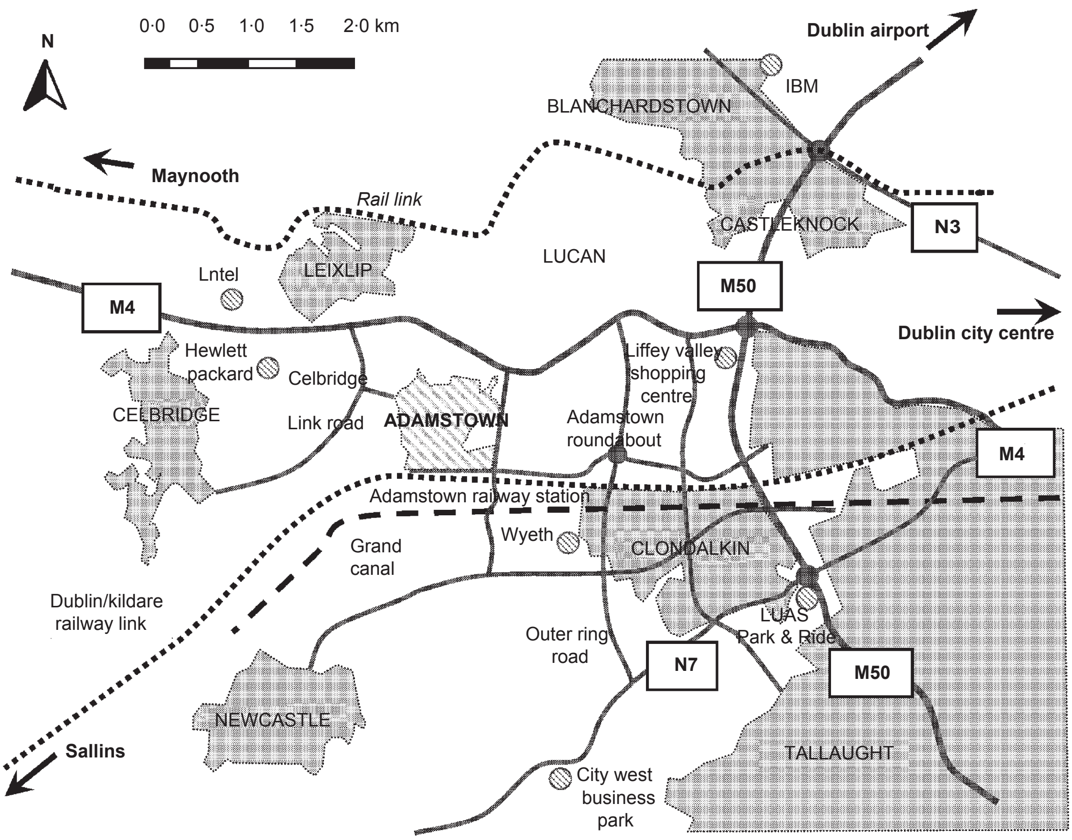

Figure 1. Adamstown's location in regard to Dublin (SDCC, 2003)

and vibrant community based on a traditional town format with a wide range and choice of dwellings, shopping services, employment, education and leisure facilities and amenities [p. 17]', moreover it was where sustainability became fully integrated into the project (Mahoney, 2007). Since this time and following on from key publications such as 'Making Ireland's development sustainable' (a review of progress since Rio, DoEHLG, 2002), there has been huge impetus towards creating sustainable communities in ROI – not least in urban areas. Therefore it is not surprising that the aim of achieving a sustainable community was fully endorsed within the 'Adamstown SDZ Planning Scheme' when it was published in 2003 (SDCCPD, 2003).

More recently draft planning guidelines (DPGs) and manuals have outlined salient features for achieving sustainable urban residential development, set within the context of ROI. The draft DPG 'Sustainable residential development in urban areas' (DoEHLG, 2008a) was published in February 2008 and the accompanying 'Urban design manual' for Adamstown and ROI, which contains a checklist of 60 indicators (in 12 categories), was published in March 2008 (DoEHLG, 2008b).

While Adamstown has been at the forefront of sustainable community initiatives in ROI, being cited as an exemplar in both of these documents, the main aim of this paper is to investigate how far the ROI checklist has gone in delivering sustainable infrastructure provision (i.e. transport, energy, water, information technology and waste). Previous work has shown that such checklists can provide a means to incorporate a clear and well-defined vision of sustainability, but that even a well-designed list may harbour internal inconsistencies (Hunt *et al.*, 2008, 2009).

Section 2 of this paper briefly sets the context for the development, including an insight into the economic climate that accelerated demand for properties; the role of strategic development zones (SDZs) in accelerating delivery of developments; the Adamstown masterplan and community; and any national and international recognition being achieved. Section 3 presents a critical examination of the infrastructure provision within Adamstown with respect to sustainability. In addition it provides a critical evaluation of the ROI checklist by comparing it to those adopted in the UK and exemplar European projects (e.g. Bedzed and Freiberg). Many sustainability issues are considered therein, including: modal splits for transport, building design and materials, supply and disposal strategies, technology adoption, user behaviour and so on. Throughout this section many parallels and differences are highlighted with regard to policy requirements and aspects of everyday living within Adamstown (ROI) and the UK; illustrating the differences between neighbouring EU countries emphasises the necessity of considering local priorities when considering sustainability (a core finding of current UK research, see www.esr.bham.ac.uk). Section 4 provides a discussion on the lessons being learned from the Adamstown development and summarises both the opportunities being seized and those being missed. Moreover it provides an insight into the legacy being left for future residents – considered in the context of possible future scenarios for the town.

Research was undertaken using both primary data (the main author lived in Adamstown Castle for 12 months) and secondary data. Future scenarios research using international case studies forms part of the research work being undertaken currently by the Urban Futures project team – research collaboration between the Universities of Birmingham, Exeter and Lancaster, and Birmingham City University. Further details are provided at www.urban-futures.org.

2. Context of Adamstown: a brief history of the development

2.1 The 'Celtic Tiger' years

Between 1995 and 2007, a period now referred to as the 'Celtic Tiger' years, ROI experienced rapid economic growth, fuelled in no small part by low corporation tax (12·5%) and net transfer payments from European Union member states. This was accompanied by high population growth and a strong demand for housing predicted to increase to over 2·5 million by 2020 (DoEHLG, 2008b) from a level of 1·0 million in 1991 (CSO, 1997). In 2004–2006 annual construction peaked between 80 000 and 90 000 homes. In comparison the UK's annual construction rate was approximately 160 000 homes, although the population was 15 times greater. The construction sector in ROI during this time was reportedly worth >12% of GDP. Scores of greenfield developments were approved on the edge of existing towns or, as in the case of 'Adamstown', a completely new town was developed.

In 2006, the first 635 completed units within the Adamstown Castle development sold out within three weeks of the launch. First-time buyers accounted for 55% of total purchasers, with 20% coming from investors and the remainder being those moving up the property ladder. An estimated 25% of potential buyers were non-nationals, highlighting the huge impact on the market of inward migration of workers to ROI in recent years (Krings, 2006). In subsequent launches (e.g. Adamstown Square on 21 January 2008) the long queues of buyers were absent – presumably related to the downturn in the market, and the reduced availability and size of mortgage lending. In November 2008, the cost of a four-bedroom townhouse had fallen to €425 000, down almost 20% on 2006 values (*Lucan Gazette*, 2008). In 2010 development on the site has slowed considerably and the costs for the same property at €275 000 have almost halved. A legacy of 2000 partially completed 'ghost estates' now exist within ROI.

2.2 Adamstown strategic development zone (SDZ)

In 2000, SDZs were introduced to speed up delivery of residential developments, which were in high demand (Irish Statute Book, 2000):

> An SDZ provides an integrated planning framework and as such is highly suitable for creating sustainable neighbourhoods. They are designated by Government Order, where the site in question is deemed to be of strategic economic or social importance to the State. They have a number of advantages in this regard, including the speedy delivery of residential development following approval of the planning scheme.
>
> Part IX of the *Planning and Development Act*

Adamstown is the most advanced SDZ – the other three being Clonburris (South Dublin), Hansfield (Fingal) and Clonmagadden (Co. Meath). An SDZ is distinct from normal developments in several ways, including: it supersedes any contrary provisions of the development plan – essentially fast tracking the development; there are no appeal opportunities to An Bord Pleanala (the Irish Planning Board); and the planning authority can use any available powers (including compulsory purchase order – CPO) in order to secure or facilitate provision of the SDZ. On 19 June 2001 the Adamstown SDZ was established by Statutory Instrument (S.I. no. 272 of 2001), and adopted on 1 July 2001 following the publication of the Adamstown LAP (Johnson, 2001).

As a greenfield development, Adamstown has not required CPO. However, in early 2000, concerns were raised by local residents in the once sleepy village of Lucan that their quality of life had been compromised in favour of profit-driven developers, when thousands of acres of agricultural lands surrounding Lucan (including Adamstown) were suddenly re-zoned for development. Schools in Lucan were reaching full capacity and roads had become gridlocked owing to poor public transport provision – the re-opening of Lucan train station, talked of for years, had never come to fruition. The adoption of Adamstown as an SDZ merely set alarms bells ringing for many residents, not least because there had been no commitment by relevant agencies to deliver the required social infrastructure (schools, public transport, playgrounds, green areas and parks) in tandem with new housing – with potentially serious implications for Lucan residents. There were already concerns over new developments built on floodplains in the greater Lucan area – owing to insufficient infrastructure provision for surface water removal, hundreds of home and business had been flooded in November 2000. An extensive national media campaign followed, and three and a half years of meetings between residents, the South Dublin Development Agency (whose responsibility it was to implement the SDZ, akin to a regional development agency in the UK), developers, politicians and Bord Pleanála, resulting finally in the delivery of social infrastructure/amenities on a phased basis in tandem with housing (Section 2.3).

2.3 The Adamstown Masterplan

The draft planning scheme for Adamstown was submitted in December 2002 and approved on 26 September 2003. The original proposal was for 1 035 000 m^2 (9950 homes) of residential and 125 000 m^2 of non-residential development (for greater detail see the Adamstown Strategic Development Zone Planning Scheme (SDCCPD, 2003) with higher density developments being provided next to transport nodes (so-called transit-oriented development associated with the new urbanism movement in the USA) in line with national policy on sustainable development (DoE, 1997).

The Masterplan consists of 11 distinct named development areas and four amenity areas (three parks and one central boulevard) (Figures 2 and 3). In many cases the names given to the various areas reflect their history, for example the area named Airlie stud was historically a stud farm. The Adamstown development details are presented in Tables 1 and 2: number and type of units, density, area of open space, building heights, type of development. In addition, progress of the development in October 2010 is shown (see also Figure 3). A total of 3428 units have received planning permission of which 1162 have been completed and occupied in three main development sites (Adamstown Castle – 565; The Paddocks – 332; Adamstown Square – 262). A total of 1384 units have been started, including 20 units on the St Helen's development site. An expanded view of Adamstown Castle, one of the completed developments, is shown in Figure 4.

The development is being carried out in 13 identified phases; an important part of the phasing, in line with the SDZ requirements, was provision of infrastructure in tandem with residential occupation. This €4 billion landmark project is funded through a mix of public finance for public transport, roads and educational infrastructure; and private finance for the rest. The €1·2 billion development of Adamstown Central (development area 11 in Table 1), one of the largest ever mixed-use planning applications in the history of ROI (Tyrell, 2008), was granted permission on 18 July 2008. As of March 2011, work had yet to start on this development site. Residents

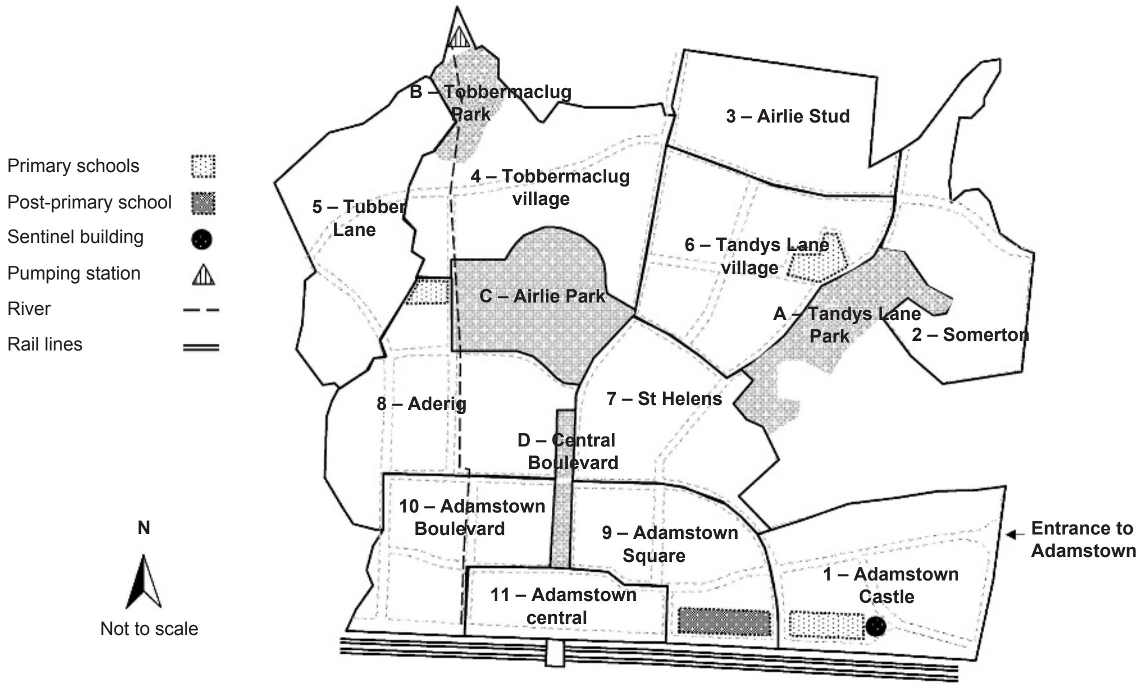

Figure 2. The Adamstown development plan (11 development areas and four amenity areas shown)

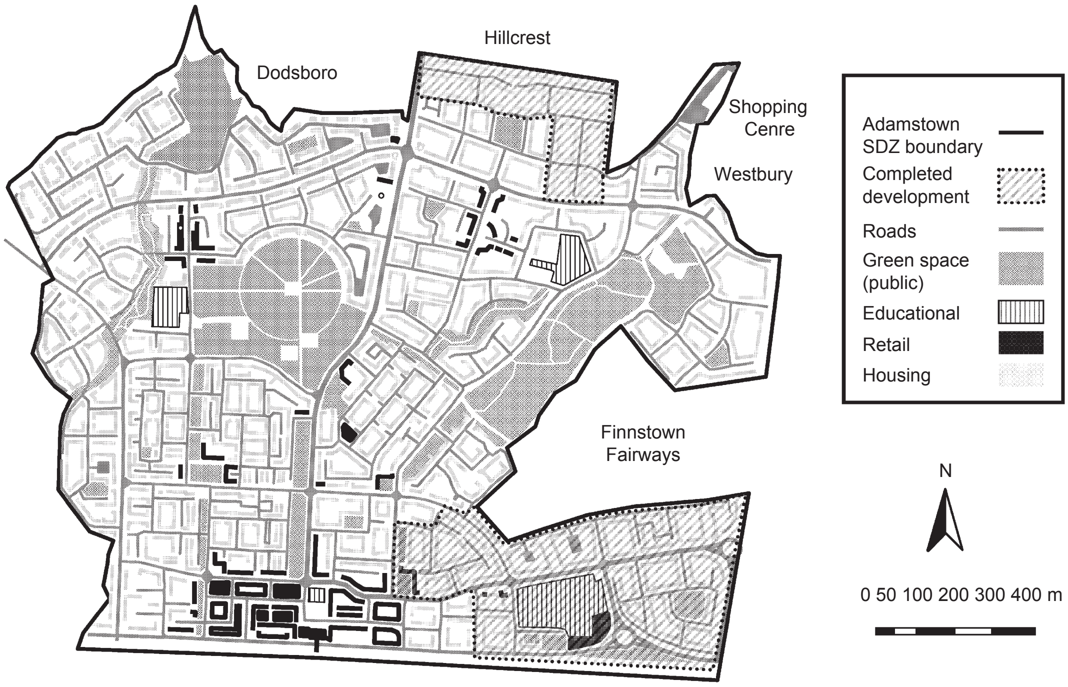

Figure 3. The Adamstown Masterplan showing completed developments (SDCC, 2010a)

have been kept fully informed as to the progress of development through the Adamstown website (www.adamstown.ie) which contains planning applications, strategy documents and design competitions (Irish Statute Book, 2000).

2.4 Achieving sustainability? National and international recognition

Adamstown has been recognised at national and European levels within planning circles

- 2005: Irish Planning Institute's Principal Award
- 2006: European Council of Spatial Planning Award, with particular reference to the way homes are being delivered in tandem with social and transport infrastructure
- 2007: Irish Residential Development of the Year
- 2008: the Local Authority Members Association (LAMA) awarded the development first place in two categories (Best Private Housing Development and Best Affordable Housing Development)
- 2009: the Royal Town and Planning Institute's (RTPI) 'Sustainable Communities' award in the UK within a category that recognises 'the creation of sustainable, mixed use developments in rural or urban contexts which balance and integrate social, economic, environmental and resource needs of the community'.

Adamstown, being the first SDZ in ROI, is undoubtedly being closely monitored as a blueprint for future town development in ROI. It is evident that the SDZ status has played a significant role in its swift delivery, and the awards would suggest that a sustainable community is being created. Section 3 will now provide a critical examination of what this means in terms of Adamstown's infrastructure provision.

3. Assessing the sustainability of Adamstown's infrastructure

In line with national policy, achievement of a sustainable residential development requires consideration beyond the physical delivery, to include both quantitative issues (e.g. timely provision of services) and qualitative issues (e.g. people's perception of what constitutes a quality environment). Sections 3.1 to 3.4 critically examine the attempts to incorporate sustainability within five different types of infrastructure provision within Adamstown, that is transport, energy, water and IT services, and waste. By comparing infrastructure related indicators from the RoI checklist (DoEHLG, 2008b) with comparable checklists derived for the UK (Defra, 2005) and exemplar European projects (i.e. Bedzed, UK (BRE, 2002) and Freiberg, Germany (Scheurer, 2001)) – Table 3, this section begins to highlight inadequacies within the Adamstown development and the existing ROI checklist.

Development area (1–11)		Area: ha	Open space: %	Residentialunits	Units started (occupied)	Type of development (see Table 2)	Density range (dwellings/ha)	Height max.: m
1	Adamstown Castle (two stage)	21·1	3·6	623	620 (565)	P.Sch, O, Re (i to v)	42–50	15
2	Somerton	14·5	3·6	650	0	FS, GS, Re (iii to v)	35–42	15
3	Airlie Stud (Paddocks: two stage)	15·6	3·6	700	356 (332)	Re (iii to v)	40–48	15
4	Tobermaclugg village	21·4	3·6	1050	0	Re (iii to v)	45–54	15
5	Tubber Lane	18·8	3·6	850	0	Re (ii to v)	40–48	15
6	Tandy's Lane village	21·7	3·6	1025	0	P.Sch, Re (ii to v)	50–60	21
7	St. Helens	16·0	3·6	1100	20 (0)	Re (ii to v)	65–78	21
8	Aderrig	21·7	3·6	1400	0	P.Sch, Re (ii to v)	65–78	21
9	Adamstown Square	15·1	3·5	1100	388 (262)	Re (ii to v)	75–90	30
10	Adamstown Boulevard	14·4	3·6	1025	0	PP.Sch, Re (i to v)	75–90	30
11	Adamstown Central (two stage)	8·3	3·6	606	0	C, Re, O, L, HC (i to v)	75–90	30
	Total	188·6	3·6	9956	1384 (1162)			
Amenity area (A to D)				Character				
A	Tandy's Lane Park	8·0	100	Major		–		
B	Tubermaclugg Park	3·8	100	Major		–		
C	Airlie Park	11·6	100	Major		–		
D	Central Boulevard	1·9	100	Urban		–		
	Total	25·3	100	–		–		

Key: C – commercial; CC – community centre; FS – fire station; GS – garda station, HC – health centre; L – leisure; O – office: P.Sch – primary school; PP.Sch – post-primary school; Re – retail

Table 1. Characteristics of the Adamstown development in October 2010 (SDCCPD, 2003)

Type		Apartments: m^2	Houses: m^2
i	One bedroom	45	50
ii	Two bedroom	65	70
iii	Three bedroom	85	90
iv	Four bedroom	105	110
v	Five bedroom	120	125

Table 2. Residential unit sizes

3.1 Transport infrastructure

When the Adamstown development was being conceived, the Department of the Environment (DoE, 1997) stipulated that an increase in both the efficiency and use of public transport systems, as opposed to private motor cars, within Irish developments would facilitate a more sustainable future. In furthering this agenda The National Development Plan 2000–2006 (NDP, 2000) outlined a 6-year investment programme to: develop, extend and increase bus capacity; implement the Luas (metro system); quadruple the Kildare rail link to Heuston (Dublin's main railway station); and provide rail links through to Connolly (Johnson, 2001). This section assesses the transport infrastructure provided within Adamstown against the indicators used in Table 3.

3.1.1 Adamstown railway station

The railway station (Figure 5) took just over 12 months to build and was opened on 16 April 2007. Situated on the Kildare line, it provides Adamstown residents with a 14 min commute into Heuston, Dublin's main rail station; the Luas provides connection with other inner city areas. The scheme was considered by Black *et al.* (2006) to be an integral part of a modern sustainable urban development, as the legacy of road-orientated urban planning and development around Dublin had already been seen to fail. Adamstown is being developed with higher residential densities around a mixed-use centre located at the railway station, the first privately built station since 1922, which resonates well with (2b), (2e) and (5a) in Table 3. The transport interchange includes 100 covered bicycle parking racks (Figure 5); pick-up and drop-off areas for buses and taxis; and a park and ride facility for 300 cars situated 200 m away.

3.1.2 Quality bus corridors (QBC)

The SDZ required that two QBCs be provided in Adamstown, one north–south and one east–west (Figure 6); these now form part of the 151 and 25X bus routes that connect through to Dublin's city centre (SDCC, 2008a). This goes directly to the achievement of (2c) and (ii) in Table 3.

3.1.3 Cycling and walking

Enhanced opportunities for walking and cycling were deemed essential for achieving a more sustainable future in Ireland (DoE, 1997). In addressing these aims, the Adamstown SDZ sought to provide 'a network of direct, safe, secure and pleasant cycle and pedestrian routes' and, in so doing, to

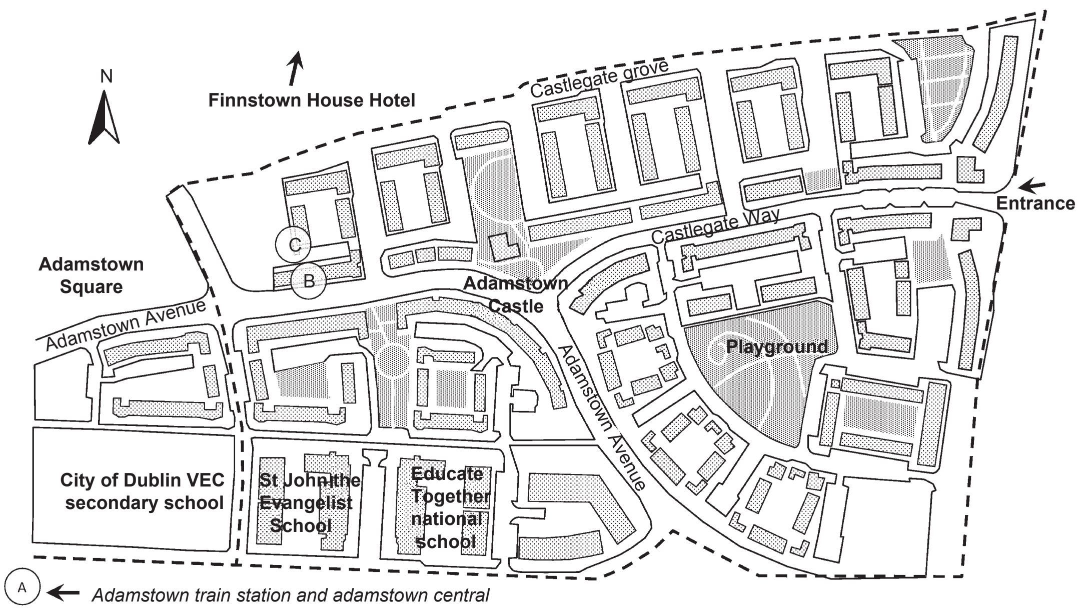

Figure 4. Arial view of Adamstown Castle (modified from SDCC, 2010a)

Component	RoI (DoEHLG, 2008a)	UK checklist (NDP, 2000)	European Exemplar checklist (Black *et al*., 2006; SDCC 2008a; SDCCPD, 2006; Hanham Hall Zero Carbon Village http://www.hanhamhall.co.uk/site/web/home; http://www.wdh.co.uk/News/NewsItem.aspx?NewsItemID=1323
Transport	(2b) The development is located in or close to a mixed-use centre (2c) The development's layout makes it easy for a bus to serve the scheme (2e) Appropriate density, dependent on location, helps support efficient public transport (5a) The proposal looks at the potential of higher density, taking into account appropriate accessibility by public transport and the objectives of good design (8e) Roads and parking areas are considered as an integral landscaped element in the design of the public realm (11a) Appropriate car parking is on street or within easy reach of the home's front door. (11b) Parked cars are overlooked by houses, pedestrians and traffic, or stored in secure underground or podium arrangements (11c) Parking is provided communally to maximise efficiency and accommodate visitors without the need to provide additional dedicated spaces (11d) Materials used for parking areas are of similar quality to the rest of the development (11e) Adequate secure facilities are provided for bicycle storage (12d) Open car parking areas are considered as an integral element within the public realm design and are treated accordingly	(Cvi) Enable a lifestyle that minimises negative environmental impact and enhances positive impacts (e.g. by creating opportunities for walking and cycling, and reducing noise pollution and dependence on cars) (Dvii) Accessibility of jobs, key services and facilities by public transport, walking and cycling (Ei) Transport facilities, including public transport, that help people travel within and between communities and reduce dependence on cars (Eii) Facilities to encourage safe local walking and cycling (Eiii) An appropriate level of local parking facilities in line with local plans to manage road traffic demand	(i) The development is based on the needs of people not cars (ii) The development is integrated with public transport facilities (iii) The development is integrated with pedestrian and cycling networks (iv) Motorised vehicles are excluded in certain areas (v) On-site car sharing facilities are provided – a 1 year free pass to public transport (vi) On-site charging points for electric cars (vii) Parking provision $< 0{\cdot}5$/unit (viii) On-site parking fees charged

RoI checklist – (2) Connections, (5) Efficiency, (8) Public realm, (9) Adaptability, (10) Privacy and amenity, (11) Parking, (12) Detailed design,
UK checklist – (C) Environmentally sensitive, (D) Well designed and built, (E) Well connected

Table 3. Various 'infrastructure' related checklist indicators related to achieving a sustainable community (continued on next page)

Energy	(5c) Buildings, gardens and public spaces are laid out to exploit the best solar orientation (9b) The homes are energy-efficient and equipped for challenges anticipated from a changing climate (12a) The materials and external design make a positive contribution to the locality	(Ci) Actively seek to minimise climate change, including through energy efficiency and the use of renewables (Civ) Make efficient use of natural resources, encouraging sustainable production and consumption (Dv) High-quality, mixed-use, durable, flexible and adaptable buildings, using sustainable construction materials	(ix) Zero carbon development (x) Buildings are constructed to meet passive house building standards – zero space heating required. (xi) Passive solar is integrated (xii) Solar supported water heating or photovoltaics are adopted (xiii) The development incorporates a co-generation plant and short distance heating system (xiv) Extensive use of ecological building materials is adopted (xv) Smart metering installed
Water	(5b) Landscaped areas are designed to provide amenity and biodiversity, protect buildings and spaces from the elements and incorporate sustainable urban drainage systems	(Cii) Protect the environment, by minimising pollution on land, in water and in the air	(xvi) Demand < 80 l/person/day (xvii) Rainwater collection and indoor use is adopted (xviii) Where applicable on-site greywater treatment is provided (xix) Infiltration of rainwater into the ground is allowed for with ecologically based sanitary systems
Waste	(5e) Appropriate recycling facilities are provided (10e) The homes are designed to provide adequate storage including space within the home for the sorting and storage of recyclables (12e) Care has been taken over siting of flues, vents and bin stores	(Ciiii) Minimise waste and dispose of it in accordance with current good practice	(xx) Zero waste development (xxi) On-site recycling facilities are provided (xxii) On-site composting facilities are provided (xxiii) Waste <105 kg/person/year
Communications		(Eiv) Widely available and effective telecommunications and internet access (Ev) Good access to regional, national and international communications networks	

RoI checklist – (2) Connections, (5) Efficiency, (8) Public realm, (9) Adaptability, (10) Privacy and amenity, (11) Parking, (12) Detailed design,
UK checklist – (C) Environmentally sensitive, (D) Well designed and built, (E) Well connected

Table 3. Continued

Figure 5. Adamstown central rail station (A in Figure 4)

'maximize the opportunity for pedestrians and cyclists to access services and facilities', not least the local and strategic public transport network (SDCCPD, 2003). This addresses indicators (11e) and (iii) in Table 3. The Adamstown cycling strategy provides finer details (SDCCPD, 2005). The proposed route broadly consists of 1·5 m cycle tracks situated on-road (north–south may be integrated as part of QBC) and 3 m wide tracks through the three parks (SDCC, 2008b).

The DoEHLG (2008b) reported Adamstown to be a sustainable exemplar in terms of its strategies for promoting cycling (e.g. one bicycle parking facility per dwelling) and walking (e.g. limiting block sizes to achieve pedestrian accessibility). The development is based on 5 and 10 min walking schemes respectively, that is 400 m to a local centre, of which there are two, and 800 m to the district centre and public transport system (Johnson, 2001; SDCCPD, 2003). Adamstown central, the main district centre, will prioritise both pedestrian and cycle movement.

Figure 6. Quality bus corridor (QBC) in Adamstown Castle (B in Figure 4)

3.1.4 The motor car

Sustainable travel underpins the vision for Adamstown and undoubtedly the Adamstown development has provided the infrastructure (discussed above) necessary to reduce significantly the requirement for private motor vehicles (SDCC, 2010a). However, as depicted in Figure 7, data from the 2009 household survey show that each household owned 1·43 cars (SDCC, 2009, 2010a). The performance of Adamstown in terms of car use in modal splits is somewhat ahead of Southern Ireland, the UK, Germany and Sweden, although, more worryingly, it is significantly behind the Greater Dublin Area (GDA) and a sustainable exemplar such as Freiberg, Germany (Beim and Haag, 2010). The 'Smarter Travel' scheme was launched by Adamstown in May 2009, an initiative to prompt a change in attitude and behaviour toward sustainable modes of transport through a series of challenges (SDCCPD, 2005). While such a scheme has been well-intentioned its success to deliver against indicators is still unclear.

This is not helped by the fact that no specific 'car clubs' ((v) in Table 3) have been adopted in Adamstown, although car pooling does amount to 2·5% of the modal split. Moreover there are no electric vehicles ((vi) in Table 3), as in other exemplar projects (e.g. Bedzed, UK – BRE, 2002). This should change dramatically in the future owing to new policy requirements to adopt 10% electric cars (250 000 vehicles) in ROI by 2020.

Roads and parking provision are considered a prerequisite for a sustainable residential development in ROI, and this is reflected by the inclusion of seven related indicators for ROI (8e), (11a–e) and (12d). While it is stated that every effort has been made to avoid domination of cars within the Adamstown development (SDCCPD, 2003), provision has been made to accommodate them within properly marked parking spaces (1/unit, or 2/unit with three or more bedrooms), within blocks, and on all roads and streets (excepting QBCs, Figure 6). Approximately 900 underground parking spaces have been allocated within the higher density developments of Adamstown Central, in line with (11b) in Table 3. Less attention to parking is given for the UK indicators, which also fall short of the standards ((iv) to (viii)) recognised for European best practice; undoubtedly these have contributed significantly to wider uptake of sustainable travel modes in these regions.

3.1.5 Disabled access

In line with national policy, disabled parking is provided throughout Adamstown. In addition, lower ground floors

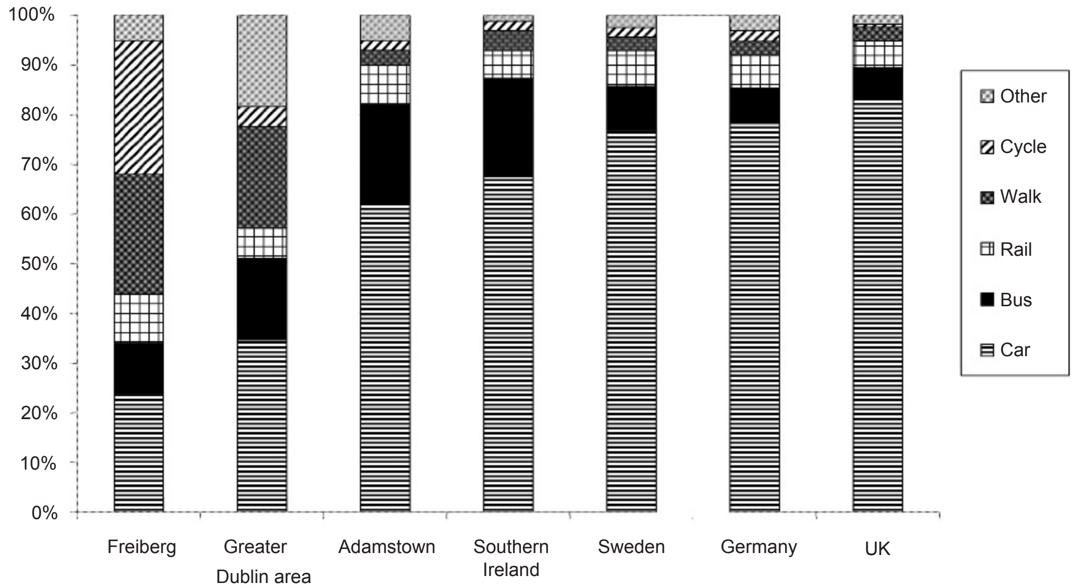

Figure 7. Modal split for transport in Adamstown as compared to national and international values (data from Beim and Haag (2010), SDCC (2009) and EEA (2006))

within the developments are wheelchair accessible. When completed it is estimated that the 24 km road network will contain 29 toucan crossings (seven others are possible), seven pelican crossings and two staggered crossings, all of which are wheelchair accessible. The finer details related to disabled access are given in 'Adamstown: Access for all strategy' (SDCCPD, 2006).

3.2 Energy infrastructure

Since ROI signed the Kyoto Protocol on 29 April 1998, it has been committed to reducing carbon dioxide emissions. ROI contributes 0·2% of total global emissions and the Irish government set itself an ambitious target of 15% reduction by 2010, greater by 5% than that proposed in the UK. The publication of several key documents, including a Green Paper: 'Towards a sustainable energy future for Ireland' (DoCMNR, 2006); and a White Paper: 'Delivering a sustainable energy future for Ireland' (DoCMNR, 2007) by the Irish government, have outlined strategies for achieving these reduction through the adoption of sustainable energy strategies, that is renewable energy technologies and improvements in energy efficiency (DoCMNR, 2006). As part of these initiatives, all homes offered for sale after 1 January 2009 now require an Irish building energy rating (BER) certification, similar to the domestic energy rating (DER) in the UK.

Adamstown has reportedly adopted a sustainable approach to energy design, specification and construction practices (Noonan, 2006) in line with such strategies; this section critically evaluates whether this has been the case.

3.2.1 Building design

Some 400 homes within the Adamstown Castle development were designed to be very energy efficient, achieving standards that complied with Sustainable Energy Ireland's (SEI, 2006) House of Tomorrow criteria. SEI was launched in 2001 to improve energy efficiency of homes in line with policy through the use of grants. One hundred homes in Adamstown Castle were funded through SEI; the other 300 were funded by the developer alone, reportedly at little extra cost (Mahoney, 2007).

Adoption of passive solar through building orientation is in line with achieving improved 'efficiency' within (5c) and (xii) Table 3, and integral to Adamstown's building design. The building fabric elements (e.g. roofs, walls, floors, doors and double-glazed windows) exceed by 40% on part L 2005 building regulations in ROI meaning that improved energy efficiency and reduced emissions within the home have been achieved, consistent with indicators for ROI (9b) and the UK (Ci) Table 3. Primary energy demands and carbon dioxide (CO_2) emissions in a typical house in Adamstown have been reduced respectively from 160 to 90 kWh/m^2/year and 32 to 19 kg CO_2/m^2/year (ODPM, 2006); this is broadly equivalent to level 3 in Code for Sustainable Homes – CSH (DFCLG, 2006). Unfortunately, this falls well short of a 'zero carbon home' (level 6 in CSH, (ix) and (x) in Table 3), for which there are many UK and European exemplar projects completed (e.g. Bedzed, Sutton, UK (BRE, 2002) and Vauban, Freiberg, Germany (Beim and Haag, 2010)) or UK Ecotowns currently underway (Direct Gov, 2010), for example (Hanham Hall, South Gloucestershire, UK and Parkdale, Castelford, Wakefield, UK).

3.2.2 Building materials

An overarching strategy for adoption of sustainable building materials is missing from ROI, despite advances on selected aspects. Low-carbon concrete and pre-cast panels have been adopted in Adamstown in order to reduce carbon emissions (and waste) throughout (Mahoney, 2007). In addition Scandinavian pine doors and windows form part of a comprehensive system for natural ventilation, draught sealing and household security (DoCMNR, 2006). Adoption of sustainable materials is a prerequisite for achieving a sustainable community in the UK (Table 3 (Dv)); this appears to be absent for ROI, except for the requirement for building materials to make a positive contribution to the locality (Table 3 (12a)). The requirement to measure and reduce the carbon footprint, a key driver for the adoption of more sustainable building materials, appears to be missing within the ROI checklist, although included to varying degrees for the UK (Table 3 (Dv)) and exemplar checklists (Table 3 (ix) to (xv)).

3.2.3 Energy supply

Thus far, all of the completed developments within Adamstown are connected to conventional mains gas and electricity supplies – a new 110 kV electrical transformer having been constructed on the western perimeter of the development. While SEI funding was secured to conduct feasibility studies considering sustainable approaches to energy within Adamstown (SDCC, 2005) these failed to look at innovative renewable energy supply schemes at the development scale as opposed to the individual home scale. This failing is thought to be attributable to unfavourable economics, contributed to in part by the nature of the Irish energy regulatory market but also the fact that a large section of the Adamstown project is low density (SDCC, 2005). This is a significant failing not least because European funding (e.g. Concerto and Thermie) could have been used to set up an Energy Saving Company (ESCO).

Recent development plans have incorporated a community heating system, supplied by 30% renewable energy, within Adamstown Central, however, the details have yet to be released. In addition the adoption of a combined-heat-and-power (CHP) system for powering the schools and leisure centre on the education and leisure campus site has been highlighted as a future possibility (ASG, 2005). If Adamstown is to make steps towards achieving sustainable credentials in terms of its energy supplies these schemes are vital. Moreover they will contribute towards 'security of supply' for ROI; one of the key aims of its energy white paper. Here it was shown that heating requirements are key issues for ROI because 80% of the natural gas supplies originate from the UK, which itself is a net importer (NDP, 2000). In addition turf is burned for heat (4·3% of Ireland's energy supply) with associated environmentally damage and, many would argue, this should be stopped (Howley *et al.*, 2008).

3.2.4 Domestic appliances

All houses in Adamstown are supplied with A-rated boilers (e.g. Mynute 25HE manufactured by Vokera) according to the SEDBUK (seasonal efficiency of domestic boilers in the UK) standard and in most cases houses were sold with pre-installed energy efficient A+ appliances, that is, fridge freezers, washing machine and dishwasher. Water and heating are operated by separate circuits and the heating is zoned (i.e. upstairs and downstairs can be operated individually) with timed temperature controls and individual radiator valves. These are valid steps within an overarching energy strategy to reduce demand, although it could be argued that this is now standard practice for new developments. The adoption of smart metering, as adopted within much older developments within Europe (Table 3 (xv)), would have shown some innovation; however, such schemes are missing from the Adamstown development.

3.2.5 Residential energy use behaviour

All new residents are informed of the behavioural changes that can be adopted in order to reduce energy demands further, by way of a housewarming pack and energy saving leaflets delivered through the door yearly. Undoubtedly people's behaviour in Adamstown is recognised as a significant driver toward reducing energy demand. While provision of information is important to incentivise behavioural changes, its effectiveness within Adamstown is as yet unknown.

3.3 Water infrastructure

3.3.1 Water supply

Adamstown has its water supplied from the new Lucan/Palmerstown high-level water supply scheme completed in 2004. Treated water is pumped by way of 26 km of new pipeline from the Leixlip water treatment plant to a new 40 Ml reservoir at Peamount Hospital. Currently there are no initiatives to source water locally (e.g. greywater or rainwater) in Adamstown and this perhaps might be surprising within the context of achieving a truly sustainable community (Hunt *et al.*, 2006). However, Table 3 indicates that this does not appear to be a requirement in ROI – moreover water is mentioned only in the context of reduced pollution within the UK (Cii). This is not surprising, perhaps, as water is a 'free' commodity in the ROI, in contrast to the UK and much of Europe where water rates are imposed.

3.3.2 Water demand and user behaviour

Adamstown is split into three local water section areas (WSAs), each of which is further divided into smaller district meter areas (DMA) in which it has been assumed that the daily demand per person will be 150 l (McCarthy, 2005). With respect to available SD benchmarks, for example the CSH in the UK (DFCLG, 2006), this is relatively high: CSH advocates a demand benchmark of 120 l/person/day for level 1–2 and 80 l/person/day for levels 5 and 6, the latter being advocated in the European exemplar list ((xvi) in Table 3).

While water demand is reduced through the adoption of various 'technical fixes' (dual flush toilets (6 l cistern), aerating taps and water-efficient appliances), these gains have been neutralised in many developments by the inclusion of power showers which significantly increase water use (24 l/min as opposed to 12 l/min). There is little sign of reduced consumption beyond what could be considered normal practice, and therefore little evidence to suggest that this is integrated anywhere within the Adamstown strategy. While reduced consumption ((Civ) in Table 3) is a key driver for achieving a sustainable community in the UK, it is not evident for ROI. Perhaps the lack of water rates is responsible, and for the lack of water meters (standard or smart) in domestic properties. As a direct consequence, residents cannot possibly be aware of, or seek to reduce, their daily or annual water consumption. In addition the inclusion of rainwater harvesting and greywater facilities ((xii) and (xiii)), as listed for the European exemplar, are absent in both the UK and ROI checklists.

3.3.3 Stormwater and flood risk

In terms of stormwater ~67% of the Adamstown development has been designed to drain by way of culverts towards the Tobermaclugg stream (see Figure 2) close to the River Liffey. The other 33% (including land from Adamstown Castle) drains toward Grifeen Valley sewer and Esker pumping station outside the eastern boundary. Most of Adamstown is located approximately 5 m above the indicative flood plain and therefore unlikely to flood, although the area around Tubber Lane has been known to flood previously. In order to avoid or alleviate downstream flood risk in the future, larger culverts ($2{\cdot}2 \times 1{\cdot}5$ m) have been introduced, sized for a 100-year flood event (McCarthy, 2008). In addition, two underground holding tanks (2400 m^3 of combined capacity) will be used to capture 'first flush' storm water and subsequently allow it to drain into the Griffeen tributary (Johnson, 2001). In so doing substantial sustainability benefits (i.e. reduced flood risk) have been gained for existing residents of this area. The preference in Adamstown appears to favour the adoption of engineered solutions for stormwater management over more natural solutions such as SUDS or porous surfaces (Ciria, 2000). While SUDS has been advocated within Adamstown (McCarthy, 2008), and is clearly recognised as having sustainability benefits in ROI (5b) and European exemplars ((xix) in Table 3), there is little evidence to show that it will be implemented in Adamstown. This is unfortunate because using combined engineered and natural solutions can significantly reduce stormwater entering the system, thus mitigating potentially significant impacts for those residents living further downstream.

3.3.4 Foul water

Foul water is transferred from Adamstown to the Lucan, Clondalkin drainage system by way of the Tobermaclugg pumping station using twin rising mains and a gravity sewer. Design calculations for foul sewers were undertaken using WinDES software (incorporating a range of dry weather flow (DWF) values up to 147 l/s (McCarthy, 2006). A design flow of 6 DWF was used based on a maximum yield of 90 units per hectare and an assumed outflow of 1000 l/unit/day (McCarthy, 2004, 2005). The new pumping station was constructed in 2006 and is located at the northern edge of the development in the new Tobermaclugg Park – it is located 300 mm above the levels predicted for a 1000 year flood event. There has been no attempt to localise water treatment in Adamstown, for example through the use of reed bed treatment systems. However, it is evident that resilience, a key element within the broader sustainability agenda, has been considered within the design of critical infrastructure components.

3.4 Information technology infrastructure

In Adamstown the developers attempted to future proof information technology (IT) through adoption of 'Smarthomes' infrastructure, providing the householder with two options (Gunne Homes, 2005).

- A bronze package consists of a complete household cabling system for connection of: digital TV, telephone, broadband, PC networking, and multi-media points throughout the home by way of a linked central hub (a user-friendly type patch panel system).
- Silver and gold packages include wiring for home cinema and audio, allowing for access to central radio, CD players and iPods throughout the home.

IT infrastructure provision formed a big selling feature within the design of Adamstown, with most developments offering access to at least two telecom ducts. While this is not directly stipulated for ROI in Table 3, it correlates well with the requirements for achievement of a sustainable community in the UK (Eiv and Ev). It could be argued that such technologies were ahead of their time when the development was being envisioned; however, there is little evidence to suggest that these go beyond what is now considered to be normal practice. Moreover the introduction of wireless technology has superseded their requirement for facilitating home working, and therefore it may be unsurprising to find specific IT indicators absent from the European exemplar checklist. Notwithstanding, there is little evidence to suggest that the impact of adopting such technological innovations on home working numbers has been monitored. 'Neutral carrier' multi-ducts (BRE, 2002). have been adopted as part of the IT infrastructure, which could be considered a more sustainable use of underground space allowing for easy upgrading and repair. That said, Adamstown, as a greenfield development, could have afforded the opportunity to completely rethink the way that utilities were placed below ground, for example through the use of innovative multi-utility conduits (i.e. an underground conduit that co-locates all utilities in an aim to avoid future disruption through maintenance procedures (Rogers and Hunt, 2006)).

3.5 Waste infrastructure

Three types of waste collection system operate within the Adamstown development: household waste, mixed recyclables, and organic waste. The collection bins for these (blue and orange and brown respectively) come in two sizes depending on type of residence (240 l for an individual dwelling and 1100 l for apartments). Adamstown householders receive an organised waste collection service for each dwelling, charges being made through the ground rent. The use of prepaid bin tags (€8 for 240 l) operates in and around the Lucan area. This method of payment contrasts with that used in the UK, where a standard charge is levied as part of council tax fee. Care has been taken over the positioning of bin stores in line with (12e) (Table 3 and Figure 8). Household waste is collected weekly, whereas recyclables and organics are collected fortnightly.

Only two requirements within Table 3 relate to waste ((5e) and (10e)) and Adamstown has addressed both. For example, appropriate recycling facilities are provided for glass (white, brown and green) and fabrics/clothes in a nearby local supermarket car park and, while it could be argued these are not exactly local, it can be seen within Table 3 such specification is not made. This contrasts significantly to the European exemplar checklist ((xxi) and (xxii), Table 3). There is little evidence to suggest that the Adamstown practices go beyond what can be considered normal for ROI, although a greenfield development could have afforded the opportunity to introduce innovative waste collection (e.g. through pneumatic systems). It might also be suggested that Adamstown has overlooked strategies that seek to minimise waste at source (e.g. composting and waste minimisation through behaviour changes) excepting the numerous charities which operate clothing collection schemes within the area. However, unlike the European exemplar checklist ((xx) and (xxiii), Table 3), these are once again not included for ROI.

Figure 8. Waste collection points and gated private parking spaces for apartments (front) with adjoining low density housing (rear) within Adamstown Castle (C in Figure 4)

Ireland does have the waste electrical and electronic equipment (WEEE) directive 2002/96/EC (a free 'take-back' service for small consumer products, e.g. toasters, portable tape players, mowers, etc.) and the environmental management cost – EMC (also known as 'producer recycler fund' added at purchase for take-back of larger goods), both of which should reduce the tendency to landfill. This is part of national policy and not related to a new initiative being adopted in Adamstown.

4. Discussion

The case study presented within this paper has been used to show the levels of infrastructure provision being considered for a new town under construction in ROI. This section discusses some important lessons that have been learned within three key areas.

4.1 Planning and development processes

Undoubtedly there have been many aspects of the planning and development process within Adamstown that would be considered essential elements for achieving a sustainable community (Table 4).

First it was essential to have all the three developers, Castlehorn, Maplewood and Tierra Ltd committed to a shared vision of developing a 'sustainable community' at the early stages of the project, and their willingness to work together was demonstrated by the formation of the Chartridge Developments Ltd consortium. Mahoney (2007) states that this enthusiasm helped filter the vision to associated parties on the respective teams: architects, engineers and landscape designers, who also bought into the process of delivering a sustainable community from an early stage. In the UK, the inability to draw developers together at the start of a development within a similar sized 170 ha urban regeneration scheme resulted in SD opportunities being missed (SDCC, 2006). Moreover the lack of a shared vision resulted in piecemeal development.

Actors	Lessons learned (actors involved)
C – Council D – Developers Pl – Planners P – Public Po – Politicians CG – Community groups	1. Integrated team (C, D, Pl) 2. Willingness to commit to a shared vision of a 'Sustainable community' early within decision-making process (C, D, Pl, Po, CG) 3. Strong early direction/leadership from South Dublin District Council (C) 4. New policy documents drawn up through lessons learned (C, Pl) 5. Early implementation of an efficient SDZ planning system (C) 6. Phased development process to allow for infrastructure to be in place (C, Pl, CG, Po) 7. High degree of information made readily available within public domain (C, D, Pl) 8. High degree of community engagement through planning process (C, D, Pl, P, CG)

Table 4. Important contributing aspects of the planning and development process

Second local and national politicians, and community groups influenced greatly the delivery process for Adamstown through submissions during the consultation period. They engaged with developers, national and local planning authorities through written and verbal consultation at planning board meetings very early in the decision-making process. The engagement of many like-minded people including local organisations such as the 'Finnstown Input Group' resulted in the requirement to phase developments within Adamstown in line with the provision of facilities, including key infrastructure components. Allied to this was the pressure applied by the Green Party upon government to secure the capital necessary for the infrastructure components.

Third South Dublin District Council (SDDC) provided strong direction both before and during the Adamstown development; as reported by Hunt *et al.* (2008) such leadership provides clear direction to all three developers and is vital to the delivery of SD. Such strong leadership may be due to the fact that Adamstown is the first SDZ to be built, and the first new town on this scale for more than 20 years in the ROI. Therefore its success is paramount to SDDC if such developments of similar scale are to be undertaken in the near future. In parallel to this the lessons learned within Adamstown are captured through new policy documents, thus facilitating the translation of lessons learned for design and planning of new towns.

Finally, a substantial amount of information is being made available to the public as part of the development process. All Adamstown planning applications (including all proposals for transport and utility infrastructure) accompany SDZ applications and are housed on the Adamstown website with hard copies made available at the local library; these are updated as new planning applications are lodged. In addition Adamstown has an information centre which is accessible to all. SDDC produces yearly updates on progress in Adamstown; hard copies are delivered by hand to residents and soft copies are posted onto the Adamstown website. Six have been produced so far (SDCC, 2005, 2006, 2007, 2008a, 2009, 2010b) Availability of such information is vital for the delivery of SD, as it facilitates public and community engagement. Moreover this new knowledge can facilitate locally derived solutions (Hunt *et al.*, 2008).

It is clear that there is a very strong will for Adamstown to succeed and to form the blueprint for meeting future housing needs of a growing national population in ROI.

4.2 Evaluating and monitoring current sustainable performance

The sustainable performance of Adamstown's infrastructure was evaluated in five key areas (transport, energy, water, information technology and waste) and throughout the evaluation process reference was made to a set of indicators for sustainable residential development that had been derived by planning authorities in ROI (Table 3).

When considered against ROI indicators for provision of transport facilities, Adamstown appears to be performing well. However, subsequent monitoring shows little change in residential car use despite provision of sufficient transport links (supported by five indicators) perhaps owing to the counter-productive measure of providing a significant amount of parking spaces (seven indicators). This may explain why European exemplars such as Bedzed and Freiberg sought to reduce parking spaces ($< 0{\cdot}5$/unit) and encourage car sharing schemes.

Adamstown has made steps toward reducing energy demands through improved building fabric; however, the level of sustainable performance is some way short of being nationally exemplary. In addition there is little evidence to suggest that any sustainable technologies will be adopted, with the possible exception of a proposed CHP system. This is a considerable shortfall because the opportunity to include a community heating system is never easier and cheaper than within a greenfield development. Unfortunately, as with existing town developments, such integration will now have to be on a retrofit basis at considerable expense. Once again it appears that the checklist system for ROI within Table 3 failed to provide sufficient direction. The same types of arguments can be used for water and waste. For example, there is little evidence to suggest that what occurs in Adamstown goes beyond normal practice in terms of reduced water consumption and waste production and yet it is in line with what is being asked for in Table 3. That said the adoption of SUDS is included in Table 3 and yet harder engineered solutions are being adopted to avoid flood risk. It appears that a more considered approach to infrastructure provision is required for ROI and perhaps this needs to be integrated with a greater appreciation for the use of underground space.

4.3 Preparing for future grand challenges – what if?

Many European examples exist that outperform Adamstown in terms of its creation of a truly sustainable community (e.g. Bedzed, London, UK and Vauban, Frieburg, Germany). Regarding its infrastructure performance, the most significant shortfalls in Adamstown appear to be its inability to significantly reduce demands or to maximise local sustainable sources of energy and water. This means that Adamstown is less well prepared than it might have been for possible challenges in the not-too-distant future: peak oil, carbon trading, climate change and extreme weather events (Glenn and Gordan, 2008).

It is very rare that developments consider thoroughly the changing requirements of future generations, not least in terms of its infrastructure provision and therefore it should come as no surprise that 'futures' thinking is missing from Table 3. While one UK indicator does state 'we should have regard for the needs of future generations in current decisions and actions' (H iii) even this does not specify how we should be considering the future. Perhaps therefore it could, and should, be argued that communities built in the name of sustainability need to provide infrastructure that is sufficiently flexible to cope with an array of future challenges, whatever they may be – that is, be sufficiently future proofed. Some may suggest that this is too logistically complex to undertake, although perhaps it simply requires a better understanding of what the future may hold. Moreover it requires a better understanding of how towns such as Adamstown might react to the future grand challenges – and these might be starkly different depending on the drivers that are in place. For example policy changes might seek to enforce reduction in demands through changes to end-user technologies; people's behaviour may change for the better – driven through a shared will to be more sustainable, they require and consume less; or it could change for the worse – driven by market forces where they want more and consume more. Alternatively it could be driven through the need to provide increased measures of security in a more fragmented hostile world. This process for thinking about the future within Adamstown is essential to the process of future proofing what is delivered today in planning terms, and it can be facilitated through asking pertinent 'what if' questions – a series of which have been compiled in Table 5. While these are focused on infrastructure, the key theme of this paper, they can be applied to any aspect related to the Adamstown development.

5. Conclusions

This paper has presented an overview of the Adamstown development in ROI and critically evaluated the steps being taken in terms of designing and planning for sustainability therein. It has been shown throughout the development process that much progress (in infrastructure terms) has been delivered, or is planned for; and most notably the development is reported to be exemplary in terms of its provision of community facilities and use of space above ground. This includes the provision of a well-coordinated public transport infrastructure system (including a new train station and bus routes) and provision for cycling that are all in line with sustainable policies for transport. Unfortunately while the provision of such infrastructure has been well intentioned it has made little impact on the ground.

When analysing the planning and development processes adopted in Adamstown it is apparent that the developers worked together with shared aims and objectives from the start of the project and this can be considered a necessary requirement in order to achieve a more sustainable outcome. Moreover this has been accompanied by early involvement from a range of stakeholders (e.g. council, developers, planners and community groups) during the consultation process. Such findings resonate well with previous research conducted using the Eastside urban regeneration project in the UK.

The paper has shown through specific examples that there are other European exemplar projects that way outperform Adamstown in terms of its sustainable performance in terms of transport, water provision, energy and waste. Moreover opportunities for maximising local water supply (e.g. rainfall harvesting), local energy supply (e.g. renewable) and minimising water demands (e.g. through end user technologies and greywater recycling) have been missed. Allied to this low performance is the inadequacy of the existing checklist system for sustainable communities in ROI. Such a shortfall may be to the detriment of Adamstown in the future, although this all depends on what the future holds. The future infrastructure requirements for a development such as Adamstown are very rarely considered and this paper has given examples of some 'what if?' questions that might have been considered. Further

Infrastructure	'What if?'
Community	1. What if the community expanded or contracted beyond that which is predicted, could the infrastructure cope with such changes? 2. What if the needs of the community changed? Would the existing built form serve those needs, if not could it be adapted or might it require complete regeneration? 3. What if more consumer goods were adopted resulting in significant increases in local demands, how would these be met? 4. What if national policies related to climate change and carbon trading required adoption of technology fixes (e.g. PV, solar thermal) to reduce emissions, how might these be implemented? 5. What if the community reduced their consumption patterns through step changes in user behaviour? How would the physical infrastructure react to this change? 6. What if the socio-economic conditions changed in Adamstown and 'security' became a critical issue, how might Adamstown ensure 'security of supply' at a local scale?
Transport	7. What if substantially more private cars running on fossil fuels were adopted? 8. What if policy required all cars to be electric? 9. What if policy required the number of car parking spaces to be reduced? 10. What if a 'no car' community was required?
Utility	11. What if more utility companies have access to the roads in the future and more road works become likely? 12. What if 'no-dig' policies are introduced for the roads and pavements, what alternative forms of utility placement could be considered? How would capacity be increased and maintenance requirements met? How might new utilities (e.g. hydrogen, CHP infrastructure) be adopted? 13. What if the utility requirements change (e.g. flow rates) or utilities simply become obsolescent (e.g. wired communications)?
Water	14. What if water demands change (increase or decrease)? Could it be supplied and how might the sewer infrastructure subsequently perform? 15. What if charges are imposed for domestic mains water supply and waste water disposal? 16. What if metering becomes mandatory? 17. What if smaller cisterns (2·5 litres) or waterless systems are required by law? 18. What if local supplies are required (e.g. rain/grey water, other) within buildings with large roof areas? How might these be integrated into community buildings? 19. What if rainfall variability occurs due to climate change, how would this variability in peak flow events be catered for? 20. What if 1 in 200 year floods became more likely due to climate change? How might SUDS be integrated seamlessly within the development in the future? 21. What if policies require that rain water is collected and re-used on-site, how might these technologies be retrofitted? 22. What if waste water needed to be treated on-site? Where might a treatment works or read beds be sited in the future?
Energy	23. What if energy costs increase significantly due in part to increased demands from a growing population but also the influence of peak oil? 24. What if less sustainable sources of energy are not allowed (e.g. burning turf) owing to its effect on climate change? 25. What if 100% carbon neutrality is required? 26. What if policy requires community heating schemes to be adopted? 27. What if policy requires that the building fabric be improved significantly, and to such an extent that heating requirements are minimised within a development? 28. What if low-energy-using technologies are adopted and peoples' energy-using behaviour changes significantly through free will? 29. What if security measures require all sources of energy to be sourced locally?
Waste	30. What if 'reducing' and 'reuse' options (e.g. composting) formed part of a mandatory requirement for waste, how might these be delivered? 31. What if landfill were prohibitively expensive or simply outlawed, how might this change the way Adamstown looked upon its waste? 32. What if waste wagons were no longer allowed on-site, how might innovative ways of collecting and sorting waste be achieved?

Table 5. Design approaches and 'what if?' scenarios for Adamstown's infrastructure

research will allow for responsive mode solutions to be derived and make future proofing more easily achievable.

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